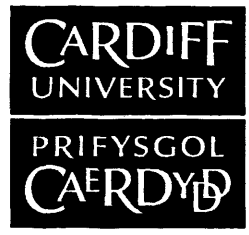

Cardiovascular Risk Prediction: how useful are web-based tools and do risk representation formats matter?

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Thesis submitted for the degree of
Doctor of Philosophy
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Abstract

Cardiovascular risk prediction tools are becoming increasing available on the web for people to use at home. However, research into the most effective ways of communicating cardiovascular risk has been limited. This thesis examined how well web-based cardiovascular risk prediction tools present cardiovascular risk and encourage risk reduction. Variation was found in both the quality of the risk communication and the number of features incorporated into the tools to facilitate decisions about lifestyle change and treatment. Additionally, past literature into the effectiveness of cardiovascular risk representation formats was systematically reviewed. This highlighted the need for more methodologically sound studies, using actual risk assessment rather than hypothetical risk scenarios.

This thesis also described a four-armed web-based randomised controlled trial (RCT) conducted to examine the effects of different cardiovascular risk representation formats on patient-based outcomes. It comprised a cardiovascular risk formatter that presented risk in one of three formats: bar graph, pictogram and metonym (e.g. image depicting the seriousness of having a myocardial infarction). There were two control groups to examine the Hawthorne effect. In total, 903 respondents took part in the trial. The most successful recruitment methods were web-based, including staff electronic noticeboards and social networking sites.

The RCT found that viewing cardiovascular risk significantly reduces negative emotions in the 'worried well', thus helping to correct inaccurate risk perceptions. There were no main effects of risk representation formats, suggesting that the way risk is presented had little influence on the population that were recruited, in terms of motivating behaviour change, facilitating understanding of risk information or altering emotion. However, a possible type II error occurred as the sample was unrepresentative, highly educated and biased towards those of low cardiovascular risk. Further research is needed to reach target audiences and engage those who would benefit the most from using risk assessment tools.

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Chapter 1. Introduction to thesis.

1.1 Introduction to thesis

This thesis describes work carried out for a PhD in cardiovascular risk communication. The aims and objectives of the thesis are described below:

This chapter defines cardiovascular disease and describes how cardiovascular risk is predicted. It will also explain the challenges and complexities surrounding the communication of cardiovascular risk.

1.2 Aims of thesis

This thesis aims to gain a deeper understanding of cardiovascular risk prediction and communication from a patient's perspective. It comprises three main studies into cardiovascular risk communication: (1) a critical appraisal of web-based cardiovascular risk prediction tools, (2) a systematic review into ways of communicating cardiovascular risk to patients, and (3) a web-based randomised controlled trial (RCT) into the effects of graphical risk representation formats.

1.2.1 Critical Appraisal

The aim of the critical appraisal was to determine which cardiovascular risk prediction tools are most likely to be found by people on-line, assess the quality of the risk communication of the tools and determine the extent that they encourage risk reduction behaviour.

The following research questions were assessed:

- What tools were most likely to be found by people on-line when they are searching for a cardiovascular risk assessment at home?
- How well did the retrieved web-based cardiovascular risk prediction tools communicate cardiovascular risk to users, according to the research evidence?
- How, and to what extent did the web-based cardiovascular risk prediction tools encourage and facilitate risk reduction through lifestyle modification and treatment options?

1.2.2 Systematic Review

The systematic review of the effectiveness of cardiovascular risk communication assessed past research conducted into cardiovascular risk communication, to see which risk representation formats are most effective for communicating cardiovascular risk to patients. The following research objectives were investigated:

(1) to compare the effectiveness of different interventions used to communicate cardiovascular risk, and (2) to assess the impact of the risk representation formats used in these interventions on patient related outcomes, such as understanding, affect, intention to modify behaviour and reduction in actual risk.

1.2.3 Randomised Controlled Trial

The overall aim of the RCT was to use a web-based risk calculator and risk representation formatter, to compare the effects of different graphical cardiovascular risk representation formats on individuals' intention to change behaviour to reduce cardiovascular risk, understanding of risk information, affect and worry about future heart disease.

The primary objectives were:

- To assess which format led to the greatest intention to change behaviour.
- To determine which format best facilitated understanding of risk information.
- To analyse which format altered emotion.
- To assess which format induces worry about future heart disease the most.
- To examine the correlational validity between intention to change behaviour, understanding of risk and worry about future heart risk. To find out if understanding led to more appropriate intentions regarding cardiovascular risk and what level of worry increases intention to change behaviour.

- To determine whether intention to change behaviour, understanding of risk, and affect were mediated by a person's risk category.

The secondary objectives of this study were:

- To examine the existence of the Hawthorne effect using two control groups.
- To analyse within-group changes between pre and post-intervention responses in the group who completed both questionnaires.
- To evaluate the use of the internet-provided risk formatter (process evaluation), including analysis of web-logs.
- To assess the efficacy of the Theory of Planned Behaviour at predicting intention to change behaviour to reduce future cardiovascular risk.

1.3 Outline of thesis

This thesis comprises 10 chapters. The following chapter (chapter 2) describes a critical appraisal of web-based cardiovascular risk prediction tools. Chapter 3 comprises a systematic review into effective ways of communicating cardiovascular risk to patients. Chapter 4 provides an overview of past research into the communication of risk.

The subsequent section of the thesis will describe a web-based randomised controlled trial into the effects of cardiovascular risk representation formats. Methodology is presented in chapter 5 and the piloting of the web-based risk

formatter in chapter 6. The results of the primary objectives are described in chapter 7 and the results from the secondary objectives in chapter 8. The trial is evaluated in chapter 9, which includes comparison with previous research and highlighting the strengths and weaknesses.

Lastly, chapter 10 discusses the thesis as a whole (e.g. the critical appraisal, systematic review and RCT). It will provide comment on future directions for research and implications for policy and practice.

1.4 MRC framework for developing and evaluating complex interventions

In 2000 the Medical Research Council (MRC) proposed a guidance framework to assist with the development and evaluation of complex interventions. This comprised a number of sequential phases of investigation in the evaluation of a complex intervention: theorectical (pre-clinical) phase, modelling (phase I), exploratory trial (phase II), definitive RCT (phase III) and long-term implementation (phase IV) (Medical Research Council 2000). However, in 2008 a revised guidance was published addressing limitations that were noted with the original framework, such as a need to pay greater attention to early phase piloting and development work, a less linear model of evaluation process and integration of outcome evaluation (Medical Research Council 2008; Craig et al. 2008). The updated framework consists of four stages (Development, Feasibility/Piloting, Evaluation and Implementation), it highlights the main interactions between the stages, emphasising that these stages do not follow a linear or cyclical sequence (Medical Research Council 2008).

This thesis follows the MRC framework in the development and evaluation of the web-based cardiovascular risk prediction tool. For example, the Development stage (which explores the theory and identifies the evidence base) was followed by critically appraising publicly available web-based cardiovascular risk prediction tools and systematically reviewing literature into effective strategies to communicate cardiovascular risk to patients (Chapters 2 and 3). The Feasibility / Piloting phase (or exploratory phase II), which tests procedures, was followed by the pilot study that preceded the main RCT of cardiovascular risk representation formats (Chapter 6). The Evaluation phase (or phase III main trial), consisting of an adequately controlled study with appropriate statistical power, relates to the main RCT on cardiovascular risk representation formats (Chapters 7 to 9). This includes evaluating the RCT by addressing standard design issues, such as identifying potential problems of bias that may limit the external validity of the trial (e.g. the extent that the trial results are generalisable to a wider population), or reduce the internal validity (e.g. the extent that the difference between the study intervention and control is real and not a product of bias) (Medical Research Council 2000; Medical Research Council 2008).

1.5 Introduction to cardiovascular risk

This section will provide a definition of cardiovascular disease and prevalence rates. It introduces the concept of cardiovascular risk prediction and explains some of the challenges and complexities surrounding the communication of cardiovascular risk to patients.

1.5.1 Definition and prevalence of cardiovascular disease

Cardiovascular disease (CVD) is a general term used to describe disorders relating to the heart and vascular system. These cardiovascular problems can result in chronic conditions persisting over a long period of time; they can also lead to acute events such as myocardial infarctions (heart attacks) and strokes. Coronary heart disease (CHD) and coronary artery disease (CAD) encompass angina, myocardial infarctions and heart failure, whereas cerebrovascular disease comprises transient ischemic attacks and strokes (South East Public Health Observatory 2010).

The British Heart Foundation statistics (derived from data from routinely collected national datasets) reports that 38% of all deaths in the UK result from CVD (British Heart Foundation 2009). This makes it the main cause of death in the UK. In 2003 approximately 233,000 people died from CVD, around half (just under 114,000) of these were caused by CHD and a quarter from stroke. Comparing this to other diseases, around 33,000 deaths in the UK in 2003 were from lung cancer, 16,000 deaths were from colorectal cancer and 13,000 deaths were from breast cancer (British Heart Foundation 2009).

Due to favourable changes in risk factors (described below) in developed countries including the UK, the incidence of myocardial infarction has decreased over the past three decades; however, it is estimated that there are still 124,000 heart attacks in the UK every year (Scarborough et al. 2010). Furthermore, CVD cost the UK economy £29.1 billion in 2004, including healthcare and productivity losses due to mortality and morbidity (Luengo-Fernández et al. 2006). This suggests that more

needs to be done at educating people about their risk and encouraging primary prevention.

1.5.2 Risk factors for cardiovascular disease

Cardiovascular disease (CVD) has a multi-factorial aetiology, and a variety of risk factors act synergistically (Anderson et al. 1990). Factors that increase the likelihood of developing CVD are both non-modifiable and modifiable.

Non-modifiable risk factors can include age, sex and ethnicity. According to recent national survey data for the UK, the British Heart Foundation reports that the prevalence of cardiovascular conditions such as myocardial infarction, stroke and angina increases sharply with age and is higher in men than women. Furthermore, there are differences in prevalence rates across regions in the UK. For example, Scotland and the North of England have the highest number of deaths from CHD, while the South of England has the lowest (Scarborough et al. 2010).

Modifiable risk factors have also been identified. These include cigarette smoking, lack of exercise, poor diet, high cholesterol (hypercholesterolemia), high blood pressure (hypertension) and obesity (Anderson et al. 1990; Grundy et al. 1999). The most important and modifiable cause of the majority of deaths from CVD is an unhealthy lifestyle, as opposed to medical conditions or genetic predispositions (Mokad et al. 2004; World Health Organisation 2002).

1.5.3 Cardiovascular risk prediction

The modifiable and non-modifiable risk factors have been identified by research carried out over the last few decades into predicting CVD. Risk prediction tools have been developed that use algorithms estimating the probability of developing future CVD according to a person's risk factors. The algorithms are derived from large prospective cohort studies. For example, the longitudinal Framingham Heart study, which started in 1948 in the USA, consisted of a cohort of 2489 men and 2856 women aged 30 to 74 years at baseline, who were followed for up to 12 years. This led to the development of the Framingham Risk function which estimates 10-year risk of CHD (e.g. fatal or non-fatal CHD event), using risk factors found to be significant predictors such as age, sex, blood pressure, cholesterol level and smoking status (D'Agostino et al. 2008; Wilson et al. 1998).

Additional cardiovascular risk prediction tools include the Prospective Cardiovascular Münster (PROCAM) risk calculator. This is based on a scoring system derived from 10-year follow up data from the PROCAM study of participants from the Münster and Northern Ruhr areas of Germany. It was initially developed and validated in 5389 men aged 35-65, of whom 325 developed acute coronary events. It was later extended to include female participants. It identifies 8 risk factors. In order of decreasing importance these are: age, LDL-cholesterol, smoking, HDL-cholesterol, systolic blood pressure, family history of myocardial infarction, diagnosis of diabetes and triglycerides. It predicts 10-year risk of an acute coronary event (Assmann 2005).

Systematic Coronary Risk Evaluation (SCORE) algorithm is based on data from 12 European cohort studies in general population settings. Risk estimates for high risk and low populations have been developed. SCORE provides assessment of CVD risk defined as the risk of developing a fatal cardiovascular event in the next 10 years (Conroy et al. 2003; Toth 2007). Other cardiovascular risk prediction algorithms include Reynolds Risk score (Ridker et al. 2007), Copenhagen Risk score for myocardial infarction (Thomesen et al. 2001), ASSIGN score (Woodward et al. 2007) and the Cardiovascular Disease Risk Prediction Charts recommended in the Joint British Societies' guidelines (Joint British Societies 2005).

The accuracy of these algorithms varies considerably between populations. For example, data from the Framingham study severely underestimates cardiovascular risk in African-American patients, and those from lower socio-economic areas (Hippisley-Cox et al. 2007). Better accuracy is achieved when the tool is used on a similar population that was used during the development and validation (Brindle et al. 2006). A recently developed and validated tool in the UK is QRISK (Hippisley-Cox et al. 2007). This was derived from the QResearch database of health records of 10 million patients. QRISK includes variables such as age, sex, social deprivation (using the Townsend deprivation score), body mass index (BMI) and use of antihypertensive medication. It has been shown to more accurately predict risk in the UK population than the Framingham and ASSIGN models. The Framingham equation over-predicted risk at 10 years by 35%, ASSIGN by 36%, whilst QRISK only over-predicted by 0.4% (Hippisley-Cox et al. 2007).

QRISK 2 has been developed as a progression of QRISK. It incorporates ethnicity, and other clinical conditions into the algorithm, such as rheumatoid arthritis and chronic renal disease. It has improved accuracy of identification of those at high risk in a nationally representative population compared to the original QRISK (Hippisley-Cox et al. 2008). This has been confirmed by an independent validation (Collins and Altman 2010).

Cardiovascular risk prediction tools are available in various formats. More calculators are becoming increasingly becoming available, and freely accessible through the internet, including PROCAM, SCORE, QRISK2 (Assmann 2005; Conroy et al. 2003; Hippisley-Cox et al. 2007).

1.5.4 Treatment and screening

Primary prevention programmes in many developed countries aim to reduce the mortality and morbidity caused by CVD through modification of risk factors (Ebrahim et al. 2006). All preventive guidelines on CVD and diabetes focus on multiple risk factors. It is agreed that risk factors increase the likelihood of a cardiovascular event and that risk is additive (Ballantyne et al. 2005). Clinical guidelines on CVD risk factor management recommend that treatment decisions should be informed by short-term estimates of absolute CVD risk (e.g. 5 or 10 years). This is because the clinician's first priority should be deciding how intensively to manage a patient's current risk. For example, if a patient's short-term risk is high, intensive management with medical/drug treatment and lifestyle changes is recommended. If risk is moderately

increased, less intensive intervention strategies involving lifestyle changes are appropriate, such as patient education and counselling regarding diet, smoking, physical activity and alcohol consumption, as there is more time to safely change behaviour and risk (Koelewijn-van Loon 2010; Wells et al. 2010).

Lifestyle modification interventions for the prevention of CVD have shown moderate but significant effects, as well as being cost-effective (Ades et al. 1997; Jolliffe et al. 2001; World Health Organisation 1998). One study has shown that the most cost effective interventions for the primary prevention of CVD (measured by the number of deaths averted and life-years saved within a 10-year period) is smoking cessation therapy; whereas a medical intervention, statins, is the least cost-effective (Franco et al. 2007). Therefore, it is important to emphasise the importance of lifestyle modification to the general population.

The UK government aims to reduce future risk of CVD, stroke, renal disease, type 2 diabetes and peripheral vascular disease in the population, and has coordinated a vascular disease control programme that involves vascular screening (Gray 2006). This programme focuses on disease prevention by early detection and treatment of the disease. A variety of risk management strategies have been put forward, such as the identification of high-risk individuals from general practice records using a computer risk calculation tool. A patient at increased risk will be presented with various strategies to reduce their risk (Davies et al. 2008; Gray 2006). The vascular screening programme recognises the importance of risk communication to ensure patients are well informed and knowledgeable about their risk, but also to increase the likelihood of them adhering to their chosen treatment plan. However, it is

acknowledged that there is little evidence of the effectiveness of aids in communicating CVD risk (Davies et al. 2008).

1.6 Cardiovascular risk communication

This section will give a brief insight into the issues surrounding risk communication and will explain why the communication of cardiovascular risk in particular is more complex and challenging.

1.6.1 General risk communication

As described in more detail in Chapter 4, there are various ways statistical risk information can be communicated to patients. Numerical expressions include percentages, natural frequencies and numbers needed to treat (Edwards et al. 2002; Gigerenzer and Edwards 2003). Graphical representations can also be used. These include bar graphs and pictograms or icon arrays (Lipkus and Hollands 1999). Much research has been done into the effects of risk presentation on patients (Covey 2007; Cuitie et al. 2008; Lipkus 2007; Politi 2007). For example, the perceptions and behaviours of patients are sensitive to the way the risk information is formatted and framed (Edwards et al. 2001; Lloyd 2001; Weinstein 1999). Risk information needs to be presented in a simple, balanced and appropriate way. It should address the patient's perception of the probability of an event as well as the importance of the event for that individual. Poor representation of statistical information may result in

sub-optimal choices and treatment (Edwards et al. 2001; Edwards et al. 2002; Gigerenzer and Edwards 2003).

1.6.2 Communication of cardiovascular risk

In addition to the general difficulties faced when communicating health risks to patients, the communication of cardiovascular risk is further complicated and complex for a number of reasons. The main ones will be described below.

Multiple risk factors

Multiple risk factors that contribute to CVD include age, cholesterol levels and smoking. It is thought that at least 80% of all CVD, stroke and type 2 diabetes, and over 50% of deaths from CVD, are attributable to the existence of modifiable risk factors such as a poor diet, lack of physical activity and tobacco use (Epping-Jordan et al. 2005). The atherosclerotic process underlying ischaemic events results from an interaction of many risk factors, with modest increases in multiple risk factors being more harmful than a significantly raised level of any single factor (Wells et al. 2010). The risk factors act synergistically, leading to minor modifications in one lifestyle factor in the presence of other risk factors, having large effects on overall risk. It is unclear whether patients understand this compounding risk effect (Sutton 1998).

Extended time horizons

Secondly, extended time horizons need to be considered. Heart disease is an insidious process and reducing its risk is work that has to be carried out over many decades, including multiple changes to lifestyle (Ballantyne et al. 2005). The optimum time to reduce risk is when aged in the early 20s and certainly in the 30s (McGill et al. 2008). However, most risk calculations are done much later and the methods almost always assume that the issue of risk is addressed in later life. For example, CVD risk calculations usually present anticipated risk over the coming 10 years and are highly dependent on age as a variable. Age is the single strongest risk factor for future cardiovascular events, but by emphasising the impact of ageing in risk prediction models, modifiable risk factors, such as blood pressure are underemphasised (Ridker and Cook 2005).

Some argue against the use of age in cardiovascular risk communication because of a danger that using it as such a strong risk factor may dishearten certain patients. What patients really want to know is whether stopping smoking, losing weight or taking statins and other medication is going to reduce their risk of CVD (Durrington 2009). However, others disagree and suggest removing age from risk calculations is not necessary and would be inappropriate (Vasan and D'Agostino 2005).

Abstract concept

Lastly, patients find CVD an abstract concept. They have difficulty interpreting personal candidacy and consider it a 'sneaky disease' (Angus et al. 2005). The abstractness of CVD is partly attributable to the numerical constructs or risk estimates derived from mathematical algorithms. The applicability of these risk estimates at an individual level is limited as they involve population data. The precise meaning of risk estimates is lost with respect to individuals as they are dichotomous, where they either occur or they do not, and patients will either be affected or not affected. Patients perceive cardiovascular risk as a dichotomous variable and do not appreciate the grey areas between the extremes, or acknowledge the spectrum of disease symptoms that could be experienced (van der Weijden et al. 2008). The lack of understanding of cardiovascular risk estimates by both patients and practitioners is believed to a barrier in the implementation of absolute CVD risk-based management (Wells et al. 2010).

Furthermore, patients' understanding of how CVD risk is made up is generally poor and insufficient. For example, interviews with patients found that many showed insufficient insight into cardiovascular diseases to be able to really understand their GP's explanation. There was a lack of knowledge about the aetiology, consequences and prevention options. The importance of cholesterol as a risk factor was overestimated, and some patients failed to realise that smoking makes the greatest impact on overall CVD risk (van Steenkiste et al. 2004a).

This lack of knowledge regarding CVD and a lack of understanding of the risk presented in prediction tools leads to unrealistic perceptions of risk. Misperceptions occur when the perceived risk does not correspond with actual risk. This can be an underestimation (incorrect optimism or optimistic bias) or overestimation (incorrect pessimism) (Frijling et al. 2004; van der Weijden et al. 2008). Misperceptions increase the difficulty in accurately interpreting and acting upon the risk information in an appropriate way (Erhardt and Hobbs 2002; van Steenkiste et al. 2004b). However, a systematic review on the effects of presenting coronary risk information concluded that coronary risk information can improve accuracy of risk perceptions and increase intention to initiate prevention strategies (Sheridan et al. 2010).

1.7 Summary

This chapter has introduced the work that has been conducted for this thesis in cardiovascular risk communication. The aims and objectives of the thesis and a breakdown of thesis chapters were given. Challenges and complexities surrounding the communication of cardiovascular risk were highlighted, such as the multiple risk factors involved, the extended time horizons that need to be considered, the abstractness of risk estimates derived from mathematical algorithms, and the difficulty patients have in understanding the risk information. Due to these complexities, there is a gap in the literature into how to effectively communicate cardiovascular risk to patients. Therefore, this thesis attempts to address this issue by determining how well existing cardiovascular risk prediction tools present risk to patients, and to further the knowledge of what representation formats are most effective in presenting risk to patients.

Chapter 2. A Critical Appraisal of the quality of risk communication of publicly available tools most likely to be found on the World Wide Web.

2.1 Introduction

Risk prediction tools use algorithms that estimate the probability of developing future CVD according to a person's risk factors. These algorithms are derived from large prospective cohort studies. A best known example is the Framingham Heart Study, which led to the Framingham Risk Function which estimates 10-year risk of CHD (D'Agostino et al. 2008; Wilson et al. 1998). Web-based versions of CVD risk prediction tools are becoming increasingly available, including PROCAM, SCORE and QRISK2 (Assmann 2005; Conroy et al. 2003; Hippisley-Cox et al. 2008).

It is common for internet users to seek health information on the World Wide Web. Recent figures suggest this may be around 60% of users (Fox 2009), and health-related websites are among the most widely used websites on the internet (Wilson 2002). Furthermore, over 20% of patients search the internet for information on CVD, which is greater than those seeking cancer or diabetes related information (Diaz et al. 2002). General search engines appear to be the first point of call for those searching for on-line health information, instead of medical portals or sites relating to medical societies and libraries (Eysenbach and Köhler 2002). An example of a general search engine is *Google.com*, which is the market leader in the Western world. An average of 34% of all global internet users visit *Google.com* on a daily

basis (Alexa 2009; Nielsen 2009; Search Engine Watch 2009). The quality of the information found on the web varies. This is a concern as users rarely pay attention to the origin of health information they find on the web and do not search for information about who stands behind the websites (Eysenbach and Köhler 2002).

The World Wide Web is changing the way people access health information and how they interact with this information. For example, web-based risk prediction tools are interactive and can offer decision support. They help users assess their individual risk and can provide personal feedback on options to reduce risk through treatment and/or changes to behaviour. Research into risk prediction tools proposes that the personalisation and interactivity of risk calculators may influence users to be more attentive, motivate systematic processing of health information and increase accuracy of risk perceptions and therefore, improve decision-making (Kreuter 1999).

Previous research into web-based cardiovascular risk prediction tools has been conducted. For example, when searching for cardiovascular risk prediction tools using different search engines, variation was found in the number of 'hits' that were retrieved (e.g. between 47 and 700,000). However, the first five risk prediction tools retrieved by the search engines were similar. Of the six tools that were assessed, there was broad agreement in the risk output results, apart from one that gave inconsistent risk scores (Roberts et al. 2007).

Another study evaluated cardiovascular risk prediction websites for their validity, type of information presented and usefulness of the information for physicians or patients. Of the eight sites included, two provided calculation of cardiovascular risk using the

Framingham equation. The others proposed guidelines or general information on cardiovascular health. The majority of sites lacked information to appraise the quality of the site's content (Gillois et al. 1999).

Furthermore, a web and literature search of cardiovascular risk calculators found variability in the different calculators, in terms of the target population, risk factors measured and the endpoints predicted. For example, some calculators did not specify exactly what they were predicting (e.g. cardiac risk only or cardiac plus cerebral risk), did not give advice about the eligible population (age range, past clinical history, family history etc.) or did not provide reference to the algorithm used by the tool. Also, there was variation in the risk representation used in the calculators. Some provided risk estimates as percentages, some used natural frequencies and some used risk categories (the exact numbers were not reported). The timeframes ranged from 5 to 10-years or could be specified by the user (Quaglini et al. 2005).

The portrayal of cancer risk in web-based prediction calculators has also been examined. In a content analysis (Waters et al. 2009), 47 web-based cancer risk prediction tools were assessed on the extent that they provided risk information that facilitated comprehension of probabilistic information and reduced biased interpretations. This included whether the tools described risk using words and numbers, used natural frequencies (e.g. *n in 1000* or *1 in N*) or percentages, provided absolute and comparative risk information (e.g. how your risk compares to the average person of the same age/sex) and included a graphical representation of risk. In general, the tools varied in their use of risk communication formats. Just over

half of the tools (n=24) provided a worded description of risk, such as 'Low' without a numerical estimate of probability. 16 (34%) provided numerical estimates alone and 5 provided both numerical estimate and worded description. Percentages were used by 17 of the tools and natural frequencies were used by 10 tools. Nearly half of the tools (n=21) provided estimates as absolute risk, 10 tools (21%) provided comparative risk information and 14 tools (30%) provided both absolute and comparative risk. Lastly, 18 tools (38%) provided a graphical representation of risk, such as bar graphs, line graphs or tables. These tools also varied in their affiliations, 8 were from cancer centres, 6 were from government organisations, 6 were by advocacy/non profit organisations, 3 were from educational institutions and 3 were commercial (Waters et al. 2009).

Apart from the variation in risk representation found by Quaglini et al 2005 (Quaglini et al. 2005), little is known about how well risk is being portrayed in web-based cardiovascular risk prediction tools, in terms of whether it adheres to evidence-based best practice and research evidence for risk communication, including recommended guidelines (Covey 2007; Cuitie et al. 2008; Edwards et al. 2006a; IPDAS 2005; Lipkus 2007; Politi 2007), and the extent that the tools offer feedback and decision support for reducing cardiovascular risk.

As new communication technology becomes freely available for the public to use, there is a concern that the risk presented could be unbalanced and without context; therefore, not giving a complete picture and having the potential to mislead (Woloshin et al. 2003). Balanced risk communication is important as different formats and framing can influence understanding, perceptions and the behaviour of an

individual (Edwards and Bastian 2001; Gigerenzer and Edwards 2003; Lloyd 2001; Weinstein 1999).

2.2 Aims and Objectives

The purpose of this critical appraisal was (1) to determine which cardiovascular risk prediction tools are most likely to be found on the World Wide Web when people seek to have their risk assessed on-line; (2) to assess the quality of the risk communication portrayals, and (3) to examine how, and to what extent, risk reduction is encouraged.

2.3 Methods and Design

2.3.1 Design

The World Wide Web was searched for cardiovascular risk prediction tools, using Mozilla Firefox version 3.5.5 browser software.

2.3.2 Method

Cross-sectional, criterion-based appraisal of web-based cardiovascular risk prediction tools most likely to be found on the internet.

2.3.3 Search term generation

Two types of searches were conducted. One using specific search terms relating to cardiovascular risk prediction, and the other using general keywords that people might use, generated from an elicitation survey. This was because although previous studies searching for web-based risk prediction tools have used terms specifically tailored to their topic of interest (Gurmankin Levy et al. 2008; Roberts et al. 2007), it is unclear whether these terms would actually be used by lay people when conducting their searches on the World Wide Web. Therefore, it was felt important to conduct the two different types of searches to enable a comparison of the results, given the likelihood of the different outputs.

General layman search

The first search was the general layman search. Search terms were generated from a search term elicitation survey, which asked people what search terms they would enter into a search engine if they were looking to assess their cardiovascular risk on-line. The elicitation survey was conducted using members of the general population, naive to the purpose of the research. 24 individuals were asked to indicate which search terms they would enter into *Google* or other search engines, if they were interested in finding out their risk of heart disease. The survey was constructed using *Google docs,* which sends an email invitation comprising a hyperlink to the survey (Appendix 1). Respondents click on the link and are taken to the survey page (Appendix 2), they complete the survey then press the submit button. The anonymous results were compiled in a Microsoft Office Excel Spreadsheet. Appendix

3 shows the responses from each respondent. The survey generated 46 search terms in total. The most common search term was *Heart disease risk,* suggested by 11 respondents. *Heart disease* was suggested by 4 respondents, *Risk of heart disease* by 3 respondents and *What is my risk of heart disease?* by 3 respondents. As there was variation in the other 43 search terms it was felt necessary to include all of them in the final search (Appendix 4).

Search specific to cardiovascular risk prediction tools

The second search comprised a list of search terms that specifically related to cardiovascular risk prediction tools. These comprised two stems, one describing cardiovascular disease (e.g. *heart risk, heart disease* and *heart attack*) and the other containing words that could be used when searching for prediction tools (e.g. *calculator, prediction, assessment* and *tool*). A brief pilot of the search terms was conducted on 8th January 2010 (Appendix 5). A noticeable difference in the results was found according to the order of presentation of the word stems. Therefore, it was decided that the order of presentation of the word stems would be altered in the main study to produce logical keywords, for example, '*heart risk calculator*' and '*calculate heart risk*'. 22 searches were conducted in total. A list of the search terms is presented in Appendix 6. These will be explained in more detail below.

Figure 2.1 demonstrates the differences in the two types of searches: the terms specific to cardiovascular risk prediction tools (on the left) and the general layman search (on the right). Only two search terms were common to both searches, these

were *Calculate heart disease* and *Heart risk calculator*. This demonstrates that the public tend not to tailor their searches and opt for more general search terms.

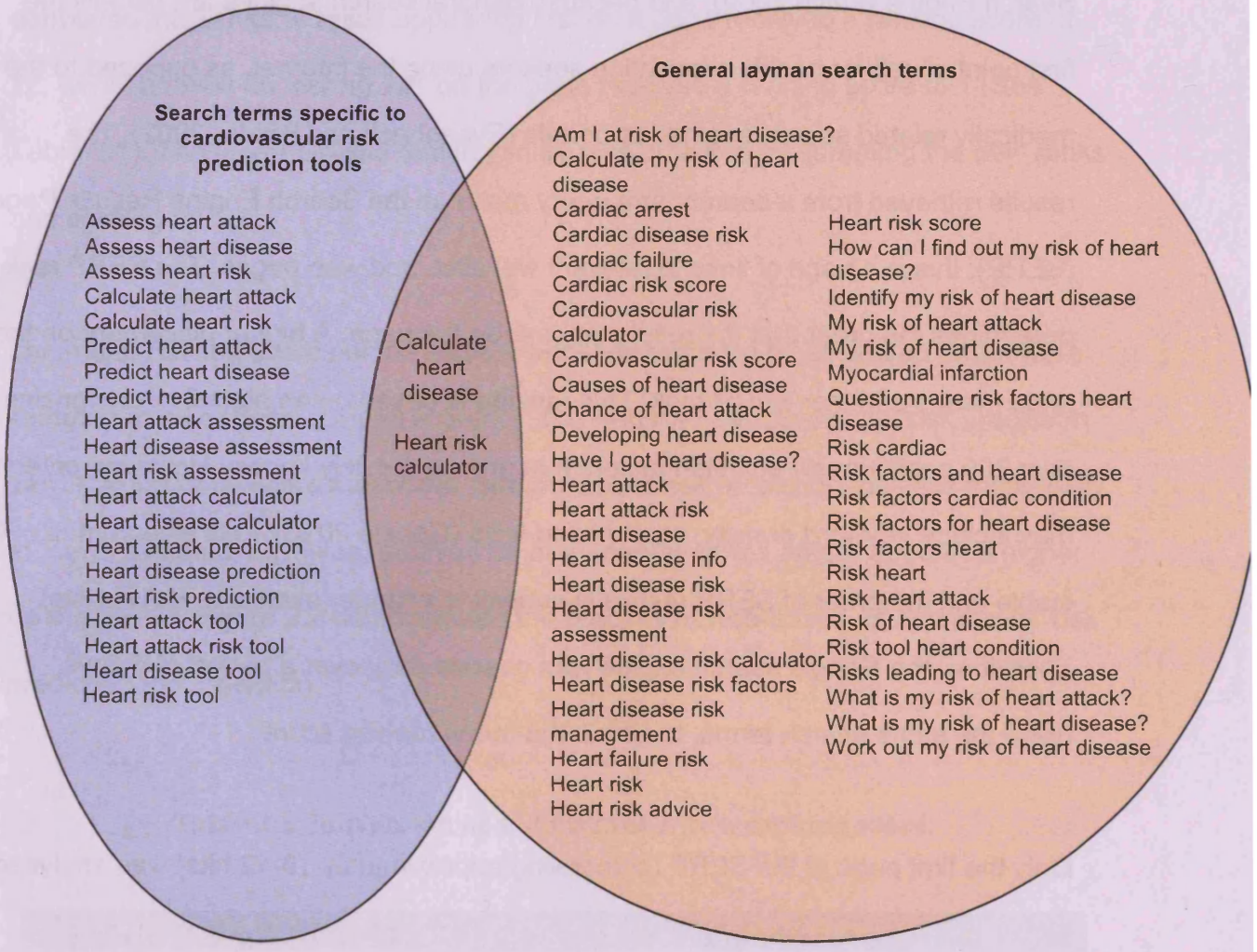


Figure 2.1 Search terms used in the search specific to cardiovascular risk prediction tools and the general layman search.

2.4 Procedure

2.4.1 Selection of cardiovascular risk prediction tools

The selected search terms were entered into *Google.com* search engine. This was chosen as it is the most popular general search engine globally (Nielsen 2009; Search Engine Watch 2009); and because general search engines are usually the first point of call for health-information seekers using the internet, as opposed to the medically related search engines or portals (Eysenbach and Köhler 2002). The results retrieved from a search term query make up the Search Engine Results Page (SERP); this is a page of links to relevant websites and web pages. The SERP rank determines the order that the results appear on the page. A higher placement on the page means a higher SERP rank. This ranking is based on an algorithm comprising over 200 continuously adjusted factors that are not publicly known. However, criteria may include keyword density, content and links (Google 2010). This algorithm is not stable and the order of SERP results is subject to change (even on a daily basis). Therefore, the *Google* search engine was queried daily over a period of 5 days, using the same search terms, to obtain the mean ranking score.

Only the first page of the SERP (comprising approximately 10-12 hits) was analysed; as it is generally acknowledged that people do not go beyond this first page of results. Studies have shown that the first page of results from search engines is significantly more likely to be accessed by health information seekers, with access to the subsequent pages exponentially declining thereafter. Users prefer to rephrase

their search terms, rather than consulting the additional pages (Eysenbach and Köhler 2002; Hansen et al. 2003).

The first page of SERP results for each search term was recorded via a screenshot. Each result on the first page of the SERP was visited and assessed for eligibility. The SERP scores of eligible websites retrieved from the five day searches were converted into ranks. A result appearing first on a page received a ranking score of 12, whilst a result appearing 12th on the page received a ranking score of 1 (See Table 2.1). The mean *Google* ranking score was obtained by summing the new ranks and dividing by 5.

The mean ranking scores of the eligible websites retrieved by all search terms were summed to give a total ranking score for that website / cardiovascular risk prediction tool. A higher total score meant the cardiovascular risk prediction tool was more likely to found by users, as it was retrieved by more search terms and/or appeared higher up the SERP. Figure 2.2 demonstrates the process of web-based cardiovascular risk prediction tool selection.

Table 2.1 Conversion of a SERP rank into a ranking score.

	Rankings											
SERP rank on page	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**	**10th**	**11th**	**12th**
Ranking Score	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**

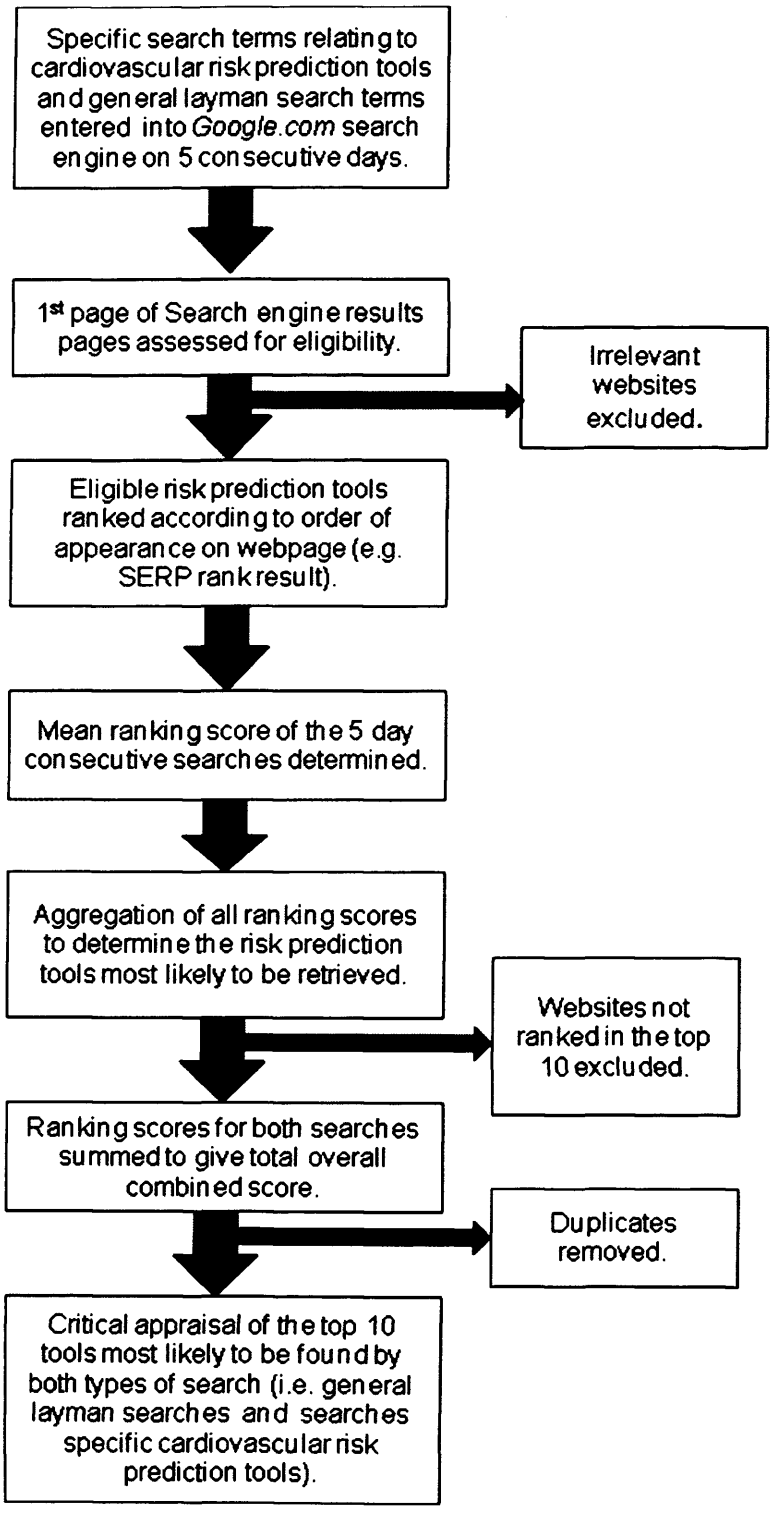


Figure 2.2 Process of selecting the cardiovascular risk prediction tools most likely to be retrieved by users: Flowchart.

2.4.2 Inclusion and exclusion criteria

The inclusion criteria for this study consisted of any interactive patient facing website, comprising a functional cardiovascular risk prediction tool (questionnaire, algorithm etc.) to assess personalised risk of any cardiovascular disease event (such as myocardial infarction, cardiac death or angina), by the user inputting risk factor variables. Tools that were in English language and freely accessible were included.

Web pages that had a visible internal or external hyperlink to a cardiovascular risk prediction tool (including sponsored links) were also included, as it was clear that the purpose of the page was to direct people straight to that risk prediction tool.

However, results were excluded if they were not interactive (e.g. did not allow the user to input risk factor variables for a personalised assessment) or did not give a personalised risk estimate.

Web pages that discussed cardiovascular risk, but did not contain links to a functional cardiovascular risk prediction tool (such as journal papers relating to development of tool) were also excluded. This extended to web pages on a website that had a risk prediction tool present, such as a *Frequently Asked Questions* page. This was because a new visitor to the page would not necessarily know that a risk prediction tool was available on that site.

Web articles or blogs that had hyperlinks to cardiovascular risk prediction tools were also excluded, as the main purpose of the page was not to direct people to the risk

prediction tool but another reason. Furthermore, web pages with more than one link to different risk prediction tools were excluded as it was not possible to determine which link would be chosen by the user. Tools requiring subscription charges or pay-to-view were excluded, as were tools not in English Language (due to the inability to assess them).

2.5 Analysis

For both the tailored search specific to cardiovascular risk prediction tools and general layman search, the 10 highest ranked cardiovascular risk prediction tools (deemed most likely to be found on *Google)* were critically appraised.

Hypothetical patient profiles (Table 2.2) for those at high and low risk were devised and inputted into the risk prediction tools to create a risk output. A standardised critical appraisal template was used (Appendix 7). This was designed by adapting existing guidelines and evaluation tools (Bedell et al. 2004; Gillois et al. 1999; IPDAS 2005).

Table 2.2 Hypothetical high and low risk patient profiles.

Risk factors	High risk patient profile	Low risk patient profile
Age	59	45
Sex	Male	Female
Ethnicity	White	White
SBP	160 mm/Hg	120 mm Hg
DBP	100 mm/Hg	80 mm Hg
HDL-C	50 mg/dL or 1.3 mmol/L	60 mg/dL or 1.5 mmol/L
LDL-C	189 mg/dL or 4.9 mmol/L	80 mg/dL or 4.4 mmol/L
Total chol	240 mg/dL or 6.2 mmol/L	200 mg/dL or 5.2 mmol/L
total-C to HDL-C ratio	4.8	3.5
Smoking status	Regular heavy smoker/ +20 a day	Non-smoker
Family history of CVD, high BP or diabetes	Yes	No
Had a heart attack, angina, stroke or TIA?	No	No
Have chronic kidney disease?	No	No
Have Atrial fibrillation?	No	No
Have rheumatoid arthritis?	No	No
Have left ventricular hypertrophy?	No	No
On blood pressure treatment?	Yes	No
Physical activity / exercise	Little or no physical activity	Regular physical activity / exercise
BMI	33	19
Height	5'6" / 168cms	5'8" / 173 cm
Weight	200 lbs / 91 kgs	125 lbs / 57 kgs
Healthy diet	No	Yes
Waist measurement	>40 "	> 35 "
Triglycerides	>150mg/dl	< 150 mg/dl
Fasting blood sugar	>100mg/dl	< 100mg/dl

Three criteria were assessed:

1) The characteristics of the risk prediction tool, including whether the algorithm was declared, whether any research evidence or information regarding the development or validation of the prediction tool was given, and whether the authors were identified.

2) The communication methods used to portray the risk, including the type of numerical format, presence of graphical representation, the timeframe/s available and type of risk (such as absolute, relative, comparison with peer-group etc).

3) The extent to which the tools encourage risk reduction by providing information about behaviour change and/or treatment options, including whether the main contributing risk factors or achievable risk reduction are reported, whether treatment goals are provided and whether progress can be recorded.

2.6 Results

2.6.1 Search terms results

In order to retrieve the cardiovascular risk prediction tools most likely to be found on the World Wide Web, two types of searches were conducted. The first was a tailored search using terms specific to cardiovascular risk prediction tools and the second was a general layman search.

For the search tailored to cardiovascular risk prediction tools, 22 search terms were used in total. However, four search terms did not retrieve any eligible cardiovascular risk prediction tools, these were: *Heart disease prediction*, *Predict heart attack*, *Predict heart disease* and *Predict heart risk*.

Figure 2.3 shows the number of eligible cardiovascular risk prediction tools retrieved by each search term. *Heart attack risk tool* and *Heart disease calculator* search terms retrieved the highest number of eligilble cardiovascular risk prediction tools on average (n=9). *Heart attack calculator* retrieved 7 risk prediction tools on average.

In the general layman search, all 46 search terms generated by the elicitation survey were used. 17 search terms did not retrieve any eligible web-based cardiovascular risk prediction tools, these were: *Identify my risk of heart disease, Heart disease info, Have I got heart disease?, Cardiac arrest, Cardiac failure, Causes of heart disease, Developing heart disease, Heart attack, Myocardial infarction, Heart failure risk, Heart disease, Risk factors for heart disease, Risk factors heart, Risk factors cardiac condition, Risk factors and heart disease, Heart disease risk factors and Heart risk advice.* The search terms retrieving the highest number of eligilble web-based cardiovascular risk prediction tools on average were *Risk tool heart condition* (n=9), *Heart disease risk calculator* (n=8), *Cardiovascular risk calculator* (n=8) and *Heart risk score* (n=7) (see Figure 2.4).

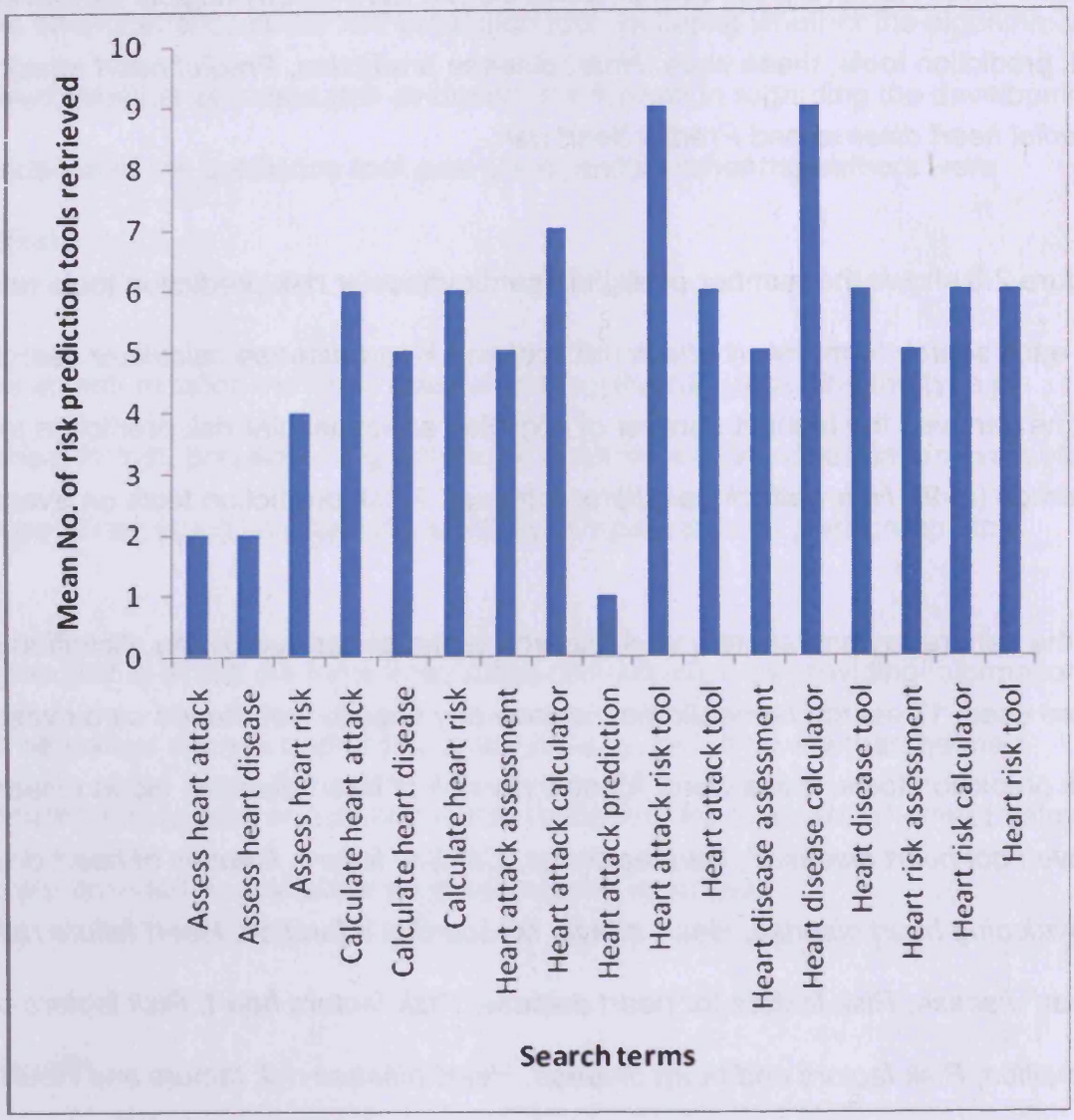


Figure 2.3 Mean number of cardiovascular risk prediction tools retrieved by the search terms used in the tailored search specific to cardiovascular risk prediction tools.

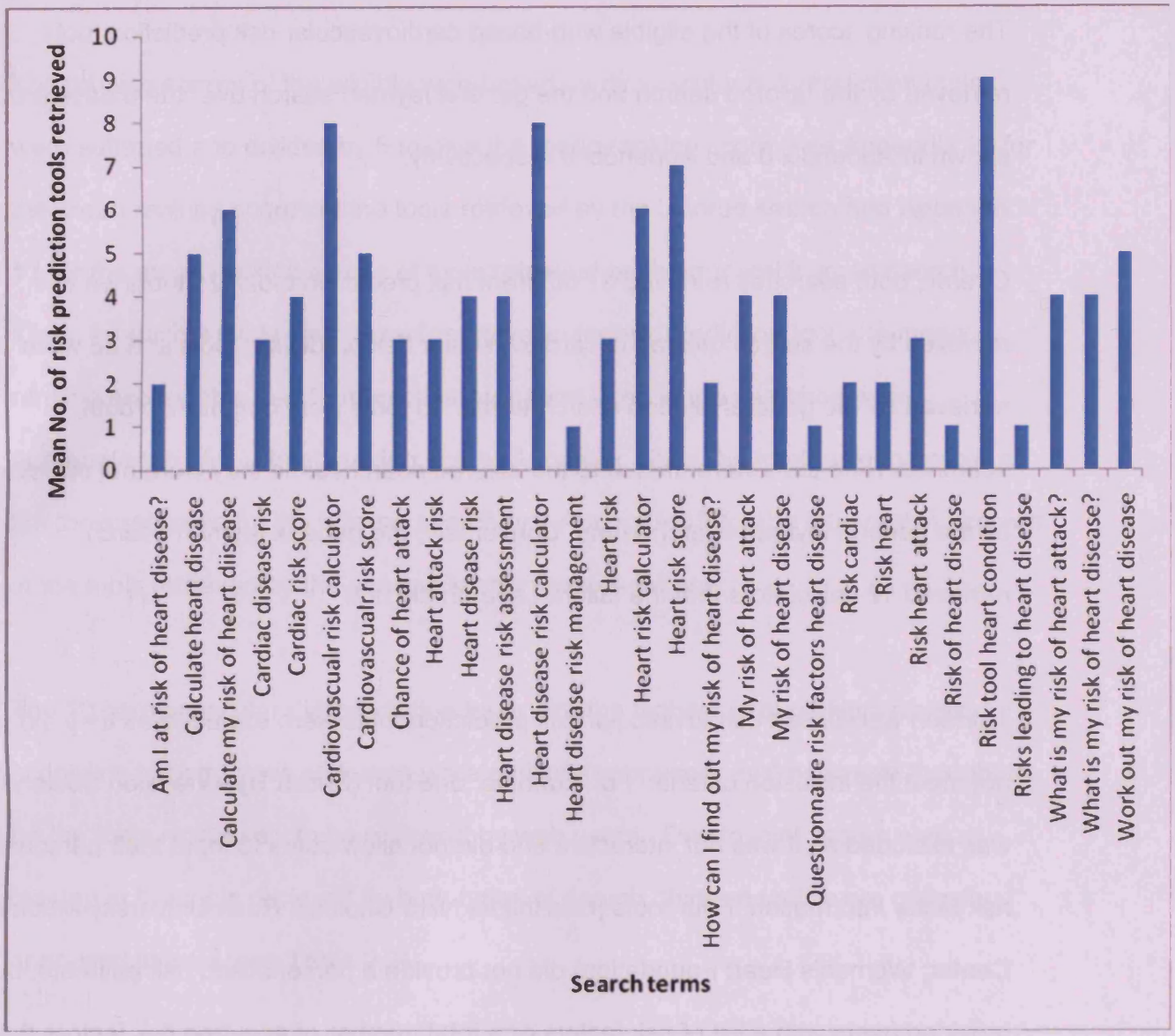


Figure 2.4 Mean number of cardiovascular risk prediction tools retrieved by the search terms used in the general layman search.

2.6.2 Web-based cardiovascular risk prediction tools retrieved

The ranking scores of the eligible web-based cardiovascular risk prediction tools retrieved by the tailored search and the general layman search over the 5 days are shown in Appendix 8 and Appendix 9 respectively.

Overall, both searches retrieved 37 different risk prediction tools. 25 tools were retrieved by the search tailored to cardiovascular risk prediction tools and 28 were retrieved by the general layman search terms. 15 tools were common to both searches. Nine tools were unique to the tailored searches, as they were not retrieved by the general layman search terms. Conversely, the general layman search retrieved 12 calculators that the tailored search did not.

Thirteen web-based cardiovascular risk prediction tools were excluded as they did not meet the inclusion criteria. For example, one tool (British Hypertension Society) was excluded as it was not interactive and did not allow users to input their personal risk factor information. Four tools (Healthline; NHS Choices; Rush University Medical Center; Woman's Heart Foundation) did not provide a personalised risk estimate, but provided users with a list of risk factors or a total number of acquired risk factors that may increase cardiovascular risk. Another four were excluded (British Hypertension Society; Framingham Heart Study; National Prescribing Service Limited; PreventDisease.com) as they provided links to more than one risk prediction tool, and therefore it cannot be determined which link a user would use to assess their risk. Lastly, another four (Detsky and Goldman calculators; EuroScore; md+calc; Physical Health Assessments) were excluded as they predicted specific forms of

CVD or risk of complications during surgery (such as unstable angina and non-ST Elevation MI, slow heart attack and cardiac surgical risk and risk of complications).

The ranking scores of the eligible web-based cardiovascular risk prediction tools were summed and divided by 5 to give the mean ranking score (see Appendix 10 for the mean ranking scores of the tools retrieved by the tailored search and Appendix 11 for the mean ranking scores of tools retrieved by the general layman search). Then, for each eligible web-based cardiovascular risk prediction tool, the mean ranking scores obtained from each search term used in the searches were aggregated to give a total ranking score (Appendix 12 for the total ranking scores of the tools retrieved by the tailored search and Appendix 13 for the total ranking scores of the tools retrieved by the general layman search terms).

The 10 cardiovascular risk prediction tools with the highest total ranking scores according to both types of search were critically appraised, as these were thought to be the tools most likely to be retrieved by web users. Due to joint scores and an overlap in the tools retrieved by both types of search, thirteen tools were critically appraised in total (see Table 2.3).

Table 2.3 The 10 highest ranking web-based cardiovascular risk prediction tools for both the tailored search specific to cardiovascular risk prediction tools and the general layman search.

Cardiovascular risk prediction tools retrieved from specific search terms for cardiovascular risk prediction tools.			Cardiovascular risk prediction tools retrieve general layman terms.	
		Total ranking score		
1st	NCEP (public) - Risk assessment tool for estimating your 10 year risk of having a heart attack.	115	1st	NCEP (public) - Risk assessment tool for estimating your 10 year risk of having a heart attack.
2nd	American Heart Association – Heart attack, coronary heart disease, metabolic syndrome risk assessment.	94	2nd	American Heart Association – Heart attack, coronary heart disease, metabolic syndrome risk assessment.
3rd	NCEP (prof) - Risk assessment tool for estimating 10 year risk of developing Hard coronary heart disease (myocardial infarction and coronary death).	90	3rd	London School of Health and Tropical Medicine – A risk score for cardiovascular disease.
4th	Healthwise – Interactive Health, heart attack risk.	60	4th	My Optum Health – Heart attack risk calculator.
5th	My Optum Health – Heart attack risk calculator.	48	5th	NCEP (prof) - Risk assessment tool for estimating 10 year risk of developing Hard coronary heart disease (myocardial infarction and coronary death).
6th	London School of Health and Tropical Medicine – A risk score for cardiovascular disease.	40	6th	Patient UK – primary cardiovascular using algorithm.
7th	Mayo clinic – Heart disease risk calculator.	39	7th	Healthwise – Interactive Health, heart attack risk.
8th	Patient UK – primary cardiovascular using algorithm.	33	8th	University of Edinburgh – Cardiovascular risk calculator.
Joint 9th	University of Edinburgh – Cardiovascular risk calculator.	20	9th	Siteman Cancer Center - Your disease risk heart disease questionnaire.
	e-tools Age – Heart attack risk calculator.			
10th	Reynolds risk score – calculating heart disease and stroke for men and women.	19	Joint 10th	Mayo clinic – Heart disease risk calculator.
				QRisk 2 – Cardiovascular disease risk calculator.

The same nine tools (American Heart Association; Healthwise; London School of Health and Tropical Medicine; Mayo Clinic; MyOptumHealth.com; National Cholesterol Education Program (prof); National Cholesterol Education Program (public); Patient UK; University of Edinburgh) were retrieved by both types of search. The two highest ranking tools (American Heart Association; National Cholesterol Education Program (public)) were the same across searches. Screenshots of the homepages of the included cardiovascular risk prediction tools are displayed in Appendix 14.

2.6.3 Results from the hypothetical high and low risk profiles

Hypothetical high and low risk patient profiles (Table 2.2) were devised and inputted into the risk prediction tools. The output results and details about the reported algorithms used in the tools are shown in Table 2.4. Most tools reported using algorithms from the Framingham Heart Study (American Heart Association; MyOptumHealth.com; National Cholesterol Education Program (prof); National Cholesterol Education Program (public); Patient UK; University of Edinburgh). Two tools (Healthwise; Mayo Clinic) indicated that their tools were adapted from National Heart, Lung and Blood Institute and National Education Cholesterol Program (Adult Treatment Panel III) guidelines. Two tools (Patient UK; University of Edinburgh) had the option of choosing the algorithm to be used. Patient UK tool gave Framingham and Joint British Societies (JBS) calculations, and University of Edinburgh tool gave the option of Framingham, JBS and Assign calculations.

Four tools (London School of Health and Tropical Medicine; QRISK2; Reynolds Risk Score; Siteman Cancer Center) used algorithms they had developed themselves. One tool (e-tools Age) did not specify which algorithm was used. However, looking at the different risk factors that it measured, it is surmised that it might be a Framingham algorithm.

There was disparity in the risk results when the hypothetical risk profiles were inputted into the risk prediction tools, but this was because the different algorithms predicted different cardiovascular end points. Risk ranged from 18.8-35% for the high risk patient profile and 0 – 1% for the low risk patient profile. Moreover, there was a lack of consistency in the results of tools that appeared to incorporate the same algorithms into their tools and measured the same endpoints (American Heart Association; MyOptumHealth.com; National Cholesterol Education Program (prof); National Cholesterol Education Program (public)), as risk ranged from 26 to 30%. However, the exact version of the algorithm that was used was not stated and therefore different versions of the same algorithm may account for this finding.

There was variation in the cardiovascular endpoints that were measured by the risk prediction tools. The risk of having a myocardial infarction / heart attack was the most commonly predicted. One tool (Patient UK) gave the choice of three algorithms to calculate risk. It was the only tool that allowed the users to choose the cardiovascular endpoint being predicted. However, this tool was intended to be used in consultation with health professionals, who would be able to define and give an explanation of the different manifestations of CVD.

Table 2.4 Summary of the algorithms used in the web-based prediction tools and results from the hypothetical risk profiles.

	Risk calculator	Reported algorithm	Cardiovascular end point predicted	High risk patient result	Low risk patient result
1	NCEP (public) - Risk assessment tool for estimating your 10 year risk of having a heart attack.	Framingham heart study (year unspecified)	10 year risk of having a heart attack.	'26% Means 26 out of 100 people with this risk will have a heart attack in the next 10 years'.	'Less than 1% Means less than 1 of 100 people with this risk level will have a heart attack in the next 10 years'.
2	American Heart Association – Heart attack, coronary heart disease, metabolic syndrome risk assessment.	Framingham Heart study (year unspecified)	10 year risk of having a heart attack or dying of coronary heart disease.	'30% High risk'.	'1% Very low risk'.
3	NCEP (prof) - Risk assessment tool for estimating 10 year risk of developing Hard coronary heart disease (myocardial infarction and coronary death).	Framingham Heart study (recent)	10 year risk for 'hard' coronary heart disease outcomes (myocardial infarction and coronary death.	'26%'.	'Less than 1%'.
4	Healthwise – Interactive Health, heart attack risk.	Adapted from NCEP / National Heart, Lung and Blood Institute	10 year risk of heart attack.	'30% of higher. 30 (or more) people in 100 with these risk factors will have a heart attack in the next 10 years'.	'1% 1 person in 100 with these risk factors will have a heart attack in the next 10 years'.

	Risk calculator	Reported algorithm	Cardiovascular end point predicted	High risk patient result	Low risk patient result
5	My Optum Health – Heart attack risk calculator.	Framingham and NCEP (ATPiii)	10 year risk of having a heart attack.	'30% or higher 30 or more people in 100 with these risk factors will have a heart attack in the next 10 years'.	'1% 1 person in 100 with these risk factors will have a heart attack in the next 10 years'.
6	London School of Health and Tropical Medicine – A risk score for cardiovascular disease.	Pocock et al Risk score for predicting risk of cardiovascular death in adults with elevated blood pressure.	5 year risk of dying from cardiovascular disease, including both stroke and heart disease.	'The patient's risk score is 47.71. This compares to the average risk score for a man in this age range (55-59) of 40.24. The predicted risk of death due to cardiovascular cause in the next 5 years for this patient is 4.86%, compared to the average risk of 2.33% for a man of similar age. The patient is therefore in the very high risk category'.	'The patient's risk score is 11.29. This compares to the average risk score for a woman in this age range (45-49) of 20.48. The predicted risk of death due to cardiovascular cause in the next 5 years for this patient is 0.13%, compared to the average risk of 0.33% for a woman of similar age. The patient is therefore in the low risk category'.
7	Patient UK – primary cardiovascular using algorithm.	JBS2 (2004) And non JBS risk calculations by Anderson et al 1991 (Framingham)	10-year risk of cardiovascular disease, cardiovascular death, stroke, coronary heart disease death, myocardial infarction or coronary heart disease.	'Using Systolic BP prediction, the 10 year risk of JBS CVD is 50%. The equivalent risk calculation with diastolic BP is 49%'.	'Using Systolic BP prediction, the 10 year risk of JBS CVD is 2%. The equivalent risk calculation with diastolic BP is 2%'.

8	Mayo clinic – Heart disease risk calculator.	NHLBI / ATPiiI adapted by Mayo Foundation for Medical Education and Research.	10 year risk of having a heart attack or dying of heart disease.	'Your risk score is 30 percent or greater. This means about one or more out of three people with this level of risk will have a heart attack or die of heart disease within the next 10 years'.	'Your risk score is 1 percent. This means about one of 100 people with this level of risk will have a heart attack or die of heart disease within the next 10 years'.
9	University of Edinburgh – Cardiovascular risk calculator.	BNF / JBS	10 year risk of developing cardiovascular disease.	'Probability of developing cardiovascular disease in the next 10 years is 33.3%'.	'Probability of developing cardiovascular disease in the next 10 years is 0.6%'.
		Assign	10 year risk of developing cardiovascular disease.	'Probability of developing cardiovascular disease in the next 10 years is 24.5%	'Probability of developing cardiovascular disease in the next 10 years is 0.5%
		Framingham	4-11 year risk of cardiovascular disease, coronary heart disease, myocardial infarction, stroke, cardiovascular death, coronary heart disease death.	The probability of developing cardiovascular disease in the next 10 years is 40%'.	Probability of developing cardiovascular disease in the next 10 years is 0.6% Probability of developing coronary heart disease in the next 10 years is 0.2%'.

	Risk calculator	Reported algorithm	Cardiovascular end point predicted	High risk patient result	Low risk patient result
10	QRisk 2 – Cardiovascular disease risk calculator.	QRISK2	1-10 year risk of developing heart disease or having a stroke / TIA.	'Your 10 year QRISK2 score is 41%. In other words, in a crowd of 100 people like you, 41 will develop heart disease or have a stroke/TIA in the next 10 years. The score of a typical person with the same age, sex, and ethnicity 12.4% Relative risk 3.3 Your QHeartAge >84' *(e.g. cardiovascular age equivalent)*	'Your 10 year QRISK2 score is 2%. In other words, in a crowd of 100 people like you, 2 will develop heart disease or have a stroke/TIA in the next 10 years. The score of a typical person with the same age, sex, and ethnicity 1.6% Relative risk 1.3 Your QHeartAge 48'.
11	Siteman Cancer Center - Your disease risk heart disease questionnaire.	Harvard Your disease risk algorithm.	Estimated risk of developing coronary heart disease compared to an average person who's the same age and sex.	'Compared to a typical man your age, your risk is very much above average'.	'Compared to a typical woman your age, your risk is very much below average'.
12	e-tools Age – Heart attack risk calculator.	Doesn't specify	10 year risk of Having a heart attack.	'Your estimated 10 year risk of heart attack is more than 30%'.	'Your estimated 10 year risk of heart attack is 1%'.

13	Reynolds risk score – calculating heart disease and stroke for women and men.	Reynolds risk score	10 year risk of having a future heart attack, stroke, or major heart disease. Also, 10 year risk projected if the patient was 10,20, 30 years older.	'As shown in the graph below, at age 59, your chance of having a heart attack, stroke, or other heart disease event at some point in the next 10 years is 35 percent. This risk is approximately 6 times higher than that of a Man the same age who has optimal levels of all modifiable risk factors'.	'As shown in the graph below, at age 45, your chance of having a heart attack, stroke, or other heart disease event at some point in the next 10 years is 1 percent'.

Summary

There is no consensus between tools in the cardiovascular endpoints that are used in the risk prediction tools. This leads to an inconsistency in results and may paint a confusing picture for both health professionals and patients. This is a concern for those who use web-based risk prediction tools at home (especially if a number of risk prediction tools are consulted). Users may not fully appreciate the different results that can be achieved when certain endpoints are predicted. For example, the risk of a specific endpoint such as cardiovascular death will be lower than the risk of an endpoint that encompasses a number of manifestations, such as coronary heart disease.

2.6.4 Characteristics of the web-based cardiovascular risk prediction tools

The characteristics of the web-based cardiovascular risk prediction tools were assessed and ordered according to their 'quality'. The tools were compared against 12 features deemed to increase the quality of the website and the information provided, such as whether the tools was intended for patient use, whether additional relevant information was provided, whether information regarding the development and validation of the algorithm used by the tool was provided, whether the user could contact the authors for further information or help and whether the website was free from commercial adverts. A 'quality' score was derived from summing the number of these features that were present. A higher score indicated a better quality website

that comprised the cardiovascular risk prediction tool. As seen in Table 2.5 the tools varied in terms of their quality. Scores ranged from 1 to 10, meaning the tools encompassed between 1 and 10 of the 'quality' features.

The highest ranking tools in terms of quality were Patient UK, QRISK 2 and Siteman Cancer Center. These possessed 10 out of 12 of the features deemed to increase the quality of the website and cardiovascular risk prediction tool. One tool (e-tools Age) scored one, possessing only one 'quality' feature (e.g. tool intended for patient use as opposed to health professional use). Thus, its usefulness to the user and the trustworthiness of this site content can be questioned. Eight tools were designed specifically for patient use, three were intended to be used by both patients or health professionals (Patient UK; University of Edinburgh), and two tools were explicitly designed for health professionals to use (London School of Health and Tropical Medicine; National Cholesterol Education Program (prof)). The tools designed for health professional use are considered not as useful to a user seeking on-line risk assessment outside of a clinical setting, mainly due to the possibility that the terminology used in the tools might not be understandable to the lay public.

Table 2.5 Characteristics of the included risk prediction tools ordered by 'quality' scores.

	Tool intended for patient use?	Creator of the tool from a professional organisation such as university or charity?	Details about development and validation?	Reference to academic papers relating to the prediction tool?	External links to additional relevant information?	Authors of website/ tool reported?	Option to contact the authors for additional help or information?	Any affiliation / funding reported?	Any conflict of interest or no conflict of interest declared?	Website free from commercial adverts?	Date stated when website was last updated?	Target audience or who is not suitable to use the tool identified?	Total quality score
Patient UK	✓	✓	✓	✓	✓	✓	✓	-	✓	-	✓	✓	10
QRisk 2	✓	✓	✓	✓	✓	✓	✓	-	-	✓	✓	✓	10
Siteman Cancer Center	✓	✓	✓	✓	✓	✓	✓	✓	-	✓	-	✓	10
University of Edinburgh	✓	✓	✓	-	✓	✓	✓	-	-	✓	✓	✓	9
London School of Health and Tropical Medicine	-	✓	✓	✓	✓	✓	✓	-	-	✓	✓	-	8
American Heart Association	✓	✓	✓	-	✓	-	-	✓	✓	-	✓	✓	8
Reynolds risk score	✓	✓	✓	✓	✓	-	-	✓	-	✓	-	✓	8

Cont

	Tool intended for patient use?	Creator of the tool from a professional organisation such as university or charity?	Details about development and validation?	Reference to academic papers relating to the prediction tool?	External links to additional relevant information?	Authors of website/ tool reported?	Option to contact the authors for additional help or information?	Any affiliation / funding reported?	Any conflict of interest or no conflict of interest declared?	Website free from commercial adverts?	Date stated when website was last updated?	Target audience or who is not suitable to use the tool identified?	Total quality score
Mayo clinic	✓	✓	✓	✓	✓	-	-	-	-	-	✓	✓	7
My Optum Health	✓	-	-	✓	✓	-	✓	✓	-	-	-	✓	6
Health-wise	✓	-	-	✓	✓	✓	-	-	-	-	✓	-	5
NCEP (public)	✓	✓	-	-	✓	-	-	-	-	✓	-	✓	5
NCEP (prof)	-	✓	-	-	✓	-	-	-	-	✓	-	✓	4
e-tools Age	✓	-	-	-	-	-	-	-	-	-	-	-	1
Total No. of tools pocessing each characteristic	11	10	8	8	12	6	6	4	2	7	7	10	

The most common feature was providing links to additional relevant information. This was done by 12 out of the 13 tools. The further information included websites of heart-related organisations (such as National Cholesterol Education Program, American College of Cardiology and High Blood Pressure Foundation), fact sheets and articles about heart disease and prevention, and options to sign up for electronic newsletters. This ease of access to relevant information increases the usefulness of the site, encouraging the user to seek information about prevention and enabling informed decisions to be made regarding risk reduction.

Specifying the target audience or who was not suitable to use the tools was another common feature of 10 tools. For example, four tools (e-tools Age; Healthwise; London School of Health and Tropical Medicine; Reynolds Risk Score) specified that the algorithm was suitable for people who did not have any manifestation of heart disease and/or diabetes. Providing this information increases the accuracy of the results, as people who are not suitable to use the tools are discouraged from assessing their risk, and thus reducing the possibility of under or over-estimating their risk. Two tools (e-tools Age; Healthwise) did not provide this information.

Most tools were from known reputable sources. For example, six were developed in a research/academic setting (London School of Health and Tropical Medicine; Mayo Clinic; QRISK2; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh). Three tools (American Heart Association; National Cholesterol Education Program (prof); National Cholesterol Education Program (public)) were from National organisations or charities. Three (Healthwise; MyOptumHealth.com; Patient UK) were tools from health-related websites. One tool (e-tools Age) was from

a general website that had a number of on-line tools such as currency converters. Additionally, the e-tools Age tool gave no information on the algorithm used in the risk assessment and did not provide links to further information.

Eight tools (American Heart Association; London School of Health and Tropical Medicine; Mayo Clinic; Patient UK; QRISK2; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh) provided information regarding the algorithm that was used in the risk prediction tool. This is reassuring to the user and strengthens the reliability of the results. Moreover, an interested user can research how their risk was calculated. References or hyperlinks to academic papers relating to the development or validation of the algorithms were provided by 7 of these tools (all except the American Heart Association tool), making the research easy for the interested user.

Seven tools gave details about when the site was last updated, indicating that their content was reviewed periodically. However, five tools (e-tools Age; MyOptumHealth.com; National Cholesterol Education Program (prof); National Cholesterol Education Program (public); Reynolds Risk Score) did not provide this information, and therefore may not include the most up-to-date version of the algorithm.

Furthermore, six tools (American Heart Association; e-tools Age; Healthwise; Mayo Clinic; MyOptumHealth.com; Patient UK) had advertisements present. Advertisements can be distracting to the user, and adverts for pharmaceutical products which may influence decisions made about risk reduction. For example, the

Healthwise tool included an advert for *Lipitor* ® (a cholesterol lowering medication) and the *American Heart Association* tool advertises the Pharmaceutical roundtable, which is a forum for pharmaceutical companies. This increases the possibility of bias, as a user may be persuaded by the option of medication rather than lifestyle modification to reduce risk.

Summary

In summary, there was variation on the quality of the web-based cardiovascular risk prediction tools. Only three of the tools were considered to be of high quality. However, most tools provided information about who was suitable or not suitable to use the algorithm for risk assessment, which reduces the possibility of an over or under-estimation of risk that contributes to inaccurate risk perceptions. Additionally, all but one provided links to further information regarding CVD and risk reduction. However, adverts for pharmaceutical products were sometimes used, which may influence decisions made about risk reduction and lead to a bias towards medication over lifestyle modification. Furthermore, wide variation in results across tools resulted, as the predicted risk for the high risk profile ranged from 18.8 to 35%. It is concluded that the variable quality of the websites visited when seeking on-line cardiovascular risk assessment justifies a consideration for standardisation in this field, in order to avoid misleading or confusing patients.

2.6.5 Methods of risk communication

The web-based cardiovascular risk prediction tools were appraised on the method of risk communication used (Table 2.6). This was broken down into four elements:

1) The type of risk that is being predicted such as absolute, relative (i.e. your risk divided by the risk of an average persons of the same age and sex with optimal risk factors) or comparative (i.e. the risk of an average person of the same age and sex with optimal risk factors).

2) The numerical formats that were used to represent the risk such as percentages, natural frequencies or cardiovascular age equivalent (e.g. an analogy to demonstrate that a person's risk may be equivalent to someone older who has optimal risk factors and therefore, has a heart that is 'older' than their biological age).

3) Graphical risk representation formats used, such as bar charts and pictograms of smiley faces.

4) The timeframes used in the prediction of future risk, such as shorter 1-5 year timeframes or longer time spans of 10 years and over.

Table 2.6 Summary of characteristics of risk communication presented in the included web-based cardiovascular risk prediction tool ordered by 'risk communication' scores.

Characteristics of risk representation present in the web-based cardiovascular risk prediction tools.																								
	Type of risk					Numerical format					Graphical format					Timeframe								
Risk prediction tool	Absolute	Comparative	Relative	No. of present characteristics Score /3	Percentage	Natural frequency	Risk categories	Cardiovascular age equivalent	Other	No. of present characteristics Score / 6	Bar graph	Pictogram	Thermometer	Other	No. of present characteristics Score / 4	1-4 years	5-9 years	10-15 years	16-20 years	Over 21 years	Other	No. of present characteristics Score / 6	**Total score for risk communication**
QRisk 2	✓	✓	✓	3	✓	✓	-	✓		3	-	✓		-	1	✓	✓	✓	-	-	-	3	**10**
University of Edinburgh	✓	-	-	1	✓	-	-	-	-	1	✓	✓[e]	✓	✓[f]	4	✓	✓	✓	-	-	-	3	**9**
London School of Health and Tropical Medicine	✓	✓	-	2	✓	-	✓	-	✓[a]	3	-	-	-	✓[b] ✓[c]	2	-	✓	-	-	-	-	1	**8**
Reynolds risk score	✓	-	✓	2	✓	-	-	-	-	1	✓	-		-	1	-	-	✓	-	-	✓[h]	2	**6**
American Heart Association	✓	-	-	1	✓	-	✓	-	-	2	✓	-	-	-	1	-	-	✓	-	-	-	1	**5**
Mayo clinic	✓	-	-	1	✓	✓	-	-	-	2	-	✓[d]	-	-	1	-	-	✓	-	-	-	1	**5**

	Type of risk				Numerical format						Graphical format					Timeframe							
	Absolute	Comparative	Relative	No. of present characteristics Score /3	Percentage	Natural frequency	Risk categories	Cardiovascular age equivalent	Other	No. of present characteristics Score / 6	Bar graph	Pictogram	Thermometer	Other	No. of present characteristics Score / 4	1-4 years	5-9 years	10-15 years	16-20 years	Over 21 years	Other	No. of present characteristics Score / 6	Total score for risk communication
NCEP (public)	✓	-	-	1	✓	✓	-	-	-	2	-	-	-	-	0	-	-	✓	-	-	-	1	4
Healthwise	✓	-	-	1	✓	✓	-	-	-	2	-	-	-	-	0	-	-	✓	-	-	-	1	4
Siteman Cancer Center	-	✓	-	1	-	-	✓	-	-	1	✓	-		-	1	-	-	-	-	-	✓[g]	1	4
NCEP (prof)	✓	-	-	1	✓	-	-	-	-	1	-	-	-	-	0	-	-	✓	-	-	-	1	3
Patient UK	✓	-	-	1	✓	-	-	-	-	1	-	-	-	-	0	-	-	✓	-	-	-	1	3
e-tools Age	✓	-	-	1	✓	-	-	-	-	1	-	-		-	0	-	-	✓	-	-	-	1	3
My Optum Health	✓	-	-	1	✓	✓	-	-	-	2	-	-	-	-	0	-	-	✓	-	-	-	1	1
Total No. of tools possessing each characteristic	**12**	**3**	**2**		**12**	**5**	**3**	**1**	**1**		**4**	**3**	**1**	**2**		**2**	**3**	**11**	**0**	**0**	**2**		

[a] risk score; [b] line graph showing how risk increases exponentially with the risk score; [c] plot graph showing distribution of risk scores / risk categories; [d] for high risk patient only; [e] no numerical explanation; [f] risk chart; [g] current risk; [h] risk demonstrated if patient was 10, 20 or 30 years older.

Each cardiovascular risk prediction tool was scored on each of these elements by a simple summation of the number of present characteristics. For example, a tool just reporting a user's absolute risk would score one for the first element 'type of risk' but a tool presenting absolute and relative risk would score two. The scores for the four elements were summed to give an overall 'risk communication' score. The higher the score, the greater the quality of the risk communication used by the web-based cardiovascular risk prediction tools.

Three tools (London School of Health and Tropical Medicine; QRISK2; University of Edinburgh) scored the highest (between 8 and10) and incorporated many of the features considered to enhance risk communication according to the research evidence. However, the other tools scored poorly in comparison, (scores ranged from 1 to 6 out of a possible 19).

1) Type of risk

All tools (apart from the Siteman Cancer Center tool) displayed absolute risk. This was the only type of risk displayed by nine of these tools (American Heart Association; e-tools Age; Healthwise; Mayo Clinic; MyOptumHealth.com; National Cholesterol Education Program (prof); National Cholesterol Education Program (public); Patient UK; University of Edinburgh) and therefore, they scored one for this element. Three tools (London School of Health and Tropical Medicine; QRISK2; Siteman Cancer Center) presented comparative risk, and two tools (QRISK2; Reynolds Risk Score) provided relative risk. These help users interpret their risk by

demonstrating how their risk compares to the 'average' same aged/sex person with optimal risk factors. One tool (QRISK2) scored three, as it presented all three types of risk (absolute, comparative and relative), increasing the chance of the risk being understood by users.

2) Numerical risk representation formats

Six tools (e-tools Age; National Cholesterol Education Program (prof); Patient UK; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh) scored one on the numerical risk representation element, as they only provided one numerical format in their risk output. In all but one case (Siteman Cancer Center) this was percentages. The Siteman Cancer Center tool did not give a numerical probability estimate, but used risk categories instead (see Figure 2.5). Users may find this format helpful as it indicates whether risk was above or below the 'average'. The American Heart Association tool and London School of Health and Tropical Medicine tool also provided risk categories, such as 'Very low risk' or 'High risk'.

Five out of the 13 tools (Healthwise; Mayo Clinic; MyOptumHealth.com; National Cholesterol Education Program (public); QRISK2) used natural frequencies as well as percentages, which are useful in explaining what the percentage figures actually mean in terms of the number of people similar to the user who will be affected by CVD in the future.

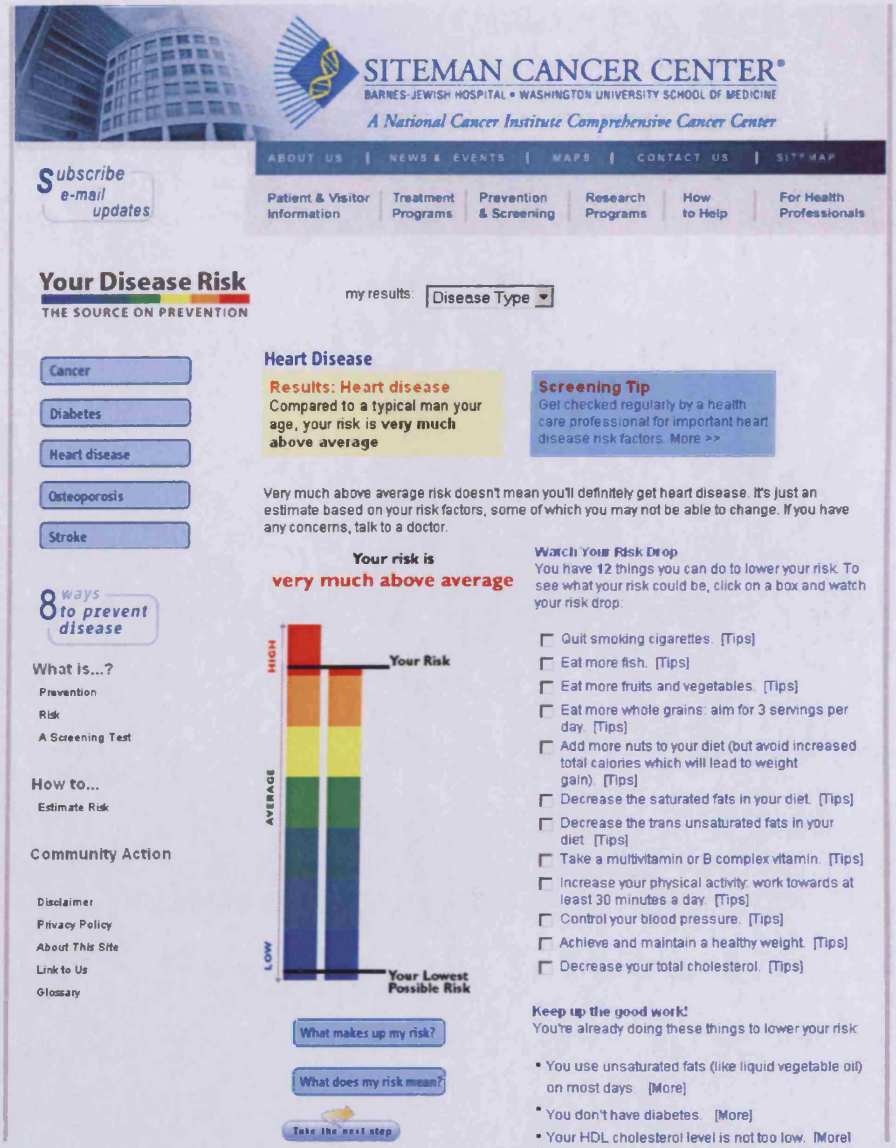


Figure 2.5 Siteman Cancer Center tool – Risk output result for the high risk patient profile.

The London School of Health and Tropical Medicine and QRISK2 tools scored three on the numerical risk representation format element, as they provided three ways of expressing the probability estimates. QRISK2 tool additionally provided the cardiovascular age equivalent (the age at which an 'average' person of the same age, sex and ethnicity has the same risk) and the London School of Health and Tropical Medicine tool additionally used a risk score to be interpreted using the provided graphs.

3) Graphical Risk Communication formats

Just over half of the tools (n=6) (e-tools Age; Healthwise; MyOptumHealth.com; National Cholesterol Education Program (prof); National Cholesterol Education Program (public); Patient UK) scored zero for the graphical risk communication element as they did not provide any visual or graphical accompaniment with their risk outputs. It is generally accepted that numerical and graphical representations should be used when depicting risk as this increase the chances that the risk information is understood, particularly for those with lower numeracy skills.

The University of Edinburgh tool scored the highest for the graphical risk communication element and had the greatest number of graphical risk representation formats (n=4) for presenting risk information (BNF risk charts, pictogram of smiley faces, a comparison thermometer or horizontal bar graphs). This function is useful to users, as they can choose which graphical format they prefer and find easiest to interpret.

Bar graphs were the most commonly used graphical risk representation format, used by four tools (American Heart Association; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh). It is congruent to use this format to depict percentages, as was done by three of these tools (American Heart Association; Reynolds Risk Score; University of Edinburgh).

Pictograms were used by three tools in total (Mayo Clinic; QRISK2; University of Edinburgh) as displayed in Figure 2.6; although the Mayo Clinic tool did this for high risk patients only. This format is most suitable for displaying natural frequencies which were used by two tools (Mayo Clinic; QRISK2). However, the University of Edinburgh tool did not provide a numerical explanation with their pictogram, which would make interpretation of this format difficult for users who are not familiar with the concept of icon arrays of smiley faces to demonstrate the number of people affected by CVD.

One tool (London School of Health and Tropical Medicine) was unique in showing a line graph to show how risk exponentially increases with the corresponding risk score. This enables the user to see the risk thresholds for the given risk scores. However, it must be noted that this tool was intended for health professional use and this function may be of more value to them rather than the general public.

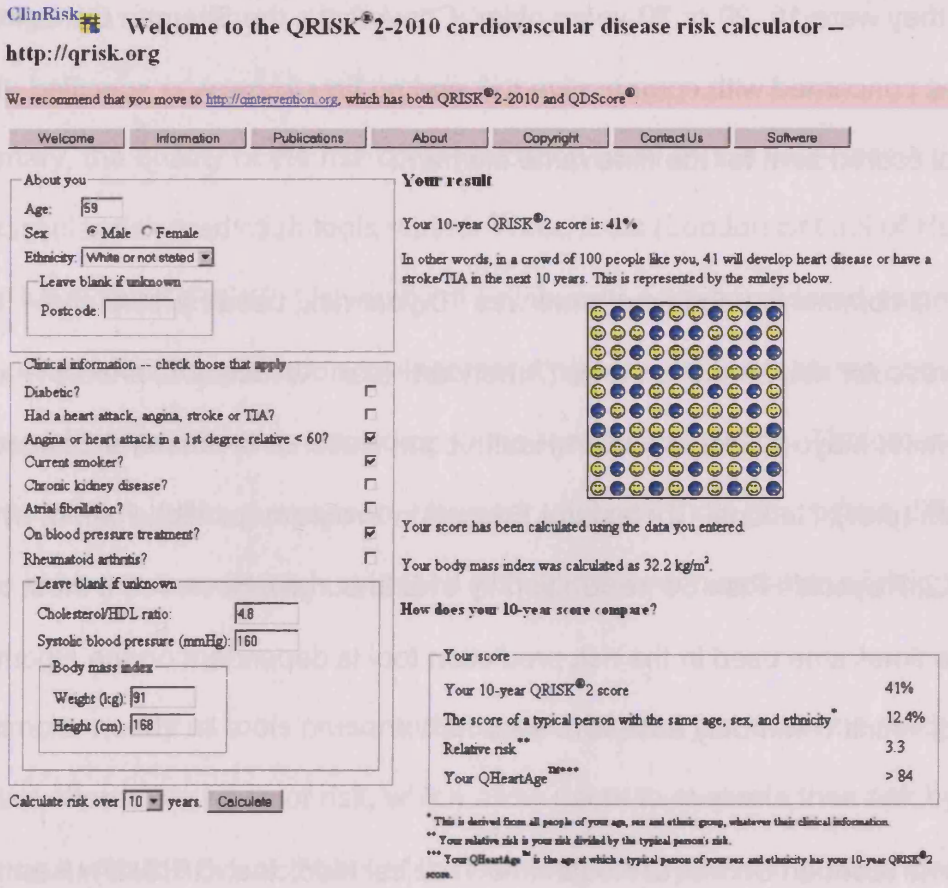


Figure 2.6 QRISK2 tool - Risk output result for the high risk patient profile.

4) Timeframe used in risk prediction

Three tools (QRISK2; Reynolds Risk Score; University of Edinburgh) scored over one for the timeframe element as they provided more than one timeframe option. QRISK2 tool had the choice of predicting 1-year to 10-year risk; and the Framingham algorithm from the University of Edinburgh tool had a choice of 4 to 11-years. A choice of timeframes enables users to see how their risk increases over time. This was also demonstrated by the Reynolds Risk Score tool as it projected the risk of the

user if they were 10, 20 or 30 years older. Conversely, the Siteman Cancer Center tool was concerned with comparative risk and no timeframe was specified, therefore this tool scored zero for the timeframe element.

The most commonly used timeframe was 10-year risk, used by 11 of the cardiovascular risk prediction tools (American Heart Association; e-tools Age; Healthwise; Mayo Clinic; MyOptumHealth.com; National Cholesterol Education Program (prof); National Cholesterol Education Program (public); Patient UK; QRISK2; Reynolds Risk Score; University of Edinburgh). However, it must be noted that the timeframe used in the risk prediction tool is dependent on the algorithm that is used, which commonly assess10-year risk.

Two tools (London School of Health and Tropical Medicine; QRISK2) used timeframes that were less than 10 years. London School of Health and Tropical Medicine tools used 5-year risk and QRISK2 tool used 1 year to 10-year risk. A user's risk displayed in a shorter timeframe may be easier to imagine and comprehend, than their future risk displayed in longer timeframes. This is because risk portrayed in the long-term is of little relevance to people as they are generally poor at forecasting how they will feel in the future and do not adjust their risk perceptions to account for the longer time spans (Fagerlin et al. 2007a; Kassam et al. 2008).

Summary

In summary, the quality of the risk communication used by the web-based cardiovascular risk prediction tools varied. Three tools (London School of Health and Tropical Medicine; QRISK2; University of Edinburgh) were considered as providing good quality risk communication, by incorporating many of the features considered to enhance risk communication according to the research evidence. The other tools scored poorly overall in comparison. However, different tools possessed different features shown in the research evidence to help the communication of risk.

For example, nearly all tools presented absolute risk; but just over one third presented alternative types of risk, which allow users to evaluate their risk by comparing it with the risk of others of the same age and sex who posses' optimal risk factors. This is more desirable than displaying absolute risk on its own as the user has a way of knowing whether their risk is good or bad / high or low etc. The most commonly used numerical risk representation format was percentages. Natural frequencies were the second most commonly used. The majority of tools provided more than one way of expressing probability of cardiovascular risk. Two tools provided three numerical formats. Under half of the tools provided graphical risk representation. In general, graphical formats were used that were congruous with the numerical probability estimates presented in the risk outputs. One tool (University of Edinburgh) allowed users to choose one of four graphical formats for viewing their results. The majority of tools provided risk in a 10-year timeframe only. Two tools demonstrated short-term risk less than 10 years, and one tool projected longer term risk by demonstrating 10-year risk if the user was 10, 20 or 30 years older than their

current age. Lastly, three tools had the facility of displaying risk in more than one timeframe option.

2.6.6 Focus on risk reduction and behaviour change

This critical appraisal assessed the extent that the risk prediction tools focused on risk reduction through behaviour change or treatment options (Table 2.8). A 'focus on risk reduction' score was derived from the number of characteristics present that facilitate risk reduction, such as whether the results could be printed out, whether there was an option to record progress as risk reduction is attempted, and whether treatment goals are provided. A higher score indicated that the tool had a greater focus of risk reduction, by providing more features that help with decisions about reducing cardiovascular risk. As seen in Table 2.7 the tools varied in terms of their focus on risk reduction.

The highest scoring tool was the American Heart Association. This tool focused on risk reduction the most, by providing all the features considered to be important when considering options to reduce cardiovascular risk. Four tools (American Heart Association; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh) possessed half or more of the risk reduction features. One tool (National Cholesterol Education Program (prof)) provided only one feature, which was the provision of further information. The e-tools Age tool scored zero and did not focus on risk reduction at all.

The most common risk reduction features were the option to print out a copy of the results and the provision of further information. The option to print out results was included by eight of the tools (American Heart Association; Healthwise; London School of Health and Tropical Medicine; Mayo Clinic; MyOptumHealth.com; Patient UK; Reynolds Risk Score; University of Edinburgh). This is useful as it can be used in consultations with health professionals, providing a useful starting point for discussing cardiovascular risk and the risk reduction options available. Further information about risk reduction was provided by eight tools (American Heart Association; London School of Health and Tropical Medicine; Mayo Clinic; National Cholesterol Education Program (prof); National Cholesterol Education Program (public); Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh). This information included websites of relevant organisations (such as the British Heart Foundation), articles relating to risk factors (such as C-reactive protein level) and tips on reducing risk (such as guides to lowering cholesterol). A user motivated to reduce their risk may find it helpful to be directed to further information regarding risk reduction, before making any decisions about what they are going to do to achieve this.

Six of the thirteen tools (American Heart Association; Healthwise; QRISK2; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh) had the option to recalculate the risk output result by modifying the risk profile. This is useful as users can interact with the tool and work out how their risk changes by inputting different risk factors. However, five tools (American Heart Association; London School of Health and Tropical Medicine; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh) provided a function that already demonstrates this

information. They showed which of the user's risk factors contributed to their overall risk. For example, the Siteman Cancer Center tool included a section entitled '*What makes up my risk*?'. Moreover, six tools (American Heart Association; Mayo Clinic; National Cholesterol Education Program (public); Patient UK; Siteman Cancer Center; University of Edinburgh) actually worked out which risk factors could be modified to reduce risk and provided possible options. This included a '*What should I do?*' section and a personalised list of modifiable risk factors. This information is valuable when taking the first steps in deciding whether risk reduction can be achieved, and which of the main risk factors might be worth tackling first.

A further function that is useful in decision making for cardiovascular risk reduction is demonstrating the exact risk reduction possible by different behaviour change and treatment options. Four tools (American Heart Association; Reynolds Risk Score; Siteman Cancer Center; University of Edinburgh) did this and some of these tools displayed the different risks together to enable a comparison. Bar charts showing the changes in risk when the risk factors were modified, were used by three of the tools (American Heart Association; Reynolds Risk Score; Siteman Cancer Center) and the University of Edinburgh tool used a thermometer (See Figure 2.7). Only two tools (American Heart Association; Siteman Cancer Center) were interactive letting users choose their own risk factors to be modified and view the corresponding result. For example, the American Heart Association tool had plus and minus buttons that changed the risk factor values, whilst displaying both current risk and the risk achievable (see Figure 2.8).

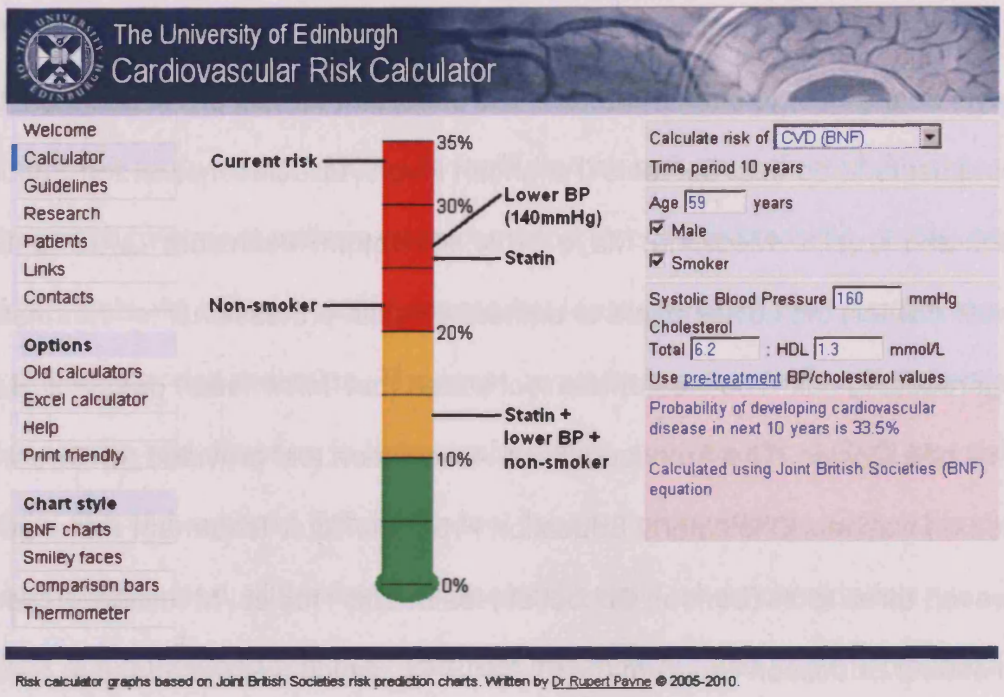


Figure 2.7 The University of Edinburgh tool - Thermometer graphical risk output for the high risk patient profile.

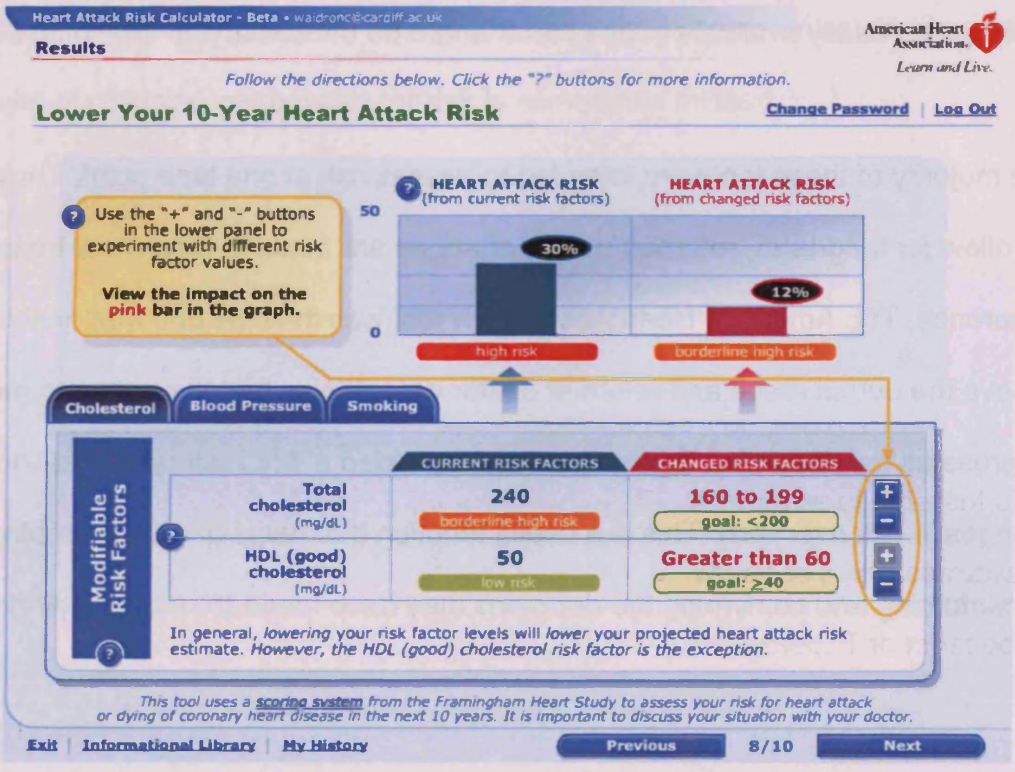


Figure 2.8 American Heart Association tool - Risk output result for the high risk patient profile.

As patients should consult with their health practitioner before undertaking any lifestyle changes or to seek treatment, it is important for risk prediction tools to remind users to do this. Six tools (American Heart Association; London School of Health and Tropical Medicine; Mayo Clinic; MyOptumHealth.com; QRISK2; Siteman Cancer Center) did advise users to contact a health professional for information about reducing risk. The Healthwise tool stated that '*Information does not replace advice of a Doctor*'. The American Heart Association tool provided treatment goals based on National Cholesterol Education Program/Adult Treatment Panel guidelines. However, three tools (London School of Health and Tropical Medicine; National Cholesterol Education Program (prof); QRISK2), which were intended to be used by health professionals, did not provide reference to treatment guidelines. If these tools are to be used by health professional in consultation with patients, having all the information readily available in one place would be beneficial and time efficient.

The majority of these tools are intended to assess risk at one time point. They did not allow for long-term, returned use as changes are made to lifestyle or treatment adherence. The American Heart Association tool was the only one that enabled you to save the output result and return at a later date. It also had the option to record progress as risk reduction is attempted and provided a 'My History' report showing changes in risk over time. This is a useful function that helps users stay motivated, by reinforcing and confirming the decisions they have made to reduce their risk.

Summary

To summarise, features considered to facilitate risk reduction through lifestyle change and/or treatment options were compiled by collating existing guidelines and evaluation tools. All but one tool possessed at least one characteristic that focused on cardiovascular risk reduction. The most common features included the option to print out results and direction to further information sources about CVD and risk reduction. The University of Edinburgh tool focused on cardiovascular risk reduction the most and provided all the features deemed helpful when considering risk reduction. It is concluded that the more features incorporated in the tools that facilitate risk reduction, the greater the likelihood of motivating the user to reduce their risk if required. It appears that risk reduction strategies have been given less attention than the calculation of risk and how the risk is communicated, meaning the final aim of reducing cardiovascular risk is sometimes missed.

Table 2.7 Summary of the extent to which the web-based cardiovascular risk prediction tools focus on risk reduction through behaviour change and treatment options ordered by 'focus on risk reduction' scores.

	Focus on risk reduction through behaviour change/ treatment options questions.												Total score
	Option to print out results?	Main factors contributing to risk reported?	Options to reduce risk given?	Option to recalculate result by modifying risk profile?	Different risk displayed together to enable comparison?	Output saved and returned to at later date?	Risk reduction achievable by behaviour change/ treatment options reported?	Option to record progress as risk reduction is attempted?	Is user directed to further information sources about risk reduction?	Advice to contact Health Practitioner?	Treatment goals provided?	Tools provided to make notes and discuss options with others?	
Risk prediction tool													
American Heart Association	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
Reynolds risk score	✓	✓	✓[a]	✓[c]	✓	-	✓	-	✓	-	-	-	7
University of Edinburgh	✓	✓	✓	✓[b]	✓	-	✓	-	✓	n/a[d]	-	-	7
Siteman Cancer Center	-	✓	✓	✓	-	-	✓	-	✓	✓	-	-	6
London School of Health and Tropical Medicine	✓	✓	-	-	✓	-	-	-	✓	✓	-	-	5

	Option to print out results?	Main factors contributing to risk reported?	Options to reduce risk given?	Option to recalculate result by modifying risk profile?	Different risk displayed together to enable comparison?	Output saved and returned to at later date?	Risk reduction achievable by behaviour change/ treatment options reported?	Option to record progress as risk reduction is attempted?	Is user directed to further information sources about risk reduction?	Advice to contact Health Practitioner?	Treatment goals provided?	Tools provided to make notes and discuss options with others?	
Mayo clinic	✓	-	✓	-	-	-	-	-	✓	✓	-	-	4
Patient UK	✓	-	✓	-	-	-	-	-	-	n/a [d]	✓	-	3
QRisk 2	-	-	-	✓ [b]	✓	-	-	-	-	✓	-	-	3
NCEP (public)	-	-	✓	-	-	-	-	-	✓	-	-	-	2
Healthwise	✓	-	-	✓	-	-	-	-	-	-	-	-	2
My Optum Health	✓	-	-	-	-	-	-	-	-	✓	-	-	2
NCEP (prof)	-	-	-	-	-	-	-	-	✓	-	-	-	1
e-tools Age	-	-	-	-	-	-	-	-	-	-	-	-	0
Total No. of tools possessing each characteristic	**8**	**5**	**7**	**6**	**5**	**1**	**4**	**1**	**8**	**6**	**2**	**1**	

[a] risk demonstrated if modifiable factors were at optimal level; [b] Risk factor questionnaire on same page as output; [c] risk already demonstrated if modifiable factors were at optimal level; [d] tool is intended for health professionals or for use in consultations.

2.7 Discussion

This section will summarise the main findings, present the strengths and weaknesses of the study, and compare the findings with the research evidence and guidelines on risk communication and research conducted into web-based cardiovascular risk prediction tools.

2.7.1 Summary of findings

This study critically appraised the web-based cardiovascular risk prediction tools most likely to be found when using the *Google* search engine. Due to an overlap in the ranking scores, 13 tools were appraised in total. The tools were assessed on (1) the quality of the website, (2) the risk communication used, such as the type of risk representation format and the timeframe/s used, and (3) the extent that risk reduction was encouraged, by providing information about behaviour change and/or treatment options, such as reporting the main contributing risk factors or providing treatment goals.

A number of different algorithms were used by the tools, meaning there was variance in the cardiovascular endpoints predicted and the risk factors assessed. The most popular algorithm was from the Framingham Heart Study and the risk of having a myocardial infarction / heart attack was most commonly predicted. Moreover, there was little consistency in results of the tools that appeared to use the same algorithms and measured the same

endpoints, as risk ranged from 26 to 30% in these tools. The majority of tools were from reputable sources such as academic institutions or national organisations. They provided clear information about who was suitable to use the tool, and all but one of the tools provided links to further information regarding CVD and risk reduction. Eight of the tools were intended for patient use and the others were for collaborative use between patients and professionals.

Many principles of effective risk communication were used in the tools; however, they varied in how they communicated risk consistent with the research evidence and best practice guidelines. Nearly all tools presented absolute risk; but just over one third presented alternative types of risk, which allow users to evaluate their risk by comparing it with the risk of others of the same age and sex who possess optimal risk factors. Three tools demonstrated comparative risk and two tools provided relative risk. The majority of tools provided more than one way of expressing probability of cardiovascular risk. Two tools provided three numerical formats. The most commonly used was percentages. Natural frequencies were the second most commonly used numerical format, used in five tools. Under half of the tools provided graphical risk representation. One tool allowed users to choose one of four graphical formats for viewing their results. Four tools used bar charts and three used pictograms of smiley faces; a comparison thermometer and line graph were also used. The majority of tools provided risk in a 10-year timeframe only. Two tools demonstrated short-term risk less than 10 years, and one tool projected longer term risk by demonstrating 10-year risk if the

user was 10, 20 or 30 years older than their current age. Lastly, three tools had the facility of displaying risk in more than one timeframe option.

Some tools provided more features deemed beneficial and helpful in facilitating risk communication than others and no tool addressed all the issues surrounding cardiovascular risk communication. One tool (*American Heart Association*) stood out as focusing on cardiovascular risk reduction the most, as it provided all the features deemed helpful when considering risk reduction. Most commonly used features included the option to print out result and direction to further information sources about cardiovascular disease and risk reduction. It was apparent that risk reduction strategies have been given less attention than the calculation of risk and how the risk is communicated, meaning the final aim of reducing cardiovascular risk is sometimes missed.

To conclude, there is a need for a standardisation of risk prediction tools available of the World Wide Web, as the variation in quality of the risk communication may lead to confusion for users at home seeking on-line risk assessment independent of their GP. This may contribute to inaccurate risk perceptions and inappropriate action taken.

2.7.2 Strengths and weaknesses

A strength of this study is that it selected and appraised cardiovascular risk prediction tools most likely to be retrieved by *Google.com* on the World Wide Web. Due to the unstable nature of *Google* SERPs, searches were conducted over a five day period to determine the mean overall ranking score.

Furthermore, it compared the tools retrieved by two different types of searches, a tailored search and a general keyword search. The tailored search used terms specifically related to cardiovascular risk assessment that were used in previous research into web-based risk prediction tools (Gurmankin Levy et al. 2008; Roberts et al. 2007). The general keyword search used results of an elicitation survey that asked people what search terms they would enter into *Google* or other search engines if they were interested in finding out their risk of heart disease. Only two search terms were common to both searches, suggesting that the public use general keywords rather than tailoring their searches using more specific search terms.

The results from both types of searches were compared to see if the web-based cardiovascular risk prediction tools retrieved differed in any way. Although the search terms for each of the types of search differed, there was considerable overlap, as 15 tools were common to both searches. The same nine tools (American Heart Association; Healthwise; London School of Health and Tropical Medicine; Mayo Clinic; MyOptumHealth.com; National

Cholesterol Education Program (prof); National Cholesterol Education Program (public); Patient UK; University of Edinburgh) that were retrieved by both types of search appeared in the top 10 that were critically appraised. The two highest ranking tools (American Heart Association; National Cholesterol Education Program (public)) for both searches were the same. This suggests that results retrieved by search engines are determined not only by the keywords entered into the search engine, but by a number of factors. These factors include the number of links that a site has from credible sources, age of the domain and the actual frequency that keywords appear in the content contained within the site. Search Engine Optimisation techniques can be employed that increase the visibility and ranking of a website, making it more likely to be found.

A weakness of this study is that is unable to determine whether the risk prediction tools most likely to be found are actually the most visited. It was originally intended to compare the tools most likely to be retrieved with a measure of how many visitors (traffic) the hosting website receives, to determine whether the sites most likely to be found are the most popular. This was because the SERP ranking comprises a number of influencing factors and is not solely based on popularity, so it is likely that the top ranking websites on the SERP may not actually be the most visited. There is no definitive measure of website popularity; however, there are methods that can be used such as *Alexa Traffic rankings*. This measures the popularity of a website from the millions of *Alexa* toolbar users and other data sources (Alexa 2010). This study intended to compare the included sites with their

corresponding *Alexa Traffic rankings*, however, this appeared impossible as only overarching websites are ranked. For example, the National Cholesterol Education Program website (http://hp2010.nhlbihin.net/atpiii/calculator.asp) is ranked under the National Institute of Health website (http://nih.gov/). Therefore, it was beyond the means of this study to determine whether the tools that are most likely to be retrieved by *Google* are actually what users use to assess their cardiovascular risk at home. Further research could contact the authors of each website to see whether they have data available on the number of visits to their websites.

2.7.3 Comparison with guidelines and research evidence

The formats used by the cardiovascular risk prediction tools will be discussed in relation to guidelines and research evidence to determine how well these tools are portraying risk in-line with best practice and recommendations.

1) It has been widely accepted that graphical accompaniments to risk information can help with understanding (Lipkus 2007). However, still nearly half of the risk prediction tools included in the critical appraisal failed to provide any graphical representation with their numerical formats.

Additionally, a tool by the University of Edinburgh was the only one to allow users to choose between four graphical formats to view the risk output. This should be acknowledged as a desirable criterion for publicly available risk prediction tools, because people will have individual preferences for one format over another.

2) Natural frequencies are the natural way people think about risk probabilities and are effective in correcting inappropriate risk perceptions (Cuitie et al. 2008; Gigerenzer and Hoffrage 1995; van der Weijden et al. 2008). Five tools in the critical appraisal gave a probability estimate in the form of a natural frequency. Three tools also used pictograms of smiley faces to demonstrate this; however, one did not provide the numerical explanation as an accompaniment and another only provided a graphical format for high-risk patients.

3) Age is the single strongest risk factor for future cardiovascular events (Ridker and Cook 2005). Two tools attempted to illustrate this by showing how risk exponentially increases with age using a line graph and offering the projection of risk if the user was 10,20 or 30 years older, demonstrating how risk increases if you do not improve your modifiable risk factors.

4) An alternate method for addressing the timeframe issue in cardiovascular risk communication is by using the cardiovascular age equivalent format ('Heart Age'). This has been shown to be more

memorable, emotionally impactful and motivating in making lifestyle changes than more conventional methods such as percentages (Goldman et al. 2006; Soureti et al. 2010). Only one of the cardiovascular risk prediction tools in this critical appraisal provided this as a format for presenting risk (QRISK2).

5) The majority of risk prediction tools in this study used 10-year timeframes and three used timeframes less than 10 years. This is in-line with the findings from the systematic review (Chapter 3) that found shorter timeframes (less than 10 years) lead to more accurate risk perceptions and increased intention to change behaviour, than timeframes longer than 10 years (Asimakopoulou et al. 2008a; Frileux et al. 2004).

6) Communication about risk reduction: in this critical appraisal, just under half of the tools reported the possible options to reduce risk. Some tools did provide means to compare the risk achievable from modifying risk factors (such as the comparison thermometer by University of Edinburgh tool). However, provision of material to help with the decision making of changing behaviour and treatment options was scarce; only one tool (American Heart Association) had the option to print out an action plan. This is not in-line with current insights such as IPDAS, which provides criteria for good practice in facilitating decision making (IPDAS 2005). These include stating possible treatment options, the comparison of different outcome probabilities, and the

provision of tools to enable discussion with others (such as a health professional).

2.7.4 Comparison with previous research into web-based cardiovascular risk prediction tools

Studies into web-based cardiovascular risk prediction tools have found variation in the numbers of tools that readily provided the information needed to assess the quality and suitability of these tools (Gillois et al. 1999; Quaglini et al. 2005). This was also found in this critical appraisal. For example, different tools had different target populations, measured different risk factors and predicted different endpoints. Some tools did not provide reference to the algorithm used, did not specify exactly what they were predicting (e.g. cardiac risk only or cardiac plus cerebral risk); and did not give advice about the eligible population.

The variation of risk representation formats used by the web-based cardiovascular risk prediction tools found in this critical appraisal mirrors what has been found by previous research into web-based cancer risk prediction tools. For example, the study by Waters et al (2009) reported that percentages, natural frequencies and relative risk ratios were used by the cancer risk prediction tools. However, a lower percentage (38%) of cancer risk prediction tools provided graphical representation of risk compared to the cardiovascular risk prediction tools in this study (54%). Of the cancer risk

prediction tools, nearly half (n=21) presented absolute risk compared to 69% (n=9) of the cardiovascular risk prediction tools. 21% (n=10) presented comparative risk information only compared to 8% (n=1) of the cardiovascular risk prediction tools; and 30% (n=14) provided both absolute and comparative risk together, which was greater than the percentage of cardiovascular risk prediction tools (15%, n=2) (Waters et al. 2009).

2.7.5 Conclusion

To conclude, some recommendations and best practices are being adopted by some of the web-based cardiovascular risk prediction tools. Although variation was found in the risk communication, as some tools provided a number of different ways of expressing the probability estimates that facilitate accurate perception and enhance understanding, and others did not.

The value of web-based risk prediction tools intended to be used outside of consultations with health practitioners is reduced if users do not fully understand or appreciate the reasons behind their risk result. Although some tools in this appraisal did attempt to define and explain the risk result, more tools should consider doing this. Also, the tools need to have consensus in the endpoints they predict, so that results are more consistent across tools. Users of more than one tool will have their risk result validated and will have more faith in their results.

Little attention has been paid to risk reduction strategies. The tools could be improved by incorporating important features that help with the decision making process of cardiovascular risk reduction, such as the option to revisit the tools and record progress as attempt is made to reduce cardiovascular risk. It is concluded that the more features incorporated in the tools that facilitate risk reduction, the greater the likelihood of motivating the user to reduce their risk if required. However, to achieve unbiased informed decision making, the tools should be unbiased and remain impartial. They should not endorse certain products or favour one option for reducing risk over another.

Standardisation of risk prediction tools available on the World Wide Web is needed, as the variation in quality of the risk communication may lead to confusion for users at home seeking on-line risk assessment independent of their GP. This may contribute to inaccurate risk perceptions. Lastly, future developers of web-based cardiovascular risk prediction tools should pay more attention to research evidence and guidelines, and incorporate as many of the 'best practice' principles as possible. This will enable the development of a fully comprehensive risk prediction tool that could be considered the 'gold standard' of cardiovascular risk communication.

Chapter 3. What are effective strategies to communicate cardiovascular risk information to patients? A Systematic Review.

3.1 Introduction

This chapter describes a systematic review of studies which have compared different ways of communicating cardiovascular risk to patients and have assessed their impact on patient-related outcomes. It describes the literature search, study inclusion and narrative synthesis of results. This systematic review has been written as a paper for Patient Education and Counseling Journal (Waldron et al. 2011). It was peer-reviewed and accepted for publication. A copy of this paper has been presented in Appendix 15.

3.2 Aim of review

The aim of this review was to compare the effectiveness of different interventions used to communicate cardiovascular risk and assess the impact of the formats used in these interventions on patient-related outcomes, such as understanding, emotion, intention to modify behaviour and reduction in actual risk.

3.3 Methods

3.3.1 Data sources and search strategy

Preceding the systematic review, the Cochrane Consumers and Communication group and the Cochrane Heart group were contacted to ensure that no other review on the effectiveness of cardiovascular risk communication existed. An initial scoping review found that the presentation of health-related risk information has been debated for some time, with a considerable gap in the literature relating specifically to the communication of cardiovascular risk.

Systematic searches of six electronic databases: ASSIA, EMBASE, MEDLINE, CINAHL, PsycINFO and Science Citation Index Expanded were conducted from January 1980 up to November 2008. Comprehensive search strategies (aiming for high recall, low precision) were adapted from Cochrane Heart Filter mesh terms. The search strategies included subject heading and keyword searching. Terms (such as cardiovascular disease, heart disease, risk communication, risk assessment) were combined. Searches were adapted to each of the databases used (Appendix 16). In addition, the 'snowballing' technique of hand searching the citations of the retrieved papers was used to identify further relevant studies.

3.3.2 Study inclusion and selection

Studies were eligible for inclusion if they: (1) were published in peer-reviewed journals written in English; (2) involved adult population (over 18 years old); (3) were of any quantitative design, such as randomised controlled trials (RCT) or observational; and (4) compared risk communication interventions (of any format) for individualised cardiovascular risk assessment in primary or secondary care, against other interventions, with a control or usual care.

Non peer-reviewed, unpublished or non-English language papers, qualitative designs, and those solely reporting the preferences patients had for risk representation formats were excluded.

A title and abstract screen was conducted to select relevant studies. The selection was validated by two additional reviewers, who each checked half of the abstracts. Disagreement was resolved by discussion. Full text papers were obtained for included studies.

3.3.3 Data extraction and analysis plan

Data extraction was undertaken using a 64-item template (Appendix 17), comprising population characteristics, risk communication strategies, outcome measures and results. Methodological quality was assessed using a checklist for both randomised and non-randomised studies (Downs and Black 1998).

This has been identified as a useful tool for assessing risk of bias (Higgins and Green 2009). It was chosen due to the broad inclusion criteria in the design of the studies.

The data were extracted, and as validation, two additional reviewers each extracted data from a random half of the studies. A meta-analysis was not feasible due to the heterogeneity in study outcomes, and therefore a narrative synthesis of findings was conducted.

Studies were categorised into those that assessed individuals' *actual* risk and *analogue* studies that used hypothetical risk profiles. Furthermore, the intention of each study was assessed and validated by an additional reviewer. They were classed as having either a 'persuasive' or 'non-persuasive' intent. For example, persuasive studies were those that reported having the explicit aim of reducing cardiovascular risk; or for those that did not openly declare but measured outcomes that related to reducing cardiovascular risk (such as behavioural intention to accept treatment or improve lifestyle), an inferred persuasive intention was given. Studies were classed as non-persuasive if they were solely concerned with comparing the presentations of cardiovascular risk.

3.4 Results

3.4.1 Included studies

Figure 3.1 summarises the study selection and extraction process. 56 full papers were retrieved for further assessment and 29 were excluded. Of the 27 studies included for detailed data extraction, four were subsequently excluded because they only varied the *degree of risk* rather than the presentation or communication of risk formats (Dahl et al. 2007; Kristiansen et al. 2002; Marshall et al. 2006; Nexoe et al. 2005). Another five were excluded because the risk communication elements were embedded in a decision aid that had other components, and therefore, the outcomes could not be attributed to the risk communication strategy alone (Benner et al. 2008; Krones et al. 2008; Man-Son-Hing et al. 1999; Sheridan et al. 2006; van Steekiste et al. 2007). Lastly, three were excluded because they were not comparative studies of risk formats or did not report their comparison group (Christian et al. 2005; Lalonde et al. 2006; Paterson et al. 2002). No additional studies were found in the hand searching of the included studies' citations.

In summary, fifteen studies were included. Only four studies assessed individual's actual risk, as the majority (n=11) were analogue studies asking individuals to imagine a hypothetical risk profile. Table 3.1 provides a detailed description of each study in terms of design, sample, risk communication intervention, outcomes and main findings.

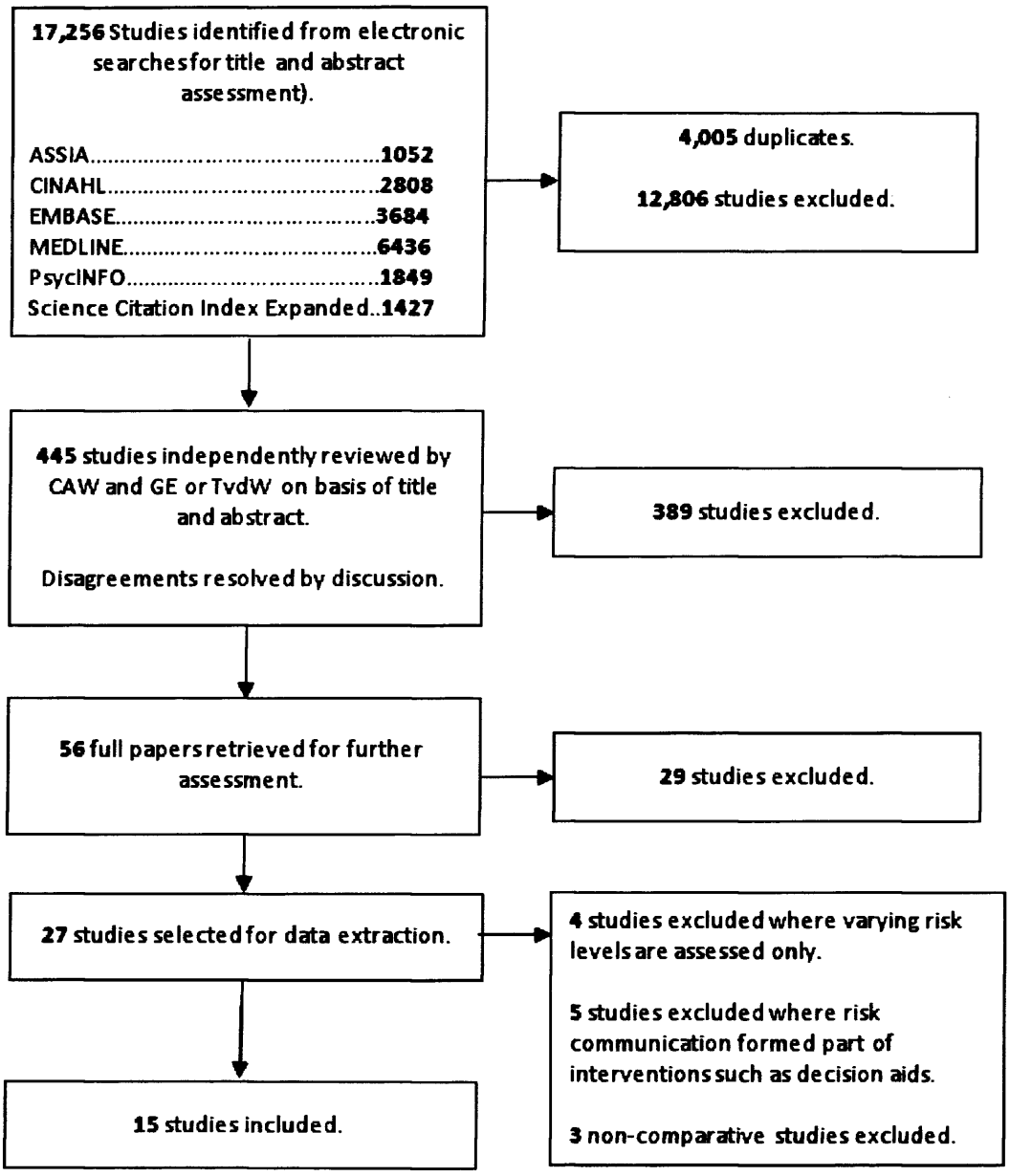


Figure 3.1 Study selection and extraction process: flowchart.

Table 3.1 Design characteristics and principal results of included studies, by type of risk assessment.

Author, year, country	Sample, Context	Design, Aim	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Actual risk assessment in patients						
Asimakopoulou et al, 2008a, UK.	95 patients with Type 2 diabetes and without existing cardiovascular disease (CVD), Diabetic Clinics and General Practitioner Surgeries.	Observational-factorial design, To examine the impact of communicating risk of CHD and stroke, using 3 time frames, on patients' perception, understanding of risk of CHD/stroke and their subsequent recall/memory for these risks.	Absolute 1, 5 or 10-year risk of developing CHD/stroke as a result of having diabetes, using the UKPDS Risk Engine v2.0.	Numerical and graphical presentation: Percentage of risk in given time-frame (1, 5, 10 years). Bar charts, with 10-slice pie chart and pictogram of 100 smiley faces used as supplements.	Risk perception, understanding and memory.	Originally inflated risk perceptions of CHD were successfully corrected with the help of the graphical tools ($F_{1,92}$=73.01; p<0.001), as was inflated stroke risk ($F_{1,91}$=119.05; p<0.001), but 10-year risk group was the most resistant to correction for both CHD and stroke as they were the only group who recalled much higher risk at 6 week follow up than they understood at the consultation ($F_{4,176}$=4.73; p<0.001).
Charlson et al 2008, USA	660 patients undergoing coronary artery catheterization, Hospital.	Randomised controlled Trial, To test whether an innovative approach of framing risk, based on 'net present value' economic theory (what patients can gain now), would be more effective in	Relative potential to improve current health status and quality of life, when modifying risk factors in intervention group; and value of preventing future health problems in control group.	Numerical presentation: Net present value (biologic age reduction achievable, if each risk factor was changed). Future risk (risk reduction framed as value of preventing future health problems).	Freedom from death, MI, stroke, angina or severe asymptomatic ischemia at 2 years, discrete stage of change and behaviour specific self-efficacy.	No significant differences were found between groups for the rates of death, stroke, MI, class II-IV angina or severe ischemia between the net present value group and future value group (p=non significant); or stage of change and self-efficacy (p=non significant). Over the 2 year follow-up, patients in both groups reached action on 1.5 risk factors.

Author, year, country	Sample, Context	Design, Aim	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Charlson et al 2008, USA cont.		behavioural intervention than the standard 'future value approach' in reducing cardiovascular morbidity and mortality following angioplasty.				
Grover et al, 2007, Canada	3053 men and women aged 30-70 years with diabetes or CVD; or men (aged 45-70) and women (aged 55-70) without CVD who had a 10 year coronary risk of at least 10% based on Framingham equations, Primary Care.	Randomised controlled Trial, To determine whether showing physicians and patient's the patient's calculated coronary risk can improve the effectiveness of treating dyslipidemia in a primary care setting.	Absolute and comparative 8- year cardiovascular risk, evidenced by increased cardiovascular age in intervention group; usual care in the control.	Numerical and graphical presentation: Percentages and cardiovascular age. Comparative risk graphically summarised by population risk tertiles, so patient could see his/her absolute risk compared with that of peers. Vertical bar graphs showing risk change after each lipid profile was taken.	Changes in blood lipid levels and non-lipid risk factors, percentage of patients reaching lipid targets and global 10 year risk.	Over the 12 month follow-up the intervention (i.e. coronary risk profile) led to greater cholesterol reductions (OR= 1.26 (95% CI; 1.07–1.48, *p* value not reported). After adjustment for baseline difference between groups, the intervention group was more likely to reach the recommended lipid targets (OR= 1.26 (95% CI; 1.04–1.53, *p* value not reported). There was a significant interaction effect between the risk profile and cardiovascular age, in that the higher a patient's risk (evidenced by increased cardiovascular age) the greater the impact associated with the risk profile (OR= 1.69 (95% CI; 1.21-2.36; $p<0.05$).

Straus, 2002, UK and Canada	17 patients admitted for nonvalvular atrial fibrillation, Hospital	Observational - pre-post design, To test a patient-centred measure of the likelihood of being helped or harmed by an intervention.	Ratios of being helped or harmed by warfarin medication (e.g. decreased risk of stroke and increased risk of haemorrhage).	Numerical presentation: • Absolute risk reduction/absolute risk increase (ARR/ARI). • Relative risk reduction/relative risk increase (RRR/RRI). • Number needed to treat / numbers needed to harm (NNT/NNH). • Likelihood of being helped or harmed) (LHH).	Patients' choice to take medication.	LLH had the highest percentage of patients choosing warfarin (76.4%, n=13). 70.4% (n=12) accepted treatment when presented with the ARR/ARI format, 47.1% (n=8) accepted treatment when presented with NNT/NNH. ARR/ARI had the lowest percentage of patients choosing warfarin (17.6%, n=3). Whether differences were significant was not reported.
Analogue studies						
Fair et al, 2008, UK.	740 respondents from general population who had not previously suffered from a medically diagnosed heart condition (heart attack or angina), Location not stated.	Quasi -experimental – factorial design, To test the hypothesis that responses to CHD risk estimates are heightened by use of ratio formats, peer group risk information, and long timeframes.	Absolute and comparative 10 or 30 risk of CHD, based on risk tables published by the Framingham Heart Study.	Numerical presentation: Natural frequencies and percentages, either with or without comparative/ peer group risk.	Risk perception, emotional response to risk information and intention to make lifestyle changes.	No main effect of time-frame on risk perception was observed. A significantly higher proportion of respondents perceived their risk to be higher when risk were presented in frequency formats (OR= 2.471 (95% CI; 1.692–3.609), $p<0.001$), or if those risks were supplemented with peer group risk information ($p=.006$). Respondents presented with risks in the form of a frequencies reported feeling more worried ($p=.0004$) and disturbed ($p=.001$) than those presented percentages.

Author, year, country	Sample, Context	Design, Aim	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Fair et al, 2008, UK cont.						Respondents who saw both personal and peer group risk information said they felt more worried (p=.002) and disturbed (p=.006) and less reassured (p=.016) than those who were presented with risk over a 10-year period. Presentation with frequencies also increased intention to make lifestyle changes (p=.047). Peer group risk information failed to have an impact on intention to change (p=non significant).
French et al, 2004, UK	970 adults aged 40-60 with no history of heart disease, Location not stated.	Observational – factorial design, To examine the emotional and cognitive impact of personal and social comparison information about health risk and to examine the effect of presenting this risk information using different probability formats, and the presence or absence of format-congruent visual representations.	Absolute and comparative 10-year risk of having a cardiac event (heart attack, angina, heart failure).	Numerical and graphical presentation: Vignettes of risk of having a cardiac event, with 4 factors manipulated: format (percentages or natural frequency); visual representation e.g. bar chart for percentages, pictogram for natural frequencies (presence or absence); level of social comparison risk (favourable or unfavourable) and level of personal risk (low or high).	Ratings of disturbance/worry, ratings of reassurance, likelihood of having a cardiac event, comparison of own risk compared to others and confidence in understanding of information given.	There were no main effects of frequency versus percentage format (p=non significant). Respondents who received a visual presentation gave lower ratings of being disturbed/worried (M=9.37) than those who did not received a visual representation (M=10.98) ($F(1,313=8.74$; $p<0.01$). This main effect was not found for the ratings of being reassured. Favourable social comparison information led to significantly less disturbance/worry, more reassurance and lower personal susceptibility ratings than unfavourable information ($p<.05$). Unfavourable social comparison information had no discernible

						impact, relative to not providing any social comparison information. No difference in the comparison of own risk compared to others, between those who received unfavourable, favourable or no social comparison information. Personal risk had more of an impact on reassurance (η^2 = 0.08) than social comparison risk (η^2 = 0.06). This was also seen for disturbance/worry (η^2 = 0.09 vs. η^2 = 0.05) and perceived risk (η^2 = 0.07 vs. η^2 = 0.03).
Frileux et al, 2004, France.	150 respondents from a convenience sample without established heart disease, Location not stated.	Observational – factorial design, To explore the impact of a preventive medical message on intention to change behaviour; the impact of the severity, its likelihood, time frame of risk, effectiveness of preventive behaviour, nature of behaviour on intention to change.	5, 10, 15, 20-year risk of coronary artery disease (presented as 2 severities: angina pectoris or heart attack).	Numerical presentation: Percentages. Four different components of a message about preventing CAD were manipulated: severity (angina pectoris and MI); probability occurrence (5, 10, 15, 20%); time horizon (5, 10, 15, 20 years); level of controllability (entirely under your control or not much you can do to reduce it).	Intention to adopt a specific behaviour.	All 4 main factors had a significant effect on the intention to adopt a preventive behaviour. Greater severity (MI) produced greater intentions than lower severity (angina pectoris) (p<0.001). The higher the probability the higher the estimated level of intention (effect stronger at low probabilities than at higher probabilities) (p<0.00001). The shorter the time horizon the higher the intention ($F_{3,414}$=229.33; p<0.001). The lower the controllability, the lower the estimated level of intention to change behaviour. (p<0.00001).

Author, year, country	Sample, Context	Design, Aim	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Goodyear-Smith et al, 2008, New Zealand.	100 patients with existing heart disease (MI, angina or both), taking statins and who had experience with taking medications and making decisions regarding medications, Family Practice.	Quasi-experimental, explorative study, To determine which methods of expressing a preventive medication's benefit encourage patients with known cardiovascular disease to decide to take the medication and which methods patients prefer.	5-year risk of a heart attack with and without medication (16% with and 23% without medication).	Numerical and graphical presentation: • Relative and absolute risk (positive and negative framing)-percentages. • Detailed and simplified natural frequencies. • NNT. • Odds ratios. • Vertical bar graphs-natural frequencies of those who have and do not have a heart attack with and without medication.	Acceptance of treatment.	81% were willing to take medication regardless of the way the benefit of medication was expressed. Absolute risk (negative framing) encouraged acceptance of treatment the most, with 89% of respondents accepting treatment. NNT least encouraged acceptance of treatment, with 67% of respondents accepting treatment. Natural frequency bar graph produced a higher acceptance rate (86%) compared to its numerical equivalent (75%), it is not reported whether this was significant (p=not reported).
Hux and Naylor, 1995, USA	100 outpatients of family practice, hypertension and cardiology centres, Private setting.	Quasi-experimental-cross-sectional design, To assess how three different formats of the same data affected the willingness to take what were implied to be different lipid-lowering drugs.	Data on effectiveness of a drug to prevent myocardial infarction and heart disease.	Numerical presentation: • RRR and ARR-percentages. • NNT. • Average gain on disease free years - number of extra 15 weeks free of heart disease. • Stratified gain in disease-free survival – percentages.	Acceptance of treatment.	RRR format had highest proportion accepting treatment (88%, n=88). NNT had lowest acceptance (31%, n=31). Average gain in disease free years had a 40% (n=40) acceptance rate and stratified gain in disease-free survival had a 56% (n=56) acceptance rate. A significantly higher percentage of patients accepted treatment on the basis of RRR (88%) than absolute risk reduction (42%) and NNT (31%) (p<0.001).

Man-Son-Hing et al, 2002, Canada.	198 Volunteers aged 60-80 years without atrial fibrillation, Recruitment from outpatient geriatric and medical clinics.	Observational – factorial design, To compare the impact of quantitative vs. qualitative descriptions of probability risk estimates in decision aids on the clinical decision-making process, regarding stroke prevention in atrial fibrillation.	Absolute 2-year probabilities of stroke and major haemorrhage with no antithrombotic therapy. Set at low (3%) or moderate (8%) risk.	Numerical and graphical presentation: Natural frequencies and pictogram of 100 faces in the quantitative (numerical) condition; Category phrases describing the risk of stroke and bleeding (e.g. low, moderate etc.) in the qualitative condition.	Choice of antithrombotic therapy, rank order of stroke risk and realistic expectations of outcomes.	No significant difference between treatment choices for the low risk arm. In the moderate risk arm, respondents in the qualitative group were more likely to choose therapy at the extremes of effectiveness (warfarin or not therapy) (p=0.01). Also, more persons in the qualitative group chose the options of aspirin and were 'unsure' than those in the quantitative group. The use of qualitative or quantitative decision aid made no significant difference in respondents' ability to rank-order their stroke risk in a quantitative or qualitative manner (all comparison p- values >0.10). The quantitative (numerical) decision aid resulted in a significantly higher percentage of respondents having realistic estimates of the numerical probabilities for all outcomes compared to the qualitative decision aid (all values p<0.01) e.g. when estimating the chance of stroke while taking warfarin, 76 and 32% of the quantitative and qualitative groups gave correct answers, respectively.

Author, year, country	Sample, Context	Design, Aim	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Mason et al, 2008, USA.	683 respondents from a reactive sample of people who weren't teachers or researchers, Internet survey completed remotely.	Observational-factorial design, To determine whether people focus primarily on information about their own risk status or on a comparison with others.	Absolute and comparative 10-year risk of having a cardiac event (heart attack, angina, heart failure).	Numerical presentation: Percentages, absolute risk and 4 levels of increasing comparison risk difference.	Negative affect responses to the risk information (disturbed and worried) and seriousness of a cardiac event in a person of the same age and sex.	When maintaining constant relative differences between personal risk and comparison risk, negative affect was higher at high personal risk (20%) than at low personal risk (10%) ($p<.01$). Respondents responded to the magnitude of the difference between personal and comparison risk, such that, as the difference increased (in which personal risk was higher than comparison risk), so did negative affect, independently of personal risk ($F_{1,530}= 9.10$, $p<.01$, $\eta_p^2 = .044$). When maintaining constant absolute differences between personal risk and comparison risk, there was no significant main effect of level of personal risk (p=non significant). Affective responses to comparison difference were sensitive to relative difference between personal and comparison risk. Relative differences correlated negatively with personal risk ($F_{3,530}= 8.19$, $p<.01$, $\eta_p^2 = .044$. At higher levels of personal risk, the role of comparison information becomes less. Judgements of the severity and prevalence of cardiac events was not affected by personal

						risk and comparison difference whether controlling for relative or absolute differences.
Misselbrook and Armstrong, 2001, UK.	274 hypertensive patients and age/sex matched non-hypertensive patients, General Practice.	Quasi-experimental-cross-sectional design, To examine patients' choice about treatment in response to different forms of risk presentation of the benefits of treating mild hypertension.	Benefit of treatment in reducing stroke.	Numerical presentation: • RRR and personal probability of benefit from treatment model- percentages. • NNT. • ARR- natural frequencies.	Acceptance of treatment.	For RRR most patients would accept treatment (92% CI; 89-96, n=255). For absolute risk reduction 75% (95% CI; 70-80, n=208) would accept treatment. For NNT 68% (95% CI; 63-74, n=188) would accept treatment. Personal probability of benefit had least patients accepting treatment (44%, 95% CI; 38-50, n=121) with the narrow majority declining treatment.
Scott, and Curbow, 2006, USA	395 College/University women, University classrooms.	Observational study – factorial design, To examine the interactive effects of message frames and CVD risk factors on women's knowledge, beliefs, efficacy and behavioural intentions.	No individualised risk estimates, generalised descriptive statements regarding the prevention of heart disease.	4 messages comprising either the probable benefits/gains of engaging in healthy behaviours or the probable costs/losses of not doing so, in either the short-term or long-term future. e.g. • Gain x Present • Gain x Future • Loss x Present • Loss x Future	Susceptibility, self-efficacy to prevent heart disease, perceived efficacy of behavioural interventions and behavioural intent.	There were no main or interactive effects of time orientation on any outcomes (p=non significant). Those who read a gain-framed message showed a significantly greater mean increase in self-efficacy to prevent heart disease compared to those who read a loss-framed message ($F_{1,291}$ =8.21, p< .05, effect size =.02). There was a significant interactive effect of message frame and parental history of high blood pressure for intention to check blood pressure (F =5.13, p< .05, effect size =0.01). Intention was significantly increased only in those with a family history exposed to the loss-framed message.

Author, year, country	Sample, Context	Design, Aim	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Scott, and Curbow, 2006, USA cont.						Conversely, only the gain-framed message significantly increased intention in those without a family history. No other significant main or interactive effects of message and health history variables on any other outcomes.
Sorensen et al, 2008, Denmark	1519 non-institutionalised Danes over 40 randomly drawn from a national database at Statistics Denmark, Location not stated.	Observational-cross-sectional design, To explore whether lay people can discriminate between preventive interventions when effectiveness is presented in terms of relative risk reduction, and whether such discrimination is influenced by presentation of baseline risk.	Death of a heart attack within 3 years.	Numerical presentation: percentages and natural frequencies (for baseline risk of heart attack). RRR achieved by a hypothetical drug treatment to prevent heart attacks presented as 10, 20,30,40,50 or 60% in order to test whether baseline risk had an effect on acceptance of treatment. Baseline numeric risk information was either present or not.	Acceptance of treatment and perceived difficulty of understanding the size of the treatment effect.	No significant difference in acceptance rates across respondents who were and were not presented with baseline risk information (p=non significant). 76% of respondents reported that RRR was not difficult to understand. There was no difference in reported understanding of RRR across respondents who were or were not presented with baseline risk information (p=non significant). Respondents, who reported no difficulties understanding the concept, were more likely to accept the hypothetical treatment irrespective of RRR-level and whether baseline risk had been presented ($p<0.05$).

Stovring et al, 2008, Denmark.	1169 respondents from a representative sample of individuals aged 40-59 with or without experience of CVD, University building	Observational - pre-post design, To study the concordance of decisions based on one of four single information formats for treatment effectiveness with subsequent decisions based on all four formats combined with a pictorial representation.	Absolute and relative 10-year risk of a fatal heart attack (5% and 19% risk).	Numerical and graphical presentation: • ARR and RRR - percentages. • NNT. • Number of months for prolongation of life without heart attack (POL) (e.g. postponement of adverse outcomes). • Smiley face pictograms showing numbers affected with and without treatment and natural frequencies bar graph. Information on treatment effectiveness presented in terms of (1) single information format and subsequently (2) picture in combination with data on NNT, RRR and life extension (POL).	Consent to therapy after the initial and final information, concordance of decision and difficulty in understanding.	Respondents initially presented with RRR generally became less likely to consent to treatment after receiving comprehensive information (73% (CI; 67-78) initial concordance rate and 67% (CI; 62-73) final concordance rate). While respondents initially presented with POL became more willing to accept treatment after having been given the fuller picture (56% (CI; 51-62) initial concordance rate and 64% (CI; 62-73) final concordance rate). However, it was not reported whether these differences were significant. ARR gave highest concordance (94%, CI; 91-97) between initial and final decision but was not statistically superior to the other formats (p=non significant). Followed by RRR, POL and NNT but differences were small. Difficulty in understanding did not affect the concordance of decision to accept treatment.

3.4.2 Quality of studies

Methodological quality of studies was assessed (Appendix 18), using the Downs and Black checklist (Downs and Black 1998) to assess internal and external validity. Two studies were determined to be of good quality (Charlson et al. 2008; Grover et al. 2007). The other studies were deemed to be of medium quality (Asimakopoulou et al. 2008a; Fair et al. 2008; French et al. 2004; Frileux et al. 2004; Goodyear-Smith et al. 2008; Hux and Naylor 1995; Man-Son-Hing et al. 2002; Mason et al. 2008; Misselbrook and Armstrong 2001; Scott and Curbow 2006; Sorensen et al. 2008; Stovring et al. 2008; Straus 2002) (Appendix 19).

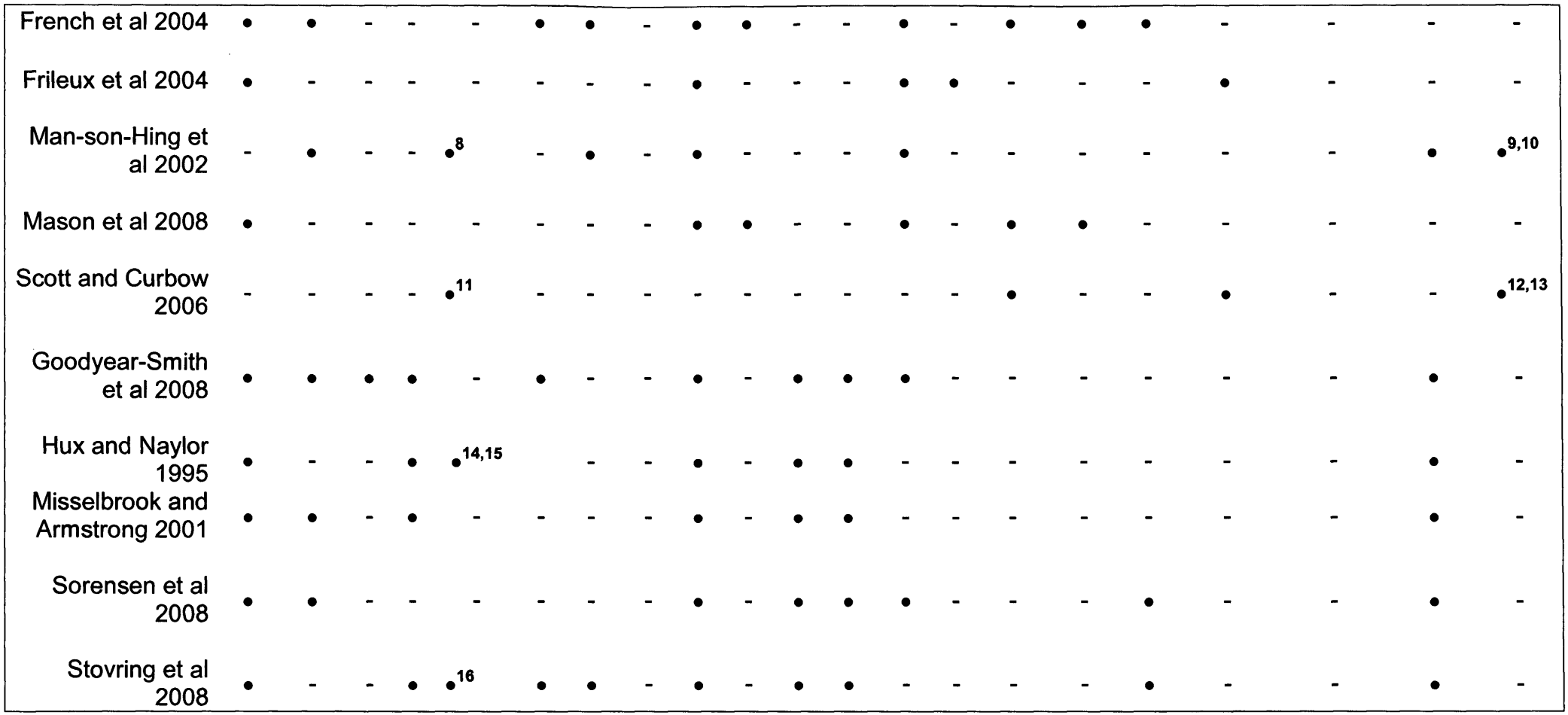
Of the four studies where individuals' actual risk was calculated (Asimakopoulou et al. 2008a; Charlson et al. 2008; Grover et al. 2007; Straus 2002), two were RCTs (Charlson et al. 2008; Grover et al. 2007) and two were observational (Asimakopoulou et al. 2008a; Straus 2002). The RCTs were of good quality, both were adequately powered and compared groups to identify possible confounders. In one trial, the outcome assessor was blinded to the randomisation groups (Charlson et al. 2008). However, in the other trial, contamination of the control group may have occurred due to the randomisation at a patient and not physician level (Grover et al. 2007). The two observational studies achieved lower quality scores.

Eleven analogue studies asked individuals to imagine a hypothetical risk profile. They were predominantly observational studies with a factorial design. Six studies randomised groups (French et al. 2004; Man-Son-Hing et al. 2002; Mason et al. 2008; Scott and Curbow 2006; Sorensen et al. 2008; Stovring et al. 2008); six attempted to identify principal confounders by comparing groups (Fair et al. 2008; Goodyear-Smith et al. 2008; Man-Son-Hing et al. 2002; Scott and Curbow 2006; Sorensen et al. 2008; Stovring et al. 2008) and two blinded participants to the manipulations (Man-Son-Hing et al. 2002; Misselbrook and Armstrong 2001). However, six studies did not report power calculations for sample sizes (Fair et al. 2008; French et al. 2004; Frileux et al. 2004; Goodyear-Smith et al. 2008; Mason et al. 2008; Misselbrook and Armstrong 2001), one was underpowered (Stovring et al. 2008), and one reported concerns about the reliability of the findings because participants failed to follow questionnaire instructions (Scott and Curbow 2006).

There was variation of included studies in terms of risk representation formats, type of cardiovascular risk, timeframe and outcomes measured (see Table 3.2)

Table 3.2 Summary of cardiovascular risk manipulation of included studies, by type of risk assessment.

Study	Numerical Formats					Graphical Formats			Risk				Time frame			Outcomes						
	Percentages	Natural Frequencies	Ratios	NNT	Other (state)	Bar graph	Pictogram	Other (state)	Absolute	Comparative	Relative	Risk reduction	≤ 10	>10	Risk perception	Emotional response	Understanding	Intention to change behaviour	Change in risk factors, Overall risk	Acceptance of treatment/ Medication choice	Other (state)
Actual risk assessment in patients																					
Asimakopoulou et al 2008a	•	-	-	-	-	•	•	•[1]	•	-	-	-	•	-	•	-	•	-	-	-	•[2]
Charlson et al 2008	-	-	-	-	•[3,4]	-	-	-	-	-	•	•	•	-	-	-	-	-	•	-	•[5,6]
Grover et al 2007	•	-	-	-	•[7]	•	-	-	•	•	-	•	•	-	-	-	-	-	•	-	-
Straus 2002	-	-	•	-	-	-	-	-	-	-	•	•	-	-	-	-	-	-	-	•	-
Analogue studies																					
Fair et al 2008	•	•	-	-	-	-	-	-	•	•	-	-	•	•	•	•	-	•	-	-	-



[1] Pie chart, [2] Memory/Recall, [3] Net present value approach (biologic age reduction), [4] Future value approach, [5] Self-efficacy, [6] Stage of change, [7] Cardiovascular age, [8] Categories, [9] Rank order of stroke risk, [10] Outcome expectation, [11] Descriptive statements (gain/loss and present/ future framing), [12] Self-efficacy, [13] Perceived efficacy of interventions, [14] Gain in disease free years, [15] Stratified gain in disease free survival, [16] Prolongation of life.

3.5 Summary of findings

3.5.1 Numerical formats

One study assessing patients' actual risk (Straus 2002) and seven analogue studies (Fair et al. 2008; French et al. 2004; Goodyear-Smith et al. 2008; Hux and Naylor 1995; Misselbrook and Armstrong 2001; Sorensen et al. 2008; Stovring et al. 2008) compared a number of different numerical risk representation formats with each other. Additionally, one actual risk study used a combination of two numerical formats in an intervention and compared it with usual care (Grover et al. 2007). One analogue study compared a numerical format with risk categories (Man-Son-Hing et al. 2002).

Two analogue studies were concerned with whether perceptions of risk and emotional responses were sensitive to numerical risk presentation (Fair et al. 2008; French et al. 2004). Fair and colleagues examined the effect of two formats (percentages and frequencies, e.g. *n in 100*) on responses to messages regarding the risk of coronary heart disease (CHD). Risk perceptions, emotions and behavioural intentions were sensitive to the format used. Frequencies led to higher perceived risk (OR= 2.471 (95% CI; 1.692–3.609), $p<0.001$), more worry ($p<0.001$), more disturbance ($p<0.001$), and increased intention to make lifestyle changes ($p<0.05$), than did percentages (Fair et al. 2008). Conversely, French et al used vignettes that presented risk of having a cardiac event in either percentage or frequency

formats, and found no differing effect on risk perception, emotion or understanding (French et al. 2004).

One study assessing actual risk (Straus 2002) and five analogue studies (Goodyear-Smith et al. 2008; Hux and Naylor 1995; Misselbrook and Armstrong 2001; Sorensen et al. 2008; Stovring et al. 2008) were mainly concerned with presenting treatment effectiveness in differing numerical formats. These studies evaluated how different formats lead to differing acceptance rates of medication. Straus compared formats for presenting the ratio of the benefits and costs of taking warfarin medication, and measured patients' intention to take warfarin. The highest percentage of patients (76.4%, n=13) chose to take warfarin when they were presented with the likelihood ratio of being helped or harmed. Conversely, the absolute risk reduction versus absolute risk increase ratio had the lowest percentage of patients choosing to take warfarin (17.6%, n=3). It was not reported whether differences were significant, and no confidence intervals were given. However, this study had a small sample (n=17) and needs to be interpreted with caution (Straus 2002).

In a cross-sectional study by Goodyear-Smith, respondents with existing CVD were presented with descriptions of the benefit of a hypothetical medication to reduce the risk of a future heart attack. The same information was expressed in different formats. Their willingness to accept the medication was measured. The presentation of negatively framed 5-year absolute risk (expressed as percentages) encouraged acceptance the most, with 89% (n=89) consenting

format was supplemented with baseline risk information (expressed as natural frequencies), which would enable a calculation to determine perspective (Sorensen et al. 2008).

In the study that compared a numerical intervention with usual care, Grover gave patients a copy of their coronary risk profile. This comprised eight-year absolute cardiovascular risk presented as increased cardiovascular age (e.g. an analogy that combines absolute and relative CVD risk, described in more detail below), comparative risk (expressed as percentages), and bar graphs (to demonstrate the changes in patients' lipid levels over time). At 12-month follow-up, patients receiving their risk profile were more likely to reach lipid targets (OR= 1.26 (95% CI; 1.04–1.53, *p* value not reported) and achieve greater cholesterol reductions (OR= 1.26 (95% CI; 1.07–1.48, *p* value not reported) than those who received usual care (Grover et al. 2007).

Cardiovascular age is calculated from a model that estimates the life expectancy of individual patients based on their annual risk of fatal coronary disease, fatal stroke and non-CVD death, and compares it with the average life expectancy of individuals of the same age and sex. The difference between the two numbers is then added or subtracted from the patient's chronological age to provide the cardiovascular age. The difference between chronological age and cardiovascular age is the 'age gap'. This measure combines both a relative component e.g. finding out if you are older or

younger than your cardiovascular age, and an absolute component e.g. the size of the age gap (Grover et al. 2007).

Man-Son-Hing et al compared two versions of a decision aid that differed in the way they presented risk, using a factorial design. The purpose of the decision aid was to help with choices regarding antithrombotic therapy to prevent stroke; the risk information was presented in either quantitative numerical formats (e.g. frequencies) with graphical representations (e.g. pictograms with smiley faces); or in a more qualitative way (e.g. high to low risk categories). When the risk of stroke without antithrombotic therapy was presented as 'moderate' (e.g. 8%), participants receiving the numerical information were significantly more likely to choose the therapy with the extremes of effectiveness (e.g. warfarin or no therapy) ($p<0.01$). Those receiving the risk category information were more likely to choose aspirin (middle of the range effectiveness) and be more uncertain about their choice. This difference was not seen when a low (e.g. 3%) risk of having a stroke with no therapy was presented. Additionally, those receiving the numerical decision aid were significantly more likely to have realistic risk perceptions, by giving correct estimates of the numerical probabilities for the outcomes achievable from therapy, than those who received the alternative risk category version ($p<0.01$) (Man-Son-Hing et al. 2002).

To summarise, studies looking at numerical risk representation formats have found that making patients aware of their risk can encourage risk reduction action to be taken, especially if this risk is high. There is conflicting evidence

regarding whether numerical representation formats can affect patients' perceptions or emotions. However, numerical representation of risk as opposed to simple risk categories (e.g. high, moderate, low) appears to lead to more accurate risk perceptions. Additionally, treatment decisions are sensitive to the way a treatment's effectiveness is presented. The RRR format appears to 'encourage' treatment the most and the NNT format leads to the least acceptance.

3.5.2 Graphical formats

Six studies in this review used graphical representations, mainly bar graphs and pictograms. Two used actual risk assessment (Asimakopoulou et al. 2008a; Grover et al. 2007) and four were analogue studies (French et al. 2004; Goodyear-Smith et al. 2008; Man-Son-Hing et al. 2002; Sorensen et al. 2008). No study compared different graphical formats with each other. Two studies compared a graphical format against its numerical equivalent (French et al. 2004; Goodyear-Smith et al. 2008). Four studies used numerical and graphical formats collectively (Asimakopoulou et al. 2008a; Grover et al. 2007; Man-Son-Hing et al. 2002; Stovring et al. 2008); two of which used more than one graphical representation and reported the effect resulting from a combination of the graphical formats (Asimakopoulou et al. 2008a; Stovring et al. 2008).

Four studies incorporated both graphical and numerical formats into their interventions. Asimakopoulou and colleagues found patients' perceived risk was grossly inflated compared to their actual risk. The graphical tools helped to correct these inflated risk perceptions of CHD risk ($F_{1,92}$=73.01; p<0.001), as well as inflated stroke risk ($F_{1,91}$=119.05; p<0.001) (Asimakopoulou et al. 2008a). Additionally, Grover presented patients with a risk profile comprising bar graphs to demonstrate the changes in patients' lipid levels over time. This was more successful in reducing cholesterol (OR= 1.26 (95% CI; 1.07–1.48, p value not reported) and meeting lipid targets (OR= 1.26 (95% CI; 1.04–1.53, p value not reported), than usual care (Grover et al. 2007).

Man-son-Hing et al found that when the risk of a stroke without antithrombotic medication was moderate and presented as a pictogram of natural frequencies, as opposed to risk categories, more realistic risk perceptions resulted (p<0.01) and therapy with extremes of effectiveness (e.g. warfarin or no therapy) was more likely to be chosen (Man-Son-Hing et al. 2002).

Stovring et al presented comprehensive information about the effectiveness of a pharmaceutical drug, using a combination of four numerical formats and a pictogram showing number of people affected with and without treatment. Initial decisions to accept treatment made when one numerical format was presented first did not change after subsequent presentation of the more comprehensive risk information (Stovring et al. 2008). This finding is contradicted by Goodyear-Smith and colleagues who found that acceptance

of medication to reduce the risk of a heart attack increased by 11% (from 75% to 86%) when bar graphs were presented (showing the number of people who do and do not have a heart attack when taking the medication, compared to those who do not take it), as opposed to when the same information was expressed only numerically as natural frequencies. However, it is not reported whether this was significant (Goodyear-Smith et al. 2008).

Lastly, the effect of the presence or absence of graphical representation was compared by French et al. When the risk of having a cardiac event was accompanied with visual representation (e.g. bar graphs for the percentage format, pictograms for the natural frequency format), significantly less disturbance and worry resulted, compared to those who did not receive visual representations ($F_{1,313}$=8.74; p<0.01). However, greater feelings of reassurance were not reported, which would intuitively be expected, and perceptions and behavioural intentions remained unaffected (French et al. 2004).

To summarise, studies that have used graphical representation in their interventions have shown that presenting risk both graphically and numerically can lead to more accurate perceptions of risk, favourable changes in risk factors (such as lipid levels and cholesterol) and can help reduce negative emotions. However, whether treatment decisions are sensitive to numerical or graphical formats used in the presentation of medication effectiveness is not clear.

3.5.3 Presentation of comparative risk

Comparative or peer-group risk can be used to demonstrate how an individual's risk compares to that of the average person of the same age and sex. The effects of presenting comparative risk information were examined by four studies. Three were analogue (Fair et al. 2008; French et al. 2004; Mason et al. 2008). Two of these compared the presentation of both personal and comparative risk against presentation of personal risk only (Fair et al. 2008; French et al. 2004). One of these also examined the effect of presenting comparative risk higher or lower than personal risk (French et al. 2004). One study examined the effects of relative differences between personal and comparison risk (Mason et al. 2008). Assessment of actual risk was used in one study, which incorporated comparative risk into an intervention comprising numerical and graphical presentations (Grover et al. 2007).

Of the two studies that compared the presentation of personal and comparative risk against personal risk only, Fair et al found that risk perceptions and emotions were sensitive to the presence of comparative risk information. When messages about CHD contained information about both personal and comparative risk, respondents perceived their risk to be significantly higher (OR= 1.578 (95% CI; 1.144–2.177), $p<0.01$), and reported more worry ($p<0.01$), more disturbance ($p<0.01$), and less reassurance

(p<0.01), than presentation of personal risk information only. However, behaviour intentions did not differ significantly (Fair et al. 2008).

The other study by French et al assessed respondents' perceptions and emotions. Personal risk had more of an impact on reassurance ($\eta^2 = 0.08$) than social comparison risk ($\eta^2 = 0.06$). This was also seen for disturbance and worry ($\eta^2 = 0.09$ vs. $\eta^2 = 0.05$) and perceived risk ($\eta^2 = 0.07$ vs. $\eta^2 = 0.03$). This study also distinguished between the presentation of favourable and unfavourable comparative risk information, and compared this against not providing any comparative risk information. Those presented with favourable comparison information (e.g. average or below average risk) reported being significantly more reassured, less disturbed and worried and thought they were less likely to have a cardiac event, than those who received unfavourable information (e.g. above average risk) (p<.05). However, unfavourable comparison information had no discernible impact on risk perceptions or emotions, relative to not providing any comparison information (French et al. 2004).

Mason et al 2008 examined whether people attend mainly to information regarding personal risk or comparative risk. They presented hypothetical scenarios about the risk of a cardiac event. Levels of personal and comparison risk varied in these scenarios. As the difference between personal risk and comparison risk increased (in which personal risk was higher than comparison risk), so did worry and disturbance. ($F_{1,530}$= 9.10, p<0.01, η_p^2 =

.044). Furthermore, responses to the varying relative differences between personal risk and comparison risk correlated negatively with personal risk ($F_{3,530}$= 8.19, p<0.01, η_p^2 = .044), suggesting that at higher levels of personal risk, the role of comparison information becomes less (Mason et al. 2008).

The study by Grover showed how an individual's risk compares to the average person by using the concept of cardiovascular age equivalent. This is calculated using the equivalent risk of a person who has no modifiable risk factors. In cases where an individual has modifiable risk factors, their risk will be higher than a person of the same age and sex without those factors; therefore their risk will be equivalent to someone older. When a risk profile was given to patients that presented comparative 8-year cardiovascular risk as cardiovascular age equivalent and percentages, patients had greater cholesterol reductions (OR= 1.26 (95% CI; 1.07–1.48, p value not reported) and were more likely to reach lipid targets (OR= 1.26 (95% CI; 1.04–1.53, p value not reported) over the 12 month follow-up, than those who did not receive their risk profile. In particular, an interaction effect was found where the higher the patient's risk (evidenced by increased cardiovascular age), the greater the impact of the risk profile (OR=1.69 (95% CI; 1.21–2.36), p<0.05) (Grover et al. 2007).

To summarise, using comparative risk together with personal risk affects risk perceptions, emotions and can influence behavioural change for reducing risk factors. However, the impact of comparison risk depends on the level of

personal risk; when personal risk is high, negative emotions are heightened and less attention is paid to comparative risk.

3.5.4 Framing of risk information

One analogue study investigated the impact of risk message framing (Scott and Curbow 2006). Scott and Curbow evaluated framing of messages regarding the probable benefits or costs of engaging in healthy behaviours relating to heart disease or not engaging in them. These were presented as 'gain-framed' (e.g. benefits of engaging in healthy behaviours) or 'loss-framed' (e.g. costs of not engaging in healthy behaviours). Gain-framed messages led to a significant increase in perceived self-efficacy to prevent heart disease as opposed to loss-framed messages ($F_{1,291}$ =8.21, p<0.05, effect size=.02). Moreover, there was a significant interactive effect of message frame and parental history of high blood pressure for reported intention to check blood pressure (F =5.13, p<0 .05, effect size=.01). Intention was significantly increased only in those with a family history exposed to the loss-framed message. Conversely, only the gain-framed message significantly increased intention in those without a family history (Scott and Curbow 2006).

3.5.5 Timeframe manipulations

The timeframe used when presenting cardiovascular risk information (i.e. 5-year or 10-year) was manipulated in one study assessing actual risk

(Charlson et al. 2008) and four analogue studies (Asimakopoulou et al. 2008a; Fair et al. 2008; Frileux et al. 2004; Scott and Curbow 2006). Specific timeframes were not used in two studies, only present vs. future (Charlson et al. 2008) and short-term vs. long-term (Scott and Curbow 2006). One study examined time horizons less than 10-years (Asimakopoulou et al. 2008a). Two studies (Fair et al. 2008; French et al. 2004) considered the presentation of risk over longer time horizons greater than 10 years.

Charlson et al presented information about the reduction of cardiovascular morbidity risk achievable by modifying risk factors, using the 'net present value' approach (biologic age reduction one could achieve either in three months or two years, e.g. respondents told that changing behaviour would decrease their biological age) or the 'future value' approach (risk reduction framed as the value of preventing future health problems, e.g. respondents told changing behaviour would increase lifespan). However, at 2 year follow-up no differences between the two groups were found in rates of death, stroke, myocardial infarction, angina or severe ischemia, stages of change or self-efficacy (Charlson et al. 2008).

Also, Scott and Curbow framed information about the costs and benefits of engaging in or not engaging in healthy behaviours, in relation to heart disease, in the short or long-term. The timeframe of the messages did not have an effect on behavioural intentions, self-efficacy or perceived susceptibility. It is argued that this may have been due to the young sample

used and the future-oriented nature of heart disease (Scott and Curbow 2006).

Asimakopoulou and colleagues presented the risk of developing CHD or stroke as a result of having diabetes in 1, 5 or 10-years, using percentages with graphical accompaniments. Originally inflated risk perceptions of CHD were successfully corrected with the help of the graphical tools ($F_{1,92}$=73.01; p<0.001), as was inflated stroke risk ($F_{1,91}$=119.05; p<0.001). However, the 10-year time frame was most resistant to correction, and those who received this timeframe recalled a much higher risk at 6 week follow-up than they understood at the initial consultation ($F_{4,176}$=4.73; p<0.001), possibly suggesting they did not understand the concept of accrual of risk over time (Asimakopoulou et al. 2008a).

Frileux and colleagues found that when individuals indicated their intention to adopt a specific behaviour for a number of scenarios about coronary artery disease risk varying in terms of the level of probability occurrence (5,10,15, or 20%) and the timeframe presented (either short 5 or 10-years, or long 15 or 20 years), shorter timeframes (i.e. 5 or 10 years) led to greater intention to change behaviour ($F_{1,138}$=29.66; p<0.001). In fact, the shorter the timeframe, the greater the intention to change behaviour ($F_{3,414}$=229.33; p<0.001). Furthermore, an interaction between age and timeframe was found, where intention to adopt a preventive behaviour was greater for older participants (aged between 60 and 80) when shorter timeframes were used, and for younger participants (aged between 20 and 30) when longer time frames

were used (Frileux et al. 2004). Conversely, Fair et al found no effect of timeframe manipulation on perceptions, emotion or behavioural intentions, when 10 or 30-year timeframes were used in messages regarding CHD risk (Fair et al. 2008).

To summarise, evidence is unclear, but it appears that patients are insensitive to the framing of risk information when presented as merely 'short-term' or 'long-term'. However, presentation of specific timeframes does have an effect; shorter timeframes (less than10 years) may lead to more accurate risk perceptions and increased intention to change behaviour, than 10 year risk or longer, especially for older patients.

3.6 Discussion and Conclusion

3.6.1 Discussion

This review demonstrates that compared to the intensive and ongoing investment in the calculation of cardiovascular risk estimates, there is a poverty of research on how to convey these estimates in a meaningful way, so as to motivate people to modify their risk of developing heart disease. The review comprised broad inclusion criteria, yet only found 15 studies, 11 of which were analogue studies and only 4 studies which dealt with the presentation of actual risk to patients. The methodological quality of studies varied, the majority had observational designs and were heterogeneous with

respect to the conceptualisation, formats and framing of cardiovascular risk probabilities. Therefore, only a few meaningful subgroups could be formulated (real or hypothesised risk, type of cardiovascular risk manipulation etc.).

The conclusions drawn from these few studies are tentative and need further exploration. Nevertheless, the results from individual studies are summarised. Making patients aware of their risk can encourage risk reduction action to be taken, especially if this risk is high. Numerical presentation of risk as opposed to simple risk categories leads to more accurate risk perceptions and can influence treatment decisions. Relative risk reduction format 'encourages' acceptance of treatment the most and numbers needed to treat (NNT) format encourages the least. The presentation of absolute and comparative risk, both graphically and numerically, affects risk perceptions and emotions and can lead to reduction in patient risk factors. However, the impact of comparison risk depends on the level of personal risk; comparative risk is attended to less when personal risk is high. Lastly, shorter timeframes (less than 10 years) lead to more accurate risk perceptions and increased intention to change behaviour, than timeframes longer than 10 years.

A strength of this review is that it comprised a comprehensive systematic literature search that aimed for high recall. Study inclusion and data extraction were agreed and validated by at least two reviewers throughout the reviewing process. Weaknesses include possible selection bias from the exclusion of unpublished literature and non-English language studies; and the fact that data extraction was not independent, but involved a validation procedure

(however, consensus between reviewers was very high). Caution needs to be taken when interpreting this review's findings as it incorporated studies that used actual risk assessment and analogue studies. Real patients differ from participants in hypothetical studies (Lloyd 2001). Additionally, multiple types of cardiovascular risk were included (such as those for primary CHD prevention, secondary prevention, and stroke prevention in Atrial Fibrillation). Therefore, there may be an interaction effect of format by type of CVD risk, in which investigation is beyond the scope of this review.

The principal findings of this review confirm previous research indicating that:

1) Visual displays have desirable properties that are helpful for representing risk, enhance understanding of risk and are favourably evaluated by patients (Hill et al. 2010; Lipkus and Hollands 1999; Price et al. 2009).

2) Cardiovascular age equivalent formats are clear, memorable and considered an 'eye-opener' or 'wake-up call' and have the potential to motivate people to make beneficial health-related behaviour change. This is in contrast to the more traditional statistical probability formats for communicating risks that were viewed as being confusing and uninspiring (Goldman et al. 2006).

3) Frequencies are the natural way people think about risk probabilities, and are effective in correcting inappropriate risk perceptions (Cuitie et al. 2008; Gigerenzer and Hoffrage 1995; van der Weijden et al. 2008).

Additionally, the results from a randomised trial published after this review was conducted, confirm the positive evaluation of frequencies (Carling et al. 2009b). When summary statistics for communicating the effects of statins on the risk of coronary heart disease were presented in different formats, natural frequencies were best understood (86% of participants reported they understood them well or very well) and participants were most satisfied with this information, compared to the other formats, such as absolute risk reduction and NNT (Carling et al. 2009b).

4) The relative risk format, despite being more persuasive, is more favourably evaluated than other formats (such as absolute risk or NNT) (Covey 2007; Cranney and Walley 1996).

Furthermore, the randomised trial by Carling et al found that treatment decisions were also influenced by the relative risk reduction format. The relative risk reduction format lead to a 21% higher probability of choosing to take statins compared to other formats (Carling et al. 2009b).

Studies in this review provided inconclusive evidence of the effect of presenting patients with comparative risk information. They demonstrated that individuals attend to risk information based on the magnitude of personal risk

and their risk in comparison to others. These appear to be independent and additive, as comparing individual risk with the 'average' may be less important when ones' personal risk is high; possibly because the salience of the personal risk overrides the comparative information in these circumstances (Mason et al. 2008). However, the exact nature of the effect on behavioural intentions, perceptions and emotion is unclear. This format is potentially important as it puts individualised risk into context and is a way demonstrating the risk attributable to non-modifiable risk factors, such as age. Previous studies have shown it to influence treatment decisions (Fagerlin et al. 2007b). However, comparative risk information has been found to make no differences to emotional responses or behavioural intentions (Lipkus et al. 1999).

Furthermore, the cardiovascular age equivalent format should be an effective motivator in reducing risk (Goldman et al. 2006), because in cases where an individual has multiple risk factors, their 'heart age' will be higher than their biological age. In this review, the cardiovascular age equivalent format was assessed by one RCT (Grover et al. 2007). An effect on the reduction of risk factors was found, especially when cardiovascular age was high; but this was only compared against not providing risk information to patients, not against alternative formats.

However, since conducting this review, a randomised trial assessing patients actual risk has been published (Soureti et al. 2010). It compared the traditional percentage format with the cardiovascular age equivalent or Heart-Age analogy format. Perceptions of absolute individual risk and comparative

risk, cognitive evaluation, affective reaction and intention to change lifestyle were assessed. There were no significant differences in individual or comparative risk perceptions between those who received the percentage and Heart-Age formats. However, those who received the Heart-Age format had risk perceptions more consistent with their actual risk. Furthermore, the Heart-Age format had greater emotional impact in younger individuals at higher CVD risk, where they were significantly more worried (p=.005) and were more likely to view it as a 'wake-up' call (p=.004) than those who received the percentage format. Emotional reactions mediated the relationship between risk perceptions and intention to change behaviour, and it was suggested that further research is needed into how to convert modified risk perceptions and emotional reactions into lifestyle behaviour change (Soureti et al. 2010). It is felt that more research should be conducted into the effects of providing cardiovascular age equivalent formats before any firm conclusions can be made regarding the benefits of this analogy format.

The inconsistency found in this review regarding the effect of longer timeframes (such as 15, 20 and 30-years) could be attributed to the fact that individuals are poorly attuned to how risk accumulates over time, are not good at forecasting the future, fail to take account of the timeframes used to represent risk and do not adjust their risk perceptions to account for the longer time spans (Fagerlin et al. 2007a; Kassam et al. 2008; Lipkus 2007; Zikmund-Fisher et al. 2005).

However, a recent focus group study comprising consumer and GP participants asked for preferences for timeframes presenting cardiovascular risk (Hill et al. 2010). It was found that most participants said they preferred knowing their CVD risk within 5-years rather than 10-year risk, as this was seen as being too far away and would act as an 'excuse' to put off making any lifestyle changes, or would not be relevant after a certain age. The GP participants argued for shorter timeframes as well (such as risk calculated over one or two years), as this would be a suitable length of time that would most motivate patients to reduce their risk. They thought that the increase in risk as the patient ages means that the risk calculation becomes bigger and 'too remote' and can become meaningless if calculated over a longer period of time; and also unhelpful in promoting behaviour change or appreciating degree of risk. However, it must be noted that this preference for the 5-year timeframes over 10-years may have been due to the fact that the format examples presented in the focus groups used 5-year time frames (Hill et al. 2010).

The few studies in this review that measured understanding, did so by recall immediately after presentation, self reported confidence or perceived difficulty in understanding (Asimakopoulou et al. 2008a; French et al. 2004; Sorensen et al. 2008; Stovring et al. 2008). A question has to be asked as to whether these methods really do measure a patient's understanding of their risk, or mere recall of information. If this is the case, is there a more suitable way to measure understanding? Furthermore, only a small number of studies in this review used graphical representations, these being mainly bar graphs and

pictograms; and no study compared graphical formats with each other (only graphics used collectively with numeric representation).

This review highlights the tension between providing patients with neutral and unbiased risk information whilst presenting risk in a way that encourages behaviour change and risk reduction. During analysis, a distinction between two types of studies emerged; studies that seemed to use risk communication to achieve risk reduction by modifying lifestyle or taking medication and those that did not. Two studies assessing real patients' risk, communicated risk in order to explicitly 'persuade' and reduce risk. They measured changes in risk factors or overall reduction of risk (Charlson et al. 2008; Grover et al. 2007). Three analogue studies had a persuasive motive as well as they measured intention to change behaviour (Fair et al. 2008; Frileux et al. 2004; Scott and Curbow 2006). Seven studies, six analogue (Goodyear-Smith et al. 2008; Hux and Naylor 1995; Man-Son-Hing et al. 2002; Misselbrook and Armstrong 2001; Sorensen et al. 2008; Stovring et al. 2008) and one using actual risk assessment (Straus 2002) also persuaded to a lesser extent, and measured the acceptance of treatment to reduce cardiovascular risk.

This raises debate as to how legitimate it is to persuade people to make decisions regarding their health, such as changing their behaviour or taking medication, versus providing information. It is sometimes difficult to distinguish between the two. In contrast, three studies, one real (Asimakopoulou et al. 2008a) and two analogue (French et al. 2004; Mason et al. 2008), were concerned only with the emotional and cognitive aspects of

the risk communication, such as what people thought about the risk presentation not how they acted upon it. The difference in outcomes measured by risk communication studies has been highlighted previously (Edwards and Elwyn 1999).

Although more weight should be given to studies involving the assessment individuals' real risk, the results from hypothetical studies included in this review have been more informative about the best ways to communicate risk. More of these studies addressed the main issues associated with cardiovascular risk, such as comparative risk information, comparing one format with another and framing of risk information. However, it must be noted that patients' perceptions of the risks of their disease differ from those participants in studies using hypothetical scenarios (Edwards et al. 2002). Therefore, more research with methodologically sound trials, assessing patients' actual cardiovascular risk that also compare different risk presentation formats need to be conducted before firm conclusions can be drawn as to the most effective ways to communicate cardiovascular risk to patients.

3.6.2 Conclusion

This review demonstrates a lack of well-designed studies in cardiovascular risk communication. This has been due to a combination of diverse methodological quality and contradictory results. It is likely that the

heterogeneity of study characteristics, such as the design, sample and type of cardiovascular risk presented have contributed to this. A wide range of outcomes have been measured and there has been little consistency in risk representation formats used; therefore, it is difficult to draw firm conclusions.

Two different aims were identified in the communication of cardiovascular risk; first, risk communication to influence patient awareness and correct inappropriate risk perceptions to facilitate the decision to reduce risk or not to reduce risk; and second, the impact of different risk reduction strategies to facilitate the decision on *how* to reduce the risk.

3.6.3 Practice implications

There is a need for more research into communication of actual risk to real patients. RCTs comparing different risk representation formats are needed to examine whether peoples' intentions, perceptions and understanding of risk vary by graphical format. Projecting risk over longer time horizons to show increase in risk as the patient ages was attempted in the studies included in this review, but failed to have any desirable impact. It needs to be accepted that patients have difficulty in forecasting their future risk, and more meaningful projections should be used instead of presenting risk in an abstract 10-year horizon. This could be in the form of more salient outcomes and forecasts of loss in the future, such as not being able to achieve important milestones, birth of grandchildren or similar.

Future research needs to present patients with the cardiovascular risk adjusted age format and compare it with other formats; to see whether it is an effective way to demonstrate the magnitude of risk, and whether it is more effective in changing behaviour than other 'more conventional', less meaningful representations. Further investigation into the framing of information regarding the benefits and harms of treatment should also be conducted. Lastly, the provision of comparison risk information that shows baseline risk and puts personal risk into context should be examined in more depth.

Determining how best to present cardiovascular risk information to patients strongly depends on the intended aims of the communication. Is the purpose to raise awareness and improve understanding, or to persuade those at risk to adopt new behaviours to reduce risk? Being clear about the communication aims would help clarify research in this complex area. If communication informs patients of their risk and gently persuades them about the fact that their risk is higher than average due to increased but modifiable risk factors, then it is time to provide neutral and balanced risk information about the impact of modifying risk factors through lifestyle and/or drug treatment, thus reducing their risk. This will free-up the burden on healthcare services and reduce the population incidence of this disease.

3.7 Summary

This chapter has described a systematic review into the effects of presenting cardiovascular risk information to patients. It found little consistency in risk presentation formats, and highlighted the need for better quality trials that compare different risk presentation formats, before conclusions can be drawn as to the most effective ways to communicate cardiovascular risk to patients. It concluded that more attention should be paid to the effective presentation of risk, to help patients reduce risk by lifestyle change or active treatment, instead of directing all the attention to the accuracy of cardiovascular risk prediction.

Chapter 4 - Risk communication literature overview and rationale for conducting a randomised controlled trial of cardiovascular risk representation formats.

4.1 Introduction

This chapter presents an overview of the research that has been conducted in the area of risk communication. It is not a comprehensive review, but a selection of studies demonstrating issues relevant to this thesis, such as framing effects and the differing outcomes resulting from numerical and graphical representation formats. Prominence has been given to the evidence from existing recent systematic reviews and other relevant overviews. The second section of this chapter provides rationale for conducting further research into cardiovascular risk representation formats. It proposes three risk representation formats that should be assessed in a randomised controlled trial (RCT) and suggests the outcomes measures that would be of interest.

4.2 Definition of risk communication

Risk communication in healthcare is defined as communication with individuals (not necessarily face-to-face) which addresses knowledge, perceptions, attitudes or behaviour relating to risk. The communication should include an element of weighing up of risks and benefits of a treatment choice or behavioural risk-reducing change (Edwards and Bastian 2001).

The interpretation of risks varies because communication about risk is usually framed in terms of language of chance or probability (Edwards and Prior 1997). The best method for presenting risk information continues to be an area of considerable debate. Few overall evidence-based recommendations can be suggested for communicating risk magnitudes. This is due to the different outcome measures that have been used to assess the effectiveness of risk communication interventions, inconsistency in the representation formats used, lack of critical tests using RCTs pitting formats against one another, and lack of theoretical progress in identifying why one format should be more effective in a specific context than another (Edwards and Elwyn 2001; Elwyn et al. 1999; Lipkus 2007).

4.3 Type of risk used in risk communication

Risk can be presented in different ways, such as absolute risk, relative risk and comparative risk in relation to peers. This section will describe these in turn.

4.3.1 Absolute and Relative risk

Risk can be presented as an absolute probability (e.g. the chance that a specified event will occur in a specified population over a specific period) and also as relative risk (e.g. the ratio of the risk of disease among those exposed to a risk factor, to the risk among those not exposed). There has been some debate as to which should be used to communicate risk information to patients, as differing effects on risk perceptions, understanding, preferences and treatment decisions have been found.

For example, framing of benefit and risk information in relative versus absolute terms has a major influence on patient preference (Malenka et al. 1993). Additionally, systematic reviews have concluded that relative risk reduction is misleading and more persuasive than absolute risk data (Edwards et al. 2001; Epstein et al. 2004).

When treatment risks and benefits are presented as relative risk reduction, the benefits of the treatments are often overestimated and can lead to an increased willingness to consent, compared to formats that use absolute risk data or other formats, such as numbers needed to treat (NNT) (Gigerenzer 2003).

For example, when relative and absolute forms of presenting risk information about influenza were compared, relative risk information presented on its own led to higher ratings of satisfaction, perceived effectiveness of the vaccination and a greater willingness to have the vaccination. However, absolute risk that presents baseline information (i.e. the predicted number of adult population affect by the flu), led to more accurate probability estimates and more positive evaluations of the risk message.

Furthermore, a recent Cochrane review of different statistical formats for presenting health information concluded that people perceive risk reductions to be larger and are more persuaded to adopt a health intervention when its effect is presented in relative terms (e.g. using relative risk reduction which represents a proportional reduction) rather than in absolute terms (e.g. using absolute risk reduction which represents a simple difference) (Akl et al. 2011).

This demonstrates the importance of presenting baseline risk information to prevent inaccurate perceptions of the absolute size of risk reductions (Natter and Berry 2005). Decisions are often made by making comparisons, and presenting absolute or relative risk in isolation can be criticised for only presenting half of the picture. Therefore, a way of minimising these biased effects is to present absolute and relative risk both together (Edwards and Elwyn 2001).

4.3.2 Comparative risk

Risk information can also be presented as comparative risk; this is the absolute risk of a person of the same age and sex with optimal risk factors (e.g. self versus others). Comparative risk can be helpful in enabling the recipient of the risk communication to interpret the information and make comparisons. However, there is contradictory evidence of the effects of presenting comparative risk information.

For example, it has been demonstrated that providing comparative risk information changes risk perceptions. Participants given comparative risk information about the hypothetical risk of breast cancer were significantly more likely to endorse taking a pill and were more likely to believe the pill provided a significant risk reduction in breast cancer, than those not provided with comparative risk information, even though the risks were equivalent (Fagerlin et al. 2007b).

Additionally, a study into the presentation of absolute and comparative risk of colorectal cancer found that comparative risk information led to an increased

awareness and higher perceived risk, than absolute risk information. However, no influence on emotional reactions and screening intentions was seen, as there were no differences between conditions for how worried, anxious and fearful participants felt about getting colorectal cancer, or intentions to get screened (Lipkus et al. 1999).

4.4 Issues surrounding risk communication

This section describes two issues that influence how risk information is intercepted, understood and acted upon. These are: (1) how the risk information is framed, and (2) the formats used to present the risk.

4.4.1 Framing of risk information

One issue that contributes to the effectiveness of risk communication is how information regarding the probability of an event occurring is framed. Framing is defined as presenting logically equivalent information in different ways (Wilson et al. 1988). Framing includes narrow manipulations of data, such as expressing the risk probability of harm and benefit associated with treatment options, in either positive or negative terms (e.g. a '*10 percent chance of the treatment being beneficial*' compared to a '*90 percent chance that the treatment will be of no benefit at all*') (Epstein et al. 2004).

The way risk information is framed can have significant effects on decisions made in clinical settings. For example, a study by Rothman et al (1993) found that

participants who were given positively framed information regarding skin cancer, such as *'if a cancerous growth is detected, 19 out of 20 growths are less deadly than nonmelonoma'*, were more likely to adopt preventive health behaviour (i.e. attending a skin cancer screening programme), than those given the negatively framed information, such as *'if a cancerous growth is detected, 1 out of 20 growths are the more deadly melanoma cancer'*. It is thought that this was because positively framed information emphasises the gains and advantages that can come from performing the behaviour, in this instance, finding out you do not have deadly nonmelonoma growth (Rothman et al. 1993).

However, negatively framed information can be more persuasive, as the dangers of not performing the behaviour are emphasised. A review into manipulations of information about the harms and benefits of treatment found that negative or loss framing (emphasising the presence of disease) leads to an increased willingness to participate in screening or adhere to treatment (odds ratio 1.18 [95% CI 1.01-1.38]), compared to positive or gain framing (e.g. emphasising the absence of disease); whereas, positive framing leads to unwillingness to participate in screening, and is more effective in persuading people to take risky options (Edwards et al. 2001). Furthermore, a meta-analysis found that loss (negatively) framed appeals are statistically significantly more persuasive than gain (positively) framed appeals for screening behaviours such as breast cancer detection (O'Keefe and Jensen 2009).

Framing effects of presenting information as survival (e.g. chance of survival) as opposed to mortality (e.g. risk of death) have also been found. For example, participants receiving vignettes about a hypothetical treatment framed as a survival

curve graph (e.g. chance of survival over time) were significantly more accurate in their understanding of the information given to them and were more likely to chose the preventative surgery, than those who received mortality curve graph (e.g. the risk of death over time) (Armstrong et al. 2002).

Methods for minimising the effects of framing have been proposed. These include presenting 'balanced' information as 'dual representation', i.e. positive and negative, mortality and survival, or loss and gain data (Wills and Holmes-Rovner 2003). Additionally, using both absolute and relative risk data, and providing comparative frames of reference has been suggested, as this makes the magnitude of the risk easier to judge (Edwards et al. 2002).

4.4.2 Risk representation formats

There are various ways risk information can be communicated to patients. This includes numerical and graphical formats. Although there is no mathematical difference in presenting data as percentages (e.g. *5%*), odds ratios (e.g. *5/100*) or natural frequencies (e.g. *5- in-100*), presentations have different cognitive impact. The format used to convey risk information is important because individuals often do not have *a priori* and stable opinions about risk magnitudes; as such, their beliefs and feelings about risk are likely to be influenced by format (Lichtenstein and Slovic 2006).

Information about risks and uncertainties is not well understood by the majority of people, including experts. The way statistical information is presented is sometimes confusing and can result in statistical innumeracy. This is defined as a difficulty in understanding and combining statistical information effectively, an inability to perform calculations involving percentages and fractions to compare risks, and being unable to comprehend the likelihood of adverse events or favourable outcomes (Dudley 2001; Hoffrage et al. 2000). This can lead to patients making misinformed decisions regarding their treatment or lifestyle choices (Gigerenzer and Edwards 2003).

The different formats for representing risk information vary in the ease that they facilitate understanding. For example, it is thought that percentages (e.g. *40% of people will reduce their risk of heart disease by taking statins*) actually hinder understanding and interpretation, as opposed to natural frequencies (e.g. *4 out of 10 people will reduce their risk of heart disease by taking statin*s) that offer insight, are easier to assimilate and facilitate statistical inferences. Natural frequencies involve Bayesian reasoning and facilitate inferences because they correspond to the way that humans have experienced and have learnt to process information. Also, they refer to the same class of observation and possess implicit information about base rates, which reduces the number of computations required for interpretation (Gigerenzer 2003; Gigerenzer and Hoffrage 1995; Hoffrage et al. 2000).

Support for natural frequencies comes from a focus group study that presented risk reduction estimates of breast cancer mortality from mammography in either frequency formats (i.e. those that present the chance of occurrence as a proportion

of discrete cases over those at risk of an occurrence) or probability formats (i.e. those displaying the chance of occurrence as a percentage). It was found that frequency formats were regarded as simpler and easier to interpret (Schapira et al. 2001).

It is suggested that the misunderstanding and miscommunication of risk information can be minimised by stating the reference class or using alternative formats where the reference class is explicitly stated in all instances, such as natural frequencies (Gigerenzer and Edwards 2003).

4.5 Examples of different risk representation formats

As described above there are a number of ways that risk information can be presented. Research into descriptive words, numerical and graphical formats will be presented in this section.

4.5.1 Descriptive terms

Risk can be communicated using qualitative verbal statements, rather than using numerical probability information. People vary in their preferences for probability information given as words, numbers or both (Wills and Holmes-Rovner 2003). Lipkus (2007) argues that using verbal terms to denote risk allow for fluidity in communication, as they are easy and natural to use. They also express the level, source and imprecision of uncertainly (Lipkus 2007). However, it has been shown

that consultations regarding the communication of cancer risk that used verbal descriptions (e.g. *'there is a possibility that this is prostate cancer')* were regarded as less comfortable, and the information less trustworthy, as opposed to when numerical risk information (e.g. *'there is a 25% chance that this is prostate cancer'*) was used (Gurmankin et al. 2004).

Describing risk magnitudes and benefits of treatments using words is challenging because the words, such as *unlikely, rare* and *probable*, are 'elastic' concepts, have different meanings and are interpreted differently by different people (Wills and Holmes-Rovner 2003). They reflect the communicator's perspective which may be a different order of magnitude to that of the patient. For example, the term 'likely' may mean a chance of 1 in 10 to one person, but a chance of 1 in 2 to another (Pauling 2003).

4.5.2 Numerical formats

Numerical representations of risk information include percentages, odds, natural frequencies and concepts such as NNT (Edwards et al. 2002; Gigerenzer and Edwards 2003). An advantage of using numerical formats to communicate risk information is that they allow for more precision in the risk estimate (Lipkus 2007).

As described previously, it has been shown that health outcomes are better understood and easier to interpret when presented as a natural frequency than a probability (Akl et al. 2011; Gigerenzer 2002). However, some findings are

contradictory. For example, when risk information regarding hypothetical medical trade-off situations (where treatment would decrease the risk of one condition at the expense of increasing the risk of another) was presented as percentages or natural frequencies, accuracy in interpreting the increase or decrease in risk by the treatment was significantly greater when probability information was presented as percentages rather than natural frequencies (Waters et al. 2006). Additionally, a recent RCT found that percentages led to better comprehension than natural frequencies, and concluded that natural frequencies are not the best format for communicating the absolute benefits and harms of treatment (Woloshin and Schwartz 2011).

In a study of three numerical risk representation formats (percentages, natural frequencies or odds ratios), it was concluded that some formats are better for certain mathematical operations than others. For instance, the percentage format is best when people have to sum two risk likelihoods or perform a sequence task; whereas the frequency format is best if people must calculate an increase or decrease in risk by computing a simple multiplication, division or trade-off. Additionally, it was found that overall accuracy of the operations performed was similar for the percentage and frequency formats; whereas, the odds ratio format was significantly more difficult to use, resulting in lower accuracy rates (Cuitie et al. 2008).

Some studies have not shown any differences between risk representation formats. For example, when presenting risk about influenza and the need for vaccination, no differences in how accurate respondents were at interpreting the risk estimates were seen between frequency and percentage formats (Natter and Berry 2005).

Additionally, a web-based RCT examining the effects of different risk formats (such as detailed numerical information that included absolute and relative risk, NNT, anchoring information by matching it to everyday or familiar risks/descriptions, and graphical presentations including bar graphs, thermometer scales, population/ crowd diagrams) in people with diabetes, found no significant effects of the interventions on decisional conflict (e.g. patients' confidence or uncertainty about whether they feel their treatment choice is the best for them personally) or satisfaction with the information. However, the qualitative component of the trial concluded that numerical formats were helpful, with natural frequencies being most preferred (Edwards et al. 2006b).

No consensus in preferences for methods used by clinicians to explain personal risk has been found. Some prefer numbers (mainly percentages and proportions, but rarely odds ratios) and some preferred words. It is concluded that a variety of techniques should be used by clinicians when communicating evidence about diagnosis, treatment, risk and prognosis to patients (Lobb et al. 2003).

Despite the inconsistent evidence for the effects of different risk representation formats on understanding and preferences for different formats, there is still limited research into how different formats affect actual behaviour (Akl et al. 2011).

4.5.3 Graphical risk representation formats

Risk information can be presented graphically such as bar graphs, crowd figures (also known as pictograms or icon arrays), thermometer scales, survival curves and pie charts. Graphical displays can improve understanding of probability information, by attracting attention, showing patterns that might not otherwise be detected, facilitating numerical computations and allowing for faster information processing than is possible with numbers alone (Lipkus and Hollands 1999; Wills and Holmes-Rovner 2003). Furthermore, recent research has demonstrated that risk information presented graphically attracts and holds attention for longer periods of time, and requires relatively little cognitive effort to extract elicit information, leading to better comprehension compared to textual risk information (Smerecnick et al. 2010).

Numerous studies have been conducted into the effects of different graphical risk representation formats. Graphs can affect risk perceptions (Lipkus and Hollands 1999), lead to greater risk aversion (Stone et al. 1997), and are associated with better understanding of risk information (Connelly and Knuth 1998; Epstein et al. 2004).

For example, graphical displays of frequency and probability formats, such as pictograms of human figures and bar graphs have been examined. Human figures presented as pictograms were easy to understand and conveyed a meaningful and contextual message to the numeric information; whereas, bar graphs were perceived as analytical, difficult to understand and having less impact (Schapira et al. 2001).

Additionally, an experiment into the accuracy and speed of processing of the probability of treatment risks and benefits, found that when interpreting 'gross-level information' (i.e. deciding which quantity is larger/smaller), bar graphs and pictograms appear to be best. Conversely, pie charts cause heavier processing burden and result in less accurate perceptions (Feldman-Stewart et al. 2000).

Further support for pictograms comes from a study that presented the benefits of treatment options in one of the six formats (including bar graphs, pictograms and pie charts). Verbatim knowledge (e.g. ability to correctly read numbers from graphs) and gist knowledge (e.g. ability to identify the essential point of the information presented) were measured. Pictograms were trusted by respondents of both high and low numeracy, and were consistently associated with achieving adequate levels of both verbatim and gist knowledge across the numeracy levels. Again, the pie chart was viewed negatively as being least trustworthy (Hawley et al. 2008).

Contradictory to previous research, Timmermans et al (2008) found that pictogram/ population figures were not evaluated as being the easiest format to understand. However, risks presented in this format were evaluated as significantly greater, and were regarded as the most frightening, worrisome and serious, compared to numerical formats (e.g. percentages and frequencies) (Timmermans et al. 2008). Additionally, patients have expressed preferences for simple bar charts, as opposed to other formats including pictograms or pie charts (Edwards et al. 2002).

The lack of consistent evidence in the area of risk communication may be because certain graphs are more suited for specific tasks. For example, a line graph conveys

trends in the data well, whereas divided bar graphs and pie charts are best for conveying proportions. Moreover, if people are asked to evaluate the magnitude of a risk or asked to compare risks, line graphs, bar graphs, histograms and dot charts are likely to lead to greater accuracy in estimation than other graphical formats (Lipkus and Hollands 1999).

It has been suggested that no single graphical format will perform optimally in all situations. The effectiveness of a display will be affected by several factors including the display characteristics (e.g. use of colours, width of lines etc), conditions of presentation (e.g. lighting or time pressure), data complexity (e.g. number of data points or configuration of the display), the task (i.e. purpose), user characteristics (e.g. cognitive styles) and the criterion for choosing the display (e.g. speed of performance or accuracy) (Lipkus and Hollands 1999). Visual representations, such as graphs or pictograms / population crowd figures, may improve the presentation and understanding of risk, although they can be manipulative as well. Therefore, it has been suggested that risk should be presented in the format that is most preferred by the patient (Gigerenzer and Edwards 2003).

There are some disadvantages of graphical risk representation. For example, some graphs are not well understood because they are poorly designed, complex and/or unfamiliar, or individuals may not possess the skills to use and interpret graphs. Additionally, graphs have the potential to mislead by calling attention to certain elements and away from others (such as graphs that present the numerator but not the denominator) (Lipkus 2007; Wills and Holmes-Rovner 2003).

Lipkus and Hollands (1999) suggest that most research using graphs and other visuals to communicate risk has been atheoretical (Lipkus and Hollands 1999). Furthermore, there is little experimental research testing whether the lay people's perceptions and understanding of risk vary by graphical format and whether the addition of graphical displays improves comprehension significantly beyond numerical or narrative translations of risk.

The evidence is contradictory and it is still not clear which format is the most effective in terms of understanding. Furthermore, not much is known about which graphical format is best for patients making medical treatment decisions (Feldman-Stewart et al. 2000).

4.5.4 Expressing treatment risks and benefits

The risks and benefits of different treatment options can be presented in various ways. Such as relative risk reduction (e.g. *a medical intervention results in a 34% relative decrease in the incidence of fatal and nonfatal myocardial infarction)*, absolute risk reduction (e.g. *a medical intervention results in a 1.4% decrease in the incidence of fatal and nonfatal myocardial infarction, 2.5% versus 3.9%*) and number needed to treat (*77 persons must be treated for an average of just over 5 years to prevent 1 fatal or nonfatal myocardial infarction*).

A meta-analysis examined the effects of these formats on people's views towards healthcare decisions. The relative risk format led to more favourable evaluations

towards treatments, than absolute risk reduction or number needed to treat (NNT) format (Covey 2007). Furthermore, when information about treatment benefits regarding a hypothetical disease were presented as NNT, absolute risk reduction (ARR) as natural frequencies, and relative risk reduction (RRR) as percentages, patients were best able to interpret the benefits of treatment when they were presented in the RRR format and accompanied with the baseline risk. NNT was often misinterpreted and it was concluded that this format should not be used in isolation to communicate risks to patients (Sheridan et al. 2003).

Further support for the persuasiveness of the RRR format is demonstrated in a pilot web-based RCT comparing summary statistics for communicating the effects of statins on the risk of coronary heart disease. Information was presented in six formats (RRR, ARR, NNT, event rates, tablets needed to take and natural frequencies). Over half the respondents preferred the RRR format and were significantly more likely to decide to take statins compared with participants who were shown any of the five other summary statistics (Carling et al. 2009b)

Politi et al (2007) concludes that research has not yet identified best practices for communicating harms and benefits of treatment to patients. The best method of presenting uncertainty depends on the task required of the patient and the type of uncertainty presented. Additionally, there is little evidence about the effect of alternate types or presentations of uncertainty on patient understanding, satisfaction, and informed decision making in clinical medicine (Politi 2007).

4.6 Summary

To summarise, the misleading effects of presenting relative and comparative risk information have been described. It has been suggested to avoid presenting relative risk in isolation from absolute risk, or at least to provide baseline risk information. Furthermore, there appears to contradictory evidence as to whether providing people with comparative risk information changes their risk perceptions and behavioural intentions. More research is needed before firm conclusions can be drawn.

Furthermore, it was concluded that the use of purely descriptive terms to communicate risk information should be avoided as there is a high degree of variability in interpretation, and a patient's interpretations of these terms does not correlate with the probabilities they are meant to be conveying. Estimated numbers should be used instead (Pauling 2003), as evidence demonstrates that showing numbers increase trust, comfort and belief in what the physician has said (Gurmankin et al. 2004).

It has been suggested that different numerical formats may facilitate cognitive work of performing mathematical operations needed to comprehend interpreting risk information. There is debate as to whether a frequency format should be used over a percentage format. It was concluded that more attempt should be made to employ strategies that reduce misunderstandings during discussions of treatment options. However, some studies have not found that different numerical representations of risk information result in differing effects.

In relation to graphical representations of risk, there is support that pictograms / population diagrams are easy to understand, convey a meaningful picture and impart knowledge. They have also been shown to have the biggest affective impact in terms of worry, seriousness and evoking fear. In contrast, bar graphs have been viewed as difficult to understand and having less of an impact, whilst pie charts are regarded as least trustworthy. There is a lack of evidence suggesting which graphical risk representation format is best for making medical decisions, and which format best facilities understanding. However, it has been suggested that the impact of the format in which information is delivered may influence medical decisions by first affecting the type and amount of knowledge gained by patients. Lastly, the effectiveness of different graphical risk representation formats may be dependent on numerous factors, such as the level of information that needs to be interpreted from the graphical format.

Finally, the evidence highlights the dangers of potentially misleading patients about the benefits of a treatment, such as providing relative risk reduction information in isolation without absolute risk information. Therefore, it is concluded that it is important when communicating the benefits of treatment to present absolute risk changes, baseline risk, or information regarding numbers needed to treat, as they allow the information to be put into perspective (Covey 2007).

4.7 Rationale for conducting a randomised controlled trial of cardiovascular risk representation formats

This section highlights the risk representation formats that warrant further investigation. This was done by considering the previous literature in risk communication (described above), along with the previous chapters of this thesis describing the critical appraisal in web-based cardiovascular risk prediction tools (Chapter 2) and the systematic review on methods of communicating cardiovascular risk to patents (Chapter 3). This section also explains why these formats should be assessed in a RCT of cardiovascular risk representation formats, and justifies the outcomes that should be measured.

4.7.1 Selection of risk representation formats

Three risk representation formats are proposed that should be further researched and compared in the RCT. These are: bar graph, pictogram and metonym (defined below). Justification for their selection is described.

Bar graph

A bar graph (graphically depicting percentages) should be assessed in the RCT, because previous chapters in this thesis have found that this format is the standard graphical presentation commonly used in cardiovascular risk research and current cardiovascular risk prediction tools. For example, 12 out of 13 cardiovascular risk

prediction tools most likely to be retrieved by internet users searching for online cardiovascular risk assessment, presented risk as percentages, and four out of the six tools that had graphical representation, used the bar graph format to graphically depict risk (Chapter 2). Additionally, the systematic literature review (Chapter 3) found that this format was used in half of the studies that assessed graphical representation. Recent research has found it to be one of the most preferred methods of risk communication (Hill et al. 2010). Therefore, the popularity of this format makes it a good control, enabling a comparison with other formats to see whether the current extensive use is justified.

Pictogram

Pictogram representing cardiovascular risk as natural frequencies should also be assessed in the RCT. The critical appraisal (Chapter 2) found that the format was used in half of the cardiovascular risk prediction tools that used graphical representation. Additionally, this format was found to be the second most commonly assessed graphical representation format in the systematic review (Chapter 3), used in four of the ten studies. Furthermore, past research shows that natural frequencies are better understood by patients and intuitively offer more insight than other formats (Gigerenzer and Edwards 2003; Weinstein 1999). Pictograms help the viewer see the risk in context and facilitate accurate judgements of probability (Lipkus 2007; Pauling 2003). However, more recent research contradicts this suggesting that pictograms can be viewed as confusing or misleading (Hill et al. 2010; Price et al. 2009). Therefore, due to the conflicting research, it was felt that this format should be included in the RCT, so it could be researched further and compared against other

risk representation formats, before any firm conclusions can be made regarding this format.

Metonym

A metonym is a type of metaphor and involves part and whole relations and associations. It is a word for a part of something, used to refer to the whole entity; or the whole is referred to in terms of something associated with it (Knowles and Moon 2006). An example of a metonym is representing heart disease by using the concept of a myocardial infarction. Metonyms are important to everyday life as their concepts structure thoughts, attitudes and actions, as well as language (Lakoff and Johnson 2003).

There are a number of reasons why the metonym may serve as an alternative way of presenting future risk of a disease. Firstly, it is not a numerically-based, precise estimate; but a more qualitative, gist representation. It is argued that gist information, and its bottom-line meaning, is used when making judgements and decision making, such as 'interpreting' risk information, as opposed to verbatim details (Reyna 2008).

Secondly, a metonym could be a way of improving affective forecasting. This is a term used to describe when people imagine themselves in the future. They envisage the external events and outcomes they are likely to encounter, and also contemplate how they will feel when the particular event takes place, such as the kinds of emotions they will experience, as well as the intensity and duration of the emotion

(Buehler et al. 2007). People are poor affective forecasters, as they are not good at predicting the future (Kassam et al. 2008). They find it difficult to place themselves in the future and imagine what it will be like and how they will feel. They are not adept at predicting the intensity and duration of their future emotional reactions, and are routinely wrong about how positive or negative their reactions to future events will be (Wilson and Gilbert 2005). Affective forecasting has implications on people's choices, decisions and behaviours regarding health conditions (Buehler et al. 2007; Halpern and Arnold 2008), such as the decision not to attempt to reduce elevated cardiovascular risk, because of a difficulty imagining what developing CVD would be like the future and how it would feel. Therefore, the metonym may help improve affective forecasting by acting as a striking symbolisation of what the disease encompasses in the future, compared to more conventional risk estimates that use abstract numerical values.

Lastly, the metonym may be beneficial to those with poor numeracy and literacy skills. It is found that patients with low literacy are up to three times more likely to experience a poor health outcome. This includes poorer knowledge, poorer health status, higher morbidity and limited use of health resources (DeWalt et al. 2004). Additionally, patients with poor numeracy and literacy are more likely to suffer from chronic conditions, such as CVD (Safeer et al. 2006).

People with low literacy and numeracy skills have difficulties interpreting risk information, as they have difficulty in understanding the meaning of the numbers that are being conveyed in the risk communication (Keller and Siegrist 2009). This can impair risk communication and affects risk perceptions and medical decisions

(Lipkus and Hollands 1999; Nelson et al. 2008). This could be due to the difficulties faced when using simple decimal places and ratio concepts (including fractions, proportions and probabilities), and can lead to reduced understanding of health-related risk information (Reyna and Brainerd 1994; Reyna and Brainerd 2007). For example, smokers with lower literacy skills are less likely to understand their risk of heart disease and stroke (Strecher et al. 1995). This may be because interpreting risk information involves a hierarchy of skills ranging from calculation, inferences and interpreting tables and charts, which are challenging for those with lower levels of numeracy (Peters et al. 2007). Therefore, less numerate individuals may benefit more from visual communication of risk (Brown et al. 2011; Lipkus and Hollands 1999; Pauling 2003). Furthermore, a review assessing the effects of pictures on health communication found that pictures can increase attention to and recall of health information and can improve comprehension (Houts et al. 2006). Therefore, metonyms presented as pictures are particularly likely to benefit those with low numeracy and literacy skills.

As far as it is known, there are no existing studies that have used the concept of a metonym to present risk information. Therefore, it is felt that this format should be tested in a trial where it could be compared against other more conventional formats, to see whether it is a promising, suitable alternative, and thus improving the communication of risk without reliance on abstract numerical risk estimates.

4.7.2 Outcomes to be measured

This thesis has previously identified the differing aims of risk communication. One aim is to achieve a desired behavioural change in a 'paternalistic' approach, e.g. motivating or persuading people to reduce their cardiovascular risk. The other aim is to facilitate informed choice with greater autonomy for the patient (Edwards and Bastian 2001; Elwyn et al. 1999). This involves informing people of their cardiovascular risk by providing balanced, unbiased information. These aims are distinct and are sometimes not made clear by previous risk communication research. A trial that measures outcomes suitable for assessing risk communication intended for both purposes is needed. For example, a suitable way to assess risk communication that has the aim of motivating behaviour change would be to measure actual behaviour change or intention to change behaviour; whereas, risk communication aiming to inform people of their risk would be suitably assessed by measuring factors such as whether the patient understands their risk, and how the risk information affects them emotionally, such as providing reassurance or evoking worry.

Intention to change behaviour

Numerous psychological theories and theoretical approaches attempt to explain health behaviour and behaviour change. These models are used when designing interventions aimed at encouraging lifestyle modification, or by research interested in measuring behaviour and behaviour change. They comprise a number of different components that are thought to predict health behaviour and behaviour change.

One example is the Theory of Planned Behaviour (TPB) (Ajzen 1991). This is an extended version of the Theory of Reasoned Action (TRA) (Ajzen and Fishbein 1980), which explains behaviour under control of the individual. The TPB additionally attempts to explain the goals, outcomes and behaviours that are not under full volitional control. The TPB postulates that behaviour is determined by a small number of factors: attitudes, subjective norms and perceived behavioural control (Figure 4.1). These belief based measures of the TPB follow the expectancy-value format.

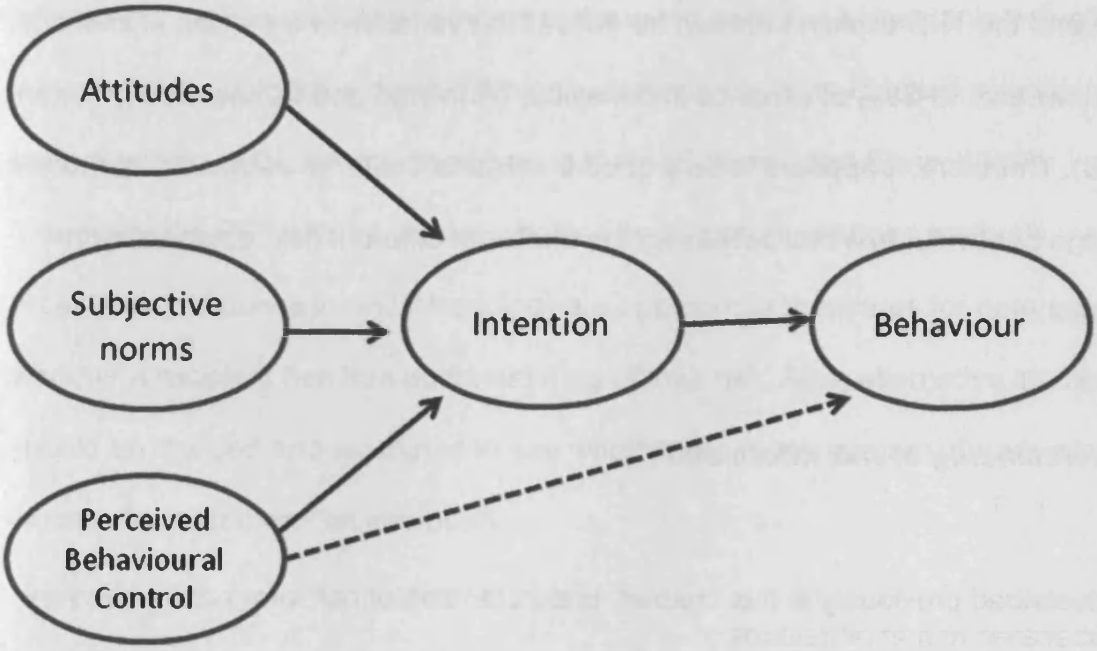


Figure 4.1 Theory of Planned Behaviour Model - Ajzen 1991.

The TPB predicts intention, which is generally regarded as a strong predictor of behaviour, as people tend to engage in behaviours that they plan to perform (Conner and Sparks 2005). In instances where it is not feasible to measure actual behaviours, intention can be an adequate proxy. Intentions capture the motivational factors that influence a behaviour and to indicate how hard people are willing to try, or how much effort they would exert to perform the behaviour (Ajzen 1991).

The TPB has been widely utilised in research and has empirical support for predicting a wide range of behaviours (Armitage and Conner 2001; Godin and Kok 1996). Previous meta-analyses have found the relationships among variables in the TRA and the TPB explain between 39-50% of the variance in behavioural intention, and between 19-38% of variance in behaviour (Armitage and Conner 2001; Sutton 1998). Therefore, it appears to be a good theoretical basis for assessing intention to change behaviour in a trial assessing the effects of different risk representation formats.

Understanding of risk information

As described previously in this chapter, understanding of risk information can vary depending on the risk representation format used to present the risk, and the characteristics of the recipient of the risk communication. Understanding of risk is generally poor (Harris and Smith 2005) and there is evidence to show that the data presented in cardiovascular risk prediction tools is often misunderstood (van Steenkiste et al. 2004a). This can inhibit people from making informed decisions regarding their health and behaviour. There is no consensus as to which format is

most effective in terms of facilitating patient understanding of their risk information (Timmermans et al. 2008); and also what the most appropriate way to measure understanding actually is.

Currently, attempts to measure understanding of risk use recall (i.e. asking participants to repeat the risk information that was presented to them), self-reported confidence in understanding (i.e. asking participants to report how confident they are that they understand the risk information), and perceived difficulty in understanding (i.e. asking participants how difficult they found it to understand the risk information). These may not be the most suitable methods to assess understanding of risk information, as it is unclear whether repetition and personal judgements actually indicate that people have derived the correct meaning of the risk and possess a true understanding of the information given to them (Edwards and Elwyn 1999). Therefore, the RCT should assess whether these commonly used methods (i.e. recall and confidence in understanding) are appropriate measures for determining whether a recipient has true understanding of their risk. Also, alternative methods should be devised and examined to see whether the measurement of understanding of risk information can be improved.

Emotions

Emotion and mood are types of affect. Emotions are relatively intense reactions to stimuli, whereas mood is milder, but a longer lasting experience that influences thoughts and behaviours (Isen 1984). As the concepts of affect, emotion and moods are inter-related there has been an inconsistency in the use of affective-based

terminology by previous research. This has limited the conclusions that can be made regarding the relationship between affect and other constructs such as risk perception (Townsend 2006). Most health behaviour theories fail to consider emotion or affect in the form of 'feelings' as opposed to 'affective judgements' (McCaul and Goetz). However, theorists in risk perception are acknowledging affect and other subjective intrapersonal experiences can influence a person's perceived risk (Loewenstein et al. 2001; Slovic et al. 2004; Slovic et al. 2005).

There is some evidence for the effects of emotion on risk perceptions (van Steenkiste et al. 2004b; Waters 2008). For example, a review of the literature on the influence of emotion and mood on risk perceptions and likelihood estimates of health hazards and life events, found that people are more likely to make optimistic likelihood estimates of a health hazard when they are experiencing positive affective states (such as happiness), and are more likely to make pessimistic likelihood estimates when experiencing negative affect (such as sadness) (Waters 2008). Risk perceptions in turn, can effect health-related behaviours and behavioural intentions (Brewer et al. 2007; Houts et al. 2006).Therefore, emotions are important when considering behaviour relating to the reduction of cardiovascular risk and should be considered an important factor when assessing the effects of cardiovascular risk representation formats.

Worry about future risk of heart disease

'Worry' is a specific emotion and is extremely relevant when thinking about one's future risk of heart disease. It has been associated with risk perception and is referred to as cognition 'coloured by affect' (Constans 2001; McCaul et al. 2007).

Some suggest that worry contains an appraisal of risk elements (such as likelihood and loss) (Tallis and Eysenck 1994) and is not necessarily maladaptive. Specifically, previous research has found that worry positively predicts behavioural intentions (Schmiege et al. 2009). When at high levels, worry can lead to the uptake of screening behaviour (Hay et al. 2006). It has also found to be the strongest predictor of contemplation to quit smoking (Magnan et al. 2009). However, evidence exists for an inverted-U or curvilinear relationship between worry and consequent behaviour (Consedine et al. 2004), where too much worry can lead to the activation of defensive mechanisms, resulting in incoming information being ignored or distorted (Witte 1998).

It is not currently known how much worry is beneficial and would lead to increase in a person's motivation to reduce risk, versus denial of the risk information presented. Therefore, it is important to further research the effects of worry when communicating cardiovascular risk, by investigating the level of worry that induces a positive intention to reduce risk, and whether there is an optimum level before the risk communication process becomes inhibitory.

4.8 Summary

This chapter has highlighted some of the issues that need to be considered when communicating risk, such as framing biases. It provided examples of studies looking into the effectiveness of risk communication, the differing effects of numerical and graphical risk representation formats, and type of risk used in the communication.

Some of the studies into risk communication have been of poor methodological quality, using analogue designs with hypothetical scenarios or relying on unrepresentative convenience samples (such as undergraduate/ student samples), instead of using patients facing real-life risk medical decisions.

The contradictory findings and conflicting evidence regarding the gold standard for communicating health risks to individuals, suggests there is no 'one size fits all' approach to risk communication, and there is no perfect risk communication format that can be applied to all situations. An underlying reason for this may be the important need to establish the goal of the risk communication. Is it to achieve a desired behavioural change in a 'paternalistic' approach (i.e. from a practitioner or population health perspective) or is it to facilitate informed choice with greater autonomy for the patient? (Edwards et al. 2001; Elwyn et al. 1999).

In addition, this chapter has also presented the rationale for conducting a RCT in graphical cardiovascular risk representation formats. It provided justification for the selection of bar graph, pictogram and metonym risk representation formats. It also

justified the important outcome measures that should be assessed, such as intention to change behaviour, understanding of risk information and emotions including worry. The following chapters in this thesis describe the methodology, results and evaluation of the RCT on cardiovascular risk representation.

Chapter 5. Methodology of Web-based Randomised Controlled Trial of the effect of cardiovascular risk presentation formats.

5.1 Introduction

This chapter will describe the methodology of the web-based randomised controlled trial (RCT) on the effects of different cardiovascular risk representation formats on intentions to change behaviour, understanding of risk information, positive and negative affect and worry about future risk of heart disease. The methodology has been written as a protocol paper for BMC Medical Informatics and Decision Making Journal (Waldron et al. 2010). It was peer-reviewed and accepted for publication. A copy of this paper has been presented in Appendix 20.

5.2 Design

RCT with a between-subjects design was used to compare the effect of each risk representation format on the specified outcomes. There were four conditions in total, comprising two intervention groups and two control groups. This was to address the possibility of the Hawthorne effect (Adair 1984) of the four groups, and the effect of thinking about cardiovascular risk before viewing actual risk. Ethical approval was granted by the Medical Dental School Research Ethics Committee at Cardiff University (Appendix 21). The RCT was registered with Current Controlled Trials database (Appendix 22) (Current Controlled Trials ISRCTN91319318).

5.3 Setting

The trial was web-based meaning participation could be done by any person from any location with access to a computer and the internet. This placed no time or locality constraints on respondents as they could participate at their convenience.

5.4 Participant eligibility

Respondents were eligible for inclusion in the trial if aged between 45 and 64 and had not been previously diagnosed with CVD. This was because the risk calculator algorithm was unsuitable for use in a population with existing heart disease, due to the possibility that it would underestimate risk. However, those with hypertension, hypercholesterolemia and diabetes were still eligible. Respondents must also have had access to a computer with the internet, adequate IT skills and the ability to read English.

5.5 Intervention

This web-based trial comprised a cardiovascular risk formatter (predicting future risk of CVD) and on-line questionnaires. The purpose of this tool was to enable the different risk representation formats to be randomly assigned to respondents, creating a platform to measure the outcomes of interest. The risk formatter was available at http://www.myheartrisk.co.uk. It was developed in four steps; the last three steps are described in Chapter 6.

1. Decision made to determine which cardiovascular risk algorithm was used in the trial.
2. Assessment of methods used in current cardiovascular risk prediction tools (Chapter 2), and systematic review of effective methods to communicate cardiovascular risk (Chapter 3), to determine which cardiovascular risk representation formats were used in the trial (described in Chapter 4).
3. Design of selected cardiovascular risk representation formats.
4. Programming of the web-based formatter by website developer.
5. Initial pilot testing and refinement of web-based risk formatter.

5.5.1 Risk calculation used the web-based cardiovascular risk formatter

The web-based risk formatter used the Personal Heart Score (Mainous et al. 2007) to predict an individual's future cardiovascular risk. This assesses 10-year risk of having a CHD event (myocardial infarction, fatal CHD or cardiac procedure). It uses self-reported, non-laboratory measurements such as age, gender, previous diagnosis of hypertension, hypercholesterolemia or diabetes, smoking status, family history of premature CHD (e.g. a parent who was under the age of 50 when they were told by their physician that they had a heart attack), level of physical activity (e.g. exercising or playing sport in leisure time) and BMI. There are slight differences in the risk factors used by the algorithm to predict risk in males and females. For example, BMI is only used in the prediction of risk in females and not males, whereas level of exercise is only assessed in males. A point scoring system

categorises risk into three groups (low risk <10%; intermediate risk 10-20%; high risk >20%) (Table 5.1).

Table 5.1 Personal Heart Score point scoring system.

Risk factor questions	Categories	Male points	Female points
Age	45-49	0	0
	50-54	0	2
	55-59	2	2
	60-64	2	2
Does your family have a history of heart disease?	Yes	2	0
	No	0	0
Has your doctor diagnosed you with any of the following?			
High blood pressure	Yes	1	2
	No	0	0
High Cholesterol	Yes	2	2
	No	0	0
Diabetes	Yes	2	4
	No	0	0
Do you smoke?	Current	2	3
	Former	0	0
	Never	0	0
Do you exercise?	Often/very often	0	0
	Sometimes	0	0
	Seldom/never	1	0
BMI	>30 kg/m2	0	0
	≤30 kg/m2	0	1
Risk category	Low (<10%)	0-2	0-6
	Moderate (10-20%)	3-5	7-9
	High (>20%)	6-12	10-14

It was recognised that other algorithms such as Framingham Risk Score, SCORE or QRISK2 (Conroy et al. 2003; D'Agostino et al. 2008; Hippisley-Cox et al. 2008), provide a more precise risk estimation, especially if they include physiological measurements such as blood pressure. However, it was believed that the Personal Heart Score was most appropriate for the purpose of this study, as it provides an estimation of risk level which could easily be presented in different formats to enable a head-to-head comparison. More importantly, it enables assessment of individuals who have not thought about their cardiovascular risk before and are unaware that they may be at high risk; most of whom are unlikely to have visited a health professional to undergo formal clinical assessment. The website recommended that respondents concerned about their risk were to visit their GP for more formal clinical investigation and before under taking lifestyle changes. Links to useful websites such as the British Heart Foundation were provided.

5.5.2 Risk representation formats used in the web-based cardiovascular risk formatter

As described in Chapter 4, the graphical risk representation formats in this trial were chosen after critically appraising the risk communication methods used by publicly available web-based cardiovascular risk prediction tools (Chapter 2), reviewing how to effectively communicate cardiovascular risk to patients (Chapter 3) and reviewing the past research into risk communication (Chapter 4). For control groups 1 and 2, a bar graph was chosen as it is the risk representation format most commonly used in current risk prediction tools. A pictogram of 100 hearts depicting natural frequencies

of those affected and not affected by CVD was chosen for the first intervention group. A metonym was the risk representation format used in intervention group 2. This is an image representing heart disease by using the concept of a myocardial infarction. The development and pilot testing of the graphical risk representation formats is described in Chapter 6.

5.5.3 Randomisation technique used in the web-based cardiovascular risk formatter

Each time a respondent visited the homepage of the website, the cardiovascular risk formatter called an inbuilt Adobe Acrobat Flash function called *Math.random*. This generated a random number between 0 and 1 that is inputted into an algorithm resulting in a number between 1 and 4 (Appendix 23), which represent the four different conditions of the trial: bar graph with pre-intervention questionnaire (control group 1), bar graph only (control group 2), pictogram (intervention group 1) or metonym (intervention group 2) (see Figure 5.1).

5.6 Procedure

A respondent visiting the website homepage, was allocated to one of the four arms of the trial, ensuring allocation concealment. A 'click to continue' button took the respondent to the subsequent web page which gave participant information and brief details about the study (Appendix 24). Respondents were then asked to indicate their informed consent electronically, and were assessed for eligibility to take part in

the trial. Eligible respondents who gave their informed consent were directed to the cardiovascular risk assessment pages. Following the risk assessment, all respondents were given their risk category (low, moderate or high) and the corresponding percentage figure (<10%, 10-20% or >20%) along with the main comparators, the graphical risk representation formats (bar graph, pictogram and metonym).

5.7 Outcome Assessment

Outcomes were assessed by means of a self-complete on-line questionnaire integrated into the website. The data were collected by an SQL-server database, transferred to Excel spreadsheets and analysed using SPSS version 16 (SPSS Inc, Chicago, IL, USA). The coding document used to create a database in SPSS is presented in Appendix 25. It shows the questions and numerical values assigned to the response options.

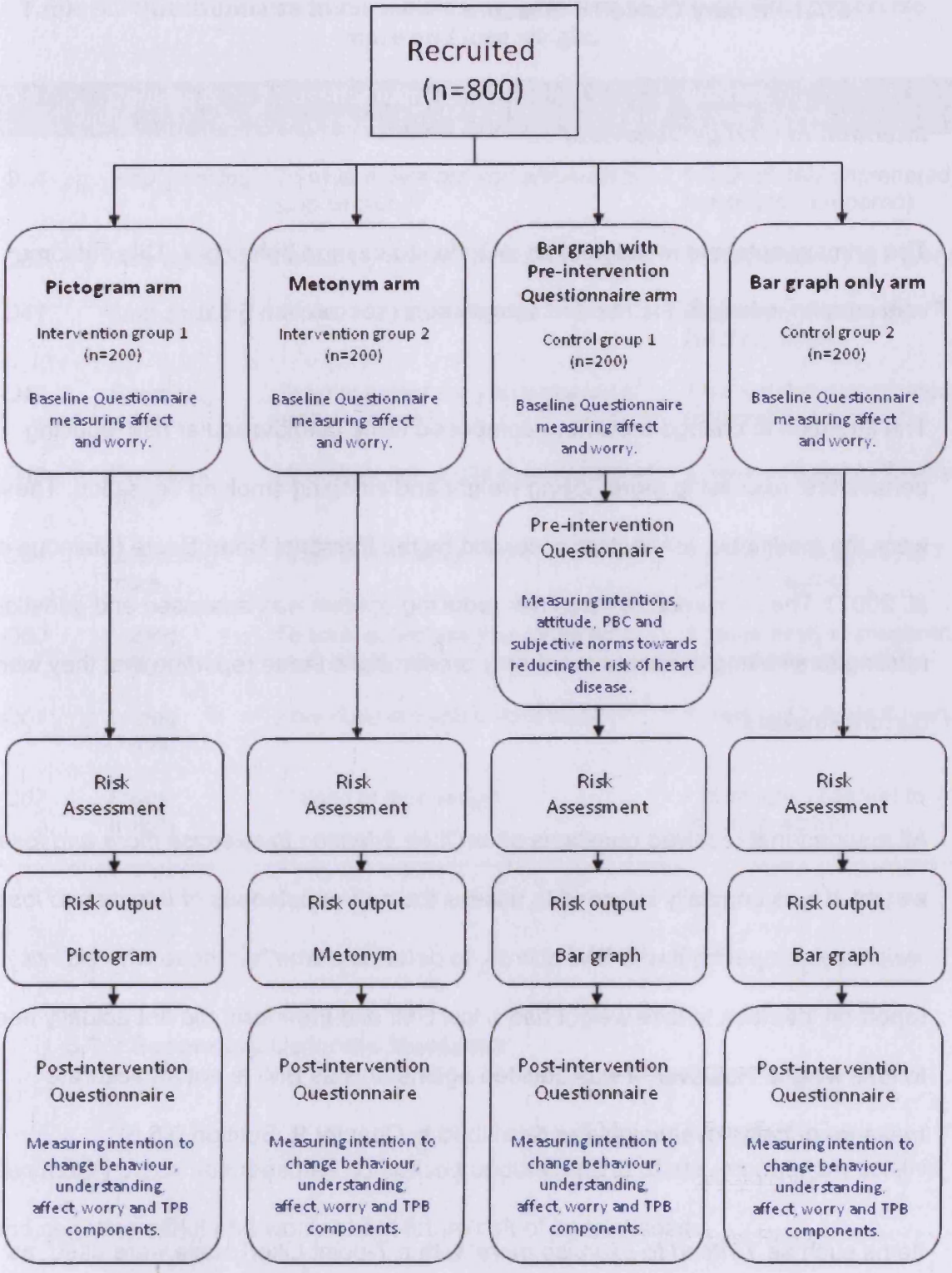


Figure 5.1 Flowchart of the RCT with intervention and control groups.

5.7.1 Primary Outcome Measure

Intention to change behaviour

The primary outcome measure was intention to change behaviour. This outcome was used to calculate the needed sample size (see section 5.8).

The intention to change behaviour comprised three cardiovascular risk reducing behaviours: exercising more, losing weight and stopping smoking cessation. These were the modifiable risk factors assessed by the Personal Heart Score (Mainous et al. 2007). The relevance of these risk reducing options was assessed and questions relating to smoking cessation were only presented to those reporting that they were current smokers.

All respondents received questions about their *intention to exercise more and lose weight*. It was originally intended to assess the appropriateness of *intention to lose weight* by comparing it with BMI scores, to determine whether those who did not report an intention to lose weight had a low BMI and therefore, did not actually need to lose weight. However, it was decided against this as BMI is not an accurate measure of being overweight (as described in Chapter 9, Section 9.5.8).

Items such as *'I intend to exercise more'* with a 7-point Likert scale were used, as shown in Table 5.2. An indirect measure of intention to change behaviour was also assessed, by examining whether individuals take the opportunity to obtain a copy of their risk output suggested to take to their GP (as shown on Appendix 26).

Table 5.2 Questionnaire items measuring intention to stop smoking, exercise more and lose weight.

Q #	Construct	Questionnaire item	Scoring
Q34	*Stop smoking*	*To what extent are you prepared to stop smoking?*	1 (completely unprepared) to 7 (completely prepared)
Q35	*Stop smoking*	*How likely are you to stop smoking?*	1 (very unlikely) to 7 (very likely)
Q41	*Stop smoking*	*I intend to stop smoking.*	1 (strongly disagree) to 7 (strongly agree)
Q47	*Exercising more*	*To what extent are you prepared to exercise more?*	1 (completely unprepared) to 7 (completely prepared)
Q48	*Exercising more*	*How likely are you to exercise more?*	1 (very unlikely) to 7 (very likely)
Q54	*Exercising more*	*I intend to exercise more.*	1 (strongly disagree) to 7 (strongly agree)
Q60	*Losing weight*	*To what extent are you prepared to stop smoking?*	1 (completely unprepared) to 7 (completely prepared)
Q61	*Losing weight*	*How likely are you to lose weight?*	1 (very unlikely) to 7 (very likely)
Q67	*Losing weight*	*I intend to lose weight.*	1 (strongly disagree) to 7 (strongly agree)

5.7.2 Secondary Outcome Measures

Secondary outcome measures comprised understanding of risk information, positive and negative affect and worry about future risk of heart disease.

Understanding of risk information

Items specific to the understanding of cardiovascular risk information were developed for the purpose of this study as no suitable validated scale existed. Items comprised *absolute probability perception*, *subjective understanding of the risk information* and *confidence in understanding the risk information* (Table 5.3). At the data analysis stage, a *level of understanding* variable was calculated by assessing the accuracy of the *probability perception* and *subjective understanding* responses. For example, it was considered that respondents possessed *no understanding* if they incorrectly answered both *probability perception* and *subjective understanding* items; that they possessed *partial understanding* if they correctly answered one of the *probability perception* or *subjective understanding* items; and that they possessed *complete understanding* if both items were correct.

Table 5.3 Questionnaire items measuring understanding of risk information.

Q #	Construct	Questionnaire item	Scoring
Q31	Probability perception	*What are your chances of having a coronary heart disease event in the next 10 years?*	1= I am at low risk 2= I am at moderate risk 3 = I am at high risk
Q33	Subjective understanding	*What should someone in your risk category do to change their risk of heart disease?*	1= Do nothing 2 = Try and do a little 3 = Do as much as they can
Q32	Confidence in understanding	*How confident are you that you have understood the risk information given to you?*	1 (not at all confident) to 7 (v confident

Affect after viewing cardiovascular risk

The Positive and Negative Affect Schedule- Short Form (PANAS-SF) was used (Thompson 2007). This is a 10-item truncated version of the PANAS, which has been well validated and cited in over 2,000 scholarly papers (Watson et al. 1988). It was felt that the original 20-item PANAS would be too time-consuming and cognitively demanding for respondents, which may have led to high dropout rates. Affect was measured at baseline (Table 5.4a), as well as after viewing the risk portrayal (Table 5.4b) to measure within-group changes.

The baseline instructions started with '*Thinking about yourself and how you normally feel, to what extent do you feel....',* with a 5-point Likert scale anchored *'not at all'* to *'extremely'.* This was adapted slightly to make it more logical for post-intervention, e.g. '*At this present moment to what extent do you feel...',* with a 5-point Likert scale anchored '*not at all*' to '*extremely*'.

Table 5.4 Questionnaire items measuring affect and worry about future risk of heart disease.

a. Baseline questionnaire.			
Q #	**Construct**	**Questionnaire item**	**Scoring**
Q 1	Pre PANAS	*To what extent do you feel...* Upset	1 (never) to 7 (always)
Q2	Pre PANAS	*To what extent do you feel...* Hostile	1 (never) to 7 (always)
Q3	Pre PANAS	*To what extent do you feel...* Alert	1 (never) to 7 (always)
Q4	Pre PANAS	*To what extent do you feel...* Ashamed	1 (never) to 7 (always)
Q5	Pre PANAS	*To what extent do you feel...* Inspired	1 (never) to 7 (always)
Q6	Pre PANAS	*To what extent do you feel...* Nervous	1 (never) to 7 (always)
Q7	Pre PANAS	*To what extent do you feel...* Determined	1 (never) to 7 (always)
Q8	Pre PANAS	*To what extent do you feel...* Attentive	1 (never) to 7 (always)
Q9	Pre PANAS	*To what extent do you feel...* Afraid	1 (never) to 7 (always)
Q10	Pre PANAS	*To what extent do you feel...* Active	1 (never) to 7 (always)
Q11	Pre worry	*How worried do you feel about developing heart disease in the future?*	1 (not at all worried) to 5 (very worried)
b. Post intervention Questionnaire.			
Q #	**Construct**	**Questionnaire item**	**Scoring**
Q20	Post PANAS	*At this present moment to what extent do you feel...* Upset	1 (not at all) to 7 (extremely)
Q21	Post PANAS	*At this present moment to what extent do you feel... Hostile*	1 (not at all) to 7 (extremely)
Q22	Post PANAS	*At this present moment to what extent do you feel...* Alert	1 (not at all) to 7 (extremely)
Q23	Post PANAS	*At this present moment to what extent do you feel...* Ashamed	1 (not at all) to 7 (extremely)
Q24	Post PANAS	*At this present moment to what extent do you feel...* Inspired	1 (not at all) to 7 (extremely)
Q25	Post PANAS	*At this present moment to what extent do you feel...* Nervous	1 (not at all) to 7 (extremely)
Q26	Post PANAS	*At this present moment to what extent do you feel...* Determined	1 (not at all) to 7 (extremely)
Q27	Post PANAS	*At this present moment to what extent do you feel...* Attentive	1 (not at all) to 7 (extremely)
Q28	Post PANAS	*At this present moment to what extent do you feel...* Afraid	1 (not at all) to 7 (extremely)
Q29	Post PANAS	*At this present moment to what extent do you feel...* Active	1 (not at all) to 7 (extremely)
Q30	Post worry	*After viewing your results how worried do you feel about developing heart disease in the future?*	1 (not at all worried) to 5 (very worried)

Worry about future heart disease

One item was used to measure this construct, in order to keep the total time needed to complete the questionnaires to a minimum. Again, this trial was interested in changes in worry about future risk of heart disease after viewing risk output, and was measured at baseline (Table 5.4a) and post intervention (Table 5.4b). No previously developed and validated scale regarding worry about future risk of heart disease existed. Therefore, the item was developed by examining previously validated scales relating to other health conditions, such the Lerman Breast Cancer Worry Scale (Lerman et al. 1991) and constructing the item along similar lines e.g. '*How worried do you feel about developing heart disease in the future?*' with a 5-point Likert scale anchored '*not at all worried*' to '*very worried*'.

5.7.3 Tertiary Outcome Measures

The following tertiary outcomes were also assessed. These comprised the sub-components of the Theory of Planned Behaviour (TPB) (Ajzen 1991): attitudes, perceived behavioural control and subjective norms. They measured the three risk reducing options (exercising more, losing weight and stopping smoking). Again, the appropriateness of the risk reducing options was assessed (e.g. omitting intention to stop smoking items to those who do not smoke).

Attitudes

This comprises evaluative (i.e. evaluation using bipolar opposites), instrumental (i.e. whether the behaviour achieves something) and experiential (i.e. how it feels to perform the behaviour) items. An example is *'For me, stopping smoking would be.....'* with a 7-point Likert scale anchored '*pleasant*' to '*unpleasant*', shown in Table 5.5.

Perceived Behavioural Control

Perceived behavioural control (PBC) items relate to either self-efficacy or the controllability of the behaviour. An example of a controllability item is '*Whether I lose weight or not is entirely up to me'* with a 7-point Likert scale to indicate the extent to which the respondent agrees with the statement. An example of a self-efficacy item is '*I am confident that I can exercise more'* with 'very *confident*' to '*not at all confident*' anchored on a 7-point Likert scale (Table 5.6).

Subjective Norms

These relate to the perceptions of the preferences held by significant others about whether one should or should not engage in a specific behaviour. An example is '*I feel under social pressure to lose weight'* with a 7-point Likert scale to indicate the extent to which the respondent agrees with the statement (Table 5.7).

Table 5.5 Questionnaire items measuring attitudes towards stopping smoking, exercising more and losing weight.

Q #	Construct	Questionnaire item	Scoring
Q37	*Stop smoking*	*For me stopping smoking would be... Bad/ Good.*	-3 (Bad) to +3 (Good)
Q38	*Stop smoking*	*For me stopping smoking would be... Harmful / Beneficial.*	-3 (Harmful) to +3 (Beneficial)
Q39	*Stop smoking*	*For me stopping smoking would be... Unpleasant / Pleasant.*	-3 (Unpleasant) to +3 (Pleasant)
Q50	*Exercising more*	*For me exercising more would be...* a negative thing to do / a positive thing to do.	-3 (Negative) to +3 (Positive)
Q51	*Exercising more*	*For me exercising more would be...* Unenjoyable / Enjoyable.	-3 (unenjoyable) to +3 (Enjoyable)
Q53	*Exercising more*	*For me exercising more would be...* Useless / Useful.	-3 (Useless) to +3 (Useful)
Q63	*Losing weight*	*For me losing weight would be...* the wrong thing to do / the right thing to do.	-3 (Wrong thing) to +3 (Right thing)
Q64	*Losing weight*	*For me losing weight would be...* unsatisfying / Satisfying.	-3 (Unsatisfying) to +3 (Satisfying)
Q65	*Losing weight*	*For me losing weight would be...* Unhelpful / Helpful.	-3 (Unhelpful) to +3 (Helpful)

Table 5.6 Questionnaire items measuring perceived behavioural control over stopping smoking, exercising more and losing weight.

Q #	Construct	Questionnaire item	Scoring
Q40	Stop smoking (self-efficacy)	*For me stopping smoking would be... Difficult / Easy.*	-3 (Difficult) to +3 (Easy)
Q45	Stop smoking (self-efficacy)	*I am confident that I can stop smoking.*	1 (strongly disagree) to 7 (str agree)
Q42	Stop smoking (controllability)	*Whether I stop smoking or not is entirely up to me.*	1 (strongly disagree) to 7 (str agree)
Q44	Stop smoking (controllability)	*The decision to stop smoking is beyond my control.*	1 (strongly disagree) to 7 (str agree)
Q52	Exercising more (self-efficacy)	*For me exercising more would be...* Difficult / Easy.	-3 (Difficult) to +3 (Easy)
Q58	Exercising more (self-efficacy)	*I am confident that I can exercise more.*	1 (strongly disagree) to 7 (str agree)
Q55	Exercising more (controllability)	*Whether I exercise more or not is entirely up to me.*	1 (strongly disagree) to 7 (str agree)
Q57	Exercising more (controllability)	*The decision to exercise more is beyond my control.*	1 (strongly disagree) to 7 (st agree)
Q66	Losing weight (self-efficacy)	*For me losing weight would be...* Difficult / Easy.	-3 (Difficult) to +3 (Easy)
Q71	Losing weight (self-efficacy)	*I am confident that I can lose weight.*	1 (strongly disagree) to 7 (str agree)
Q68	Losing weight (controllability)	*Whether I lose weight or not is entirely up to me.*	1 (strongly disagree) to 7 (str agree)
Q70	Losing weight (controllability)	*The decision to lose weight is beyond my control.*	1 (strongly disagree) to 7 (str agree)

Table 5.7 Questionnaire items measuring subjective norms to stopping smoking, exercising more and losing weight.

Q #	Construct	Questionnaire item	Scoring
Q36	Stop smoking	*Most people who are important to me think that I... should not stop smoking / should stop smoking.*	3 (should not) to +3 (should)
Q43	Stop smoking	*I feel under social pressure to stop smoking.*	1 (strongly disagree) to 7 (strongly agree)
Q46	Stop smoking	*It is expected of me to stop smoking.*	1 (strongly disagree) to 7 (strongly agree)
Q49	Exercising more	*Most people who are important to me think that I... should exercise more/ should not exercise more.*	-3 (should not) to +3 (should)
Q56	Exercising more	*I feel under social pressure to exercise more.*	1 (strongly disagree) to 7 (strongly agree)
Q59	Exercising more	*It is expected of me to exercise more.*	1 (strongly disagree) to 7 (strongly agree)
Q62	Losing weight	*Most people who are important to me think that I...* Should not lose weight / Should lose weight.	-3 (should not) to +3 (should)
Q69	Losing weight	*I feel under social pressure to lose weight.*	1 (strongly disagree) to 7 (strongly agree)
Q72	Losing weight	*It is expected of me to lose weight.*	1 (strongly disagree) to 7 (strongly agree)

Pre-intervention questionnaire given to control group 1

Those in the bar graph and pre-intervention questionnaire group (control group 1) (see Figure 5.1) also completed a questionnaire before viewing their cardiovascular risk. This was a partially parallel version of the post-intervention questionnaire (Table 5.8, enabling an assessment of the Hawthorne effect of the four groups, and a

comparison of those who are asked to think about their cardiovascular risk and provide their baseline intentions to reduce this, against those who are not. However, to keep the total number of items to a minimum, the focus was on reducing overall cardiovascular risk, instead of specific behaviours that lead to risk reduction.

Theory of Planned Behaviour Item construction

Items relating to cardiovascular risk reduction were developed using guidance from the Manual for constructing questionnaires based on the TPB from the Centre of Health Services Research, University of Newcastle (Francis et al. 2004). It was developed to assist psychologists and non-psychologists produce an effective questionnaire to measure TPB constructs. The manual integrates advice from previous literature on the TPB and has gone through a process of extensive reviewing and trialling (Francis et al. 2004).

This manual was chosen as it has been widely used in previous research that has required TPB questionnaire development (Frosch et al. 2008; Giles et al. 2007; Tavousi et al. 2009). Additionally, it also demonstrates a way of measuring the TPB constructs directly, as opposed to indirectly. Direct measures assess intention by using three generalised intention items and three predictor variables. This is sufficient if the purpose of the research is to predict the variance in behavioural intentions (as with this trial). However, if the research seeks to identify specific beliefs that contribute to the predictor variables, indirect measures are needed as well. For example, the research would need to measure behavioural beliefs and

outcome evaluations for the attitude component; normative beliefs and motivation to comply for the subjective norms component; control beliefs and influence of control beliefs for the perceived behavioural control component (Francis et al. 2004).

Table 5.8 Pre-intervention questionnaire items measuring risk perception, intention to reduce future risk of heart disease and sub-components of TPB.

Q #	Construct	Questionnaire item	Scoring
Q12	Pre risk perception probability	*I think my risk of heart disease in the next 10* years is..	1 = low 2= moderate 3= High
Q13	Pre intention to reduce heart disease	*I want to reduce my risk of heart disease.*	1 (strongly agree) to 7 (strongly disagree)
Q15	Pre subjective norms	*People who are important to me want me to reduce my risk of heart disease.*	1 (strongly agree) to 7 (strongly disagree)
Q14	Pre perceived behavioural control (controllability)	*The decision to reduce my risk of heart disease is mostly up to me.*	1 (strongly agree) to 7 (strongly disagree)
Q16	Pre perceived behavioural control (self-efficacy)	*Reducing my risk of heart disease would be Easy / Difficult.*	-3 (easy) to +3 (difficult)
Q17	Pre attitudes	*Reducing my risk of heart disease would be Rewarding/Unrewarding.*	-3 (rewarding) to +3 (unrewarding)
Q18	Pre attitudes	*Reducing my risk of heart disease would be Undesirable / Desirable.*	-3 (undesirable) to +3 (desirable)
Q19	Pre attitudes	*Reducing my risk of heart disease would be Worthless / Worthwhile.*	-3 (worthless) to +3 (worthwhile)

Direct measures also have the advantage of reducing the number of items in the questionnaire, and thus keeping the cognitive demand of the participants to a minimum, reducing the possibility of drop-out (attrition). Furthermore, recent research has demonstrated no difference in direct and indirect measures of the TPB in predicting teaching behaviour, where the proportion of variance of the behaviour that was accounted for was 24% for the direct measures and 23% for the indirect measures (Jeong 2011).

Questionnaire scoring

In accordance with guidelines from Francis et al 2004, items where the response format completes an otherwise incomplete sentence (e.g. I should not / I should) comprised a mix of positive and negative endpoints (Francis et al. 2004). Therefore, at the data analysis stage, items with negatively worded anchors to the left of the scale were re-coded by reversing their scores using the *transform vales* function in SPSS. These items were pre-intention to reduce heart disease, pre-subjective norms, pre-perceived behavioural control, pre-attitudes, stopping smoking PBC (controllability), exercising more PBC (controllability), losing weight PBC (controllability).

Furthermore, it was suggested that bipolar items, defined as evaluative questions with pairs of opposites, are scored -3 to +3, as opposed to unipolar items requiring the respondent to make a judgement about the probability that the item is true, which are scored 1 to 7 (Francis et al. 2004). This enables a score of zero to represent a neutral opinion, negative scores to represent views against the behaviour, and

positive scores to represent views in favour of the behaviour. The bipolar items were pre-PBC (self-efficacy), stopping smoking PBC (self-efficacy), smoking subjective norm, exercising more PBC (self-efficacy), exercising more subjective norm, losing weight PBC (self-efficacy), losing weight subjective norm. However, at the data analysis stage these scores had to be converted into 1 to 7 to make a calculation of the mean score possible. This was because there were other items measuring the same components that were unipolar. Therefore, a higher score on the 1 to 7 scale indicated a more positive opinion towards the behaviour.

To address possible response bias occurring from fatigue, items measuring the different outcomes and components of the TPB were mixed up in the questionnaire, with exception of the primary outcome which was always posed first, as recommended by Ajzen (Ajzen [no date]). This is demonstrated in the SPSS database coding document (Appendix 25).

At the data analysis stage the mean intention, attitudes, perceived behavioural control and subjective norm scores were calculated, so that higher scores represent a greater intention to perform the target behaviour, more positive attitude towards the targeted behaviour, a greater level of control over the targeted behaviour, a greater social pressure to do the targeted behaviour.

5.7.3 Other data collection

Other data collection comprised:

- *Respondent characteristics* (risk category, gender, age, family history of heart disease, diagnosis of hypertension, hypercholesterolemia, diabetes, smoking status, physical activity status, height and weight for BMI calculation and whether the respondent requests an electronic copy of their risk output for their GP).
- *Web logs* examining how long respondents took to complete the study and how long they spent on each page.

5.8 Sample size calculation

For simplicity, the sample size calculation was based on a comparison of means, though the analysis recognises the ordinal nature of the data. It was hard to speculate on the difference between the groups and so the sample size was based on comparing two groups on the primary outcome measure (intention to change behaviour); this gave a group size which was used for all the groups. It was proposed that recruitment continue until 800 respondents (200 in each group) completed the trial. The likely uptake rate was unknown and a number of the recruitment methods were implemented (see section 5.10). Based on a study that used a similar Likert Scale scoring system for a different risk context (Wright et al.

2008), the scores on intention to change behaviour within a group should have an SD of about 1.5. Therefore, it was calculated that the total sample size in each group of 200 would then be sufficient to detect a difference of 0.5 point between two groups, with 90% power and significance value of α= 0.05.

5.9 Analysis

The results were stored on a SQL database and fed back to the researcher via the server that hosted the website. The data was stored on the shared drive, and was password protected; only accessible to the researcher. Data was retrieved, coded and inputted into computer software. Microsoft Office Excel 2007 was used for data manipulation and SPSS version 16 for the main data analyses. The trial was reported according to Consolidated Standards of Reporting Trials (CONSORT) guidelines (Schulz et al. 2010).

5.9.1 Plan of analysis

Descriptive statistics were presented to summarise baseline characteristics of the study sample. Continuous variables such as age and level of cardiovascular risk were summarised using mean and SD and/or median and quartiles. Binary variables such as gender and whether the respondent requested an electronic copy of their risk output were summarised by counts and proportions. Summary statistics were obtained for the study population as a whole and for the four randomised groups.

The main analyses of efficacy relate to the primary outcome measure: *intention to change behaviour,* and the secondary outcome measures: *understanding of risk information*, *affect* and *worry about future heart disease*. Summary statistics for the four groups were presented. The four groups were first compared on an equal footing using one-way ANOVA. The three selected pairwise contrasts between the specified groups were constructed (e.g. bar graph only v. pictogram; bar graph only v. Metonym; bar graph and pre-intervention questionnaire v. bar graph only).

Several secondary analyses were performed. For the bar graph and pre-intervention questionnaire group (control group 1), paired analyses were used to assess serial changes in outcome measures between pre- and post-intervention questionnaires.

A multiple regression model was used to look for correlations between risk category on *intention to change behaviour*, *understanding of risk information* and post *worry about future heart disease* outcomes, to see if responses were mediated by risk category. The model was also used to assess the correlational validity between *intention to change behaviour, worry about future heart disease* and *understanding of risk information*; to determine what level of worry increases intention to change behaviours and whether understanding also results in appropriate intentions. The subcomponents of the TPB (attitudes, perceived behavioural control and subjective norms) were also examined, to see if they predicted intention to change behaviour (in order to test the efficacy of the TPB in predicting cardiovascular-related behaviour change).

The direct and indirect measures of *intention to change behaviour* were correlated, to see whether those who report that they intend to change their behaviour actually take the opportunity to obtain their risk results to take to their GP. Furthermore, a correlation between accurate *understanding of risk information* and *confidence in understanding* was conducted. Lastly, paired T-tests compared baseline and post-intervention *affect* and *worry about future heart disease* scores, to determine whether scores generally decreased after viewing the risk representation formats, or increase demonstrating a possible negative emotional impact.

For all analyses, point estimates and confidence intervals were obtained, as well as p-values. In the event of substantial departure from Gaussian distributional form, transformation of scale and/or analogous non-parametric methods were considered.

5.9.2 Comparisons

There were two main comparisons:

1. (a) Bar graph only v. Pictogram
   (b) Bar graph only v. Metonym

This enabled a head-to-head comparison of the outcomes resulting from the different risk representation formats as shown in Figure 5.2.

2. Bar graph and pre-intervention questionnaire v. Bar graph only

Responses from viewing the bar graph and completing the baseline questionnaire were compared with those from viewing the bar graph only. Additionally, within group changes between baseline and post-intervention questionnaires were analysed in the group who completed both questionnaires (control group 1).

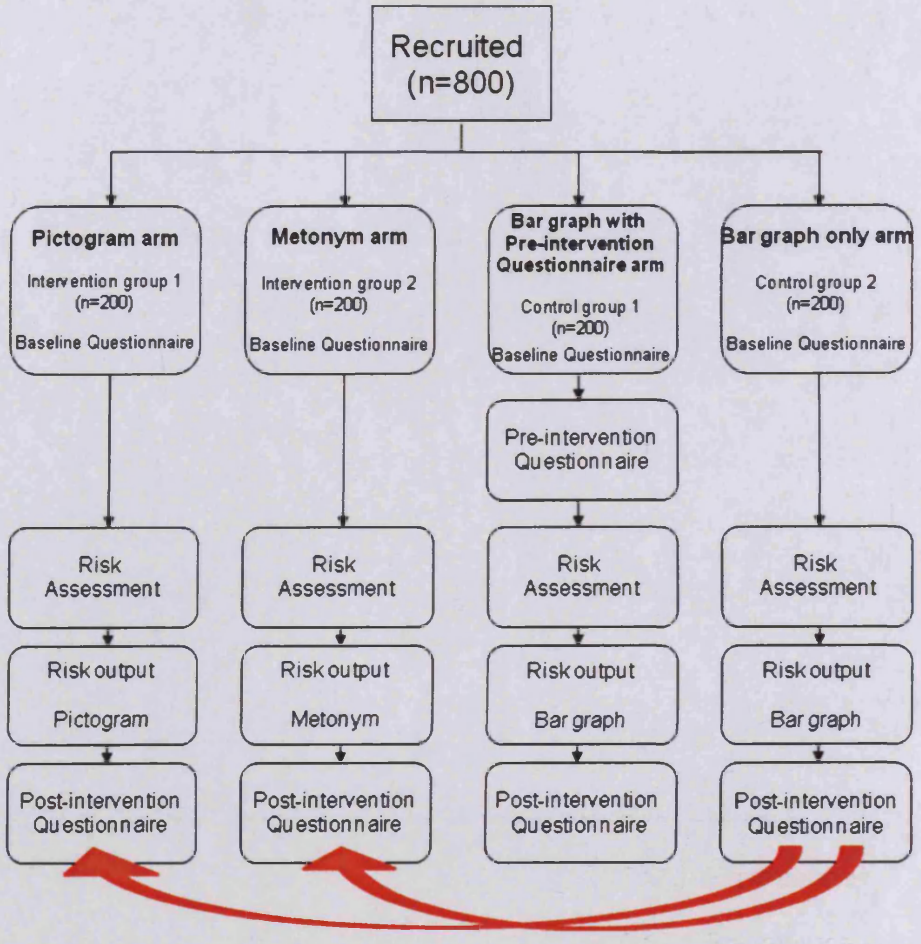


Figure 5.2 Comparison of Bar graph only v. Pictogram and Bar graph only v. Metonym conditions.

The two control groups were compared (e.g. control group 1 comprising a bar graph format and pre-intervention questionnaire, and control group 2 comprising a bar graph without questionnaire) to assess the Hawthorne effect of the questionnaire on reducing cardiovascular risk. It was expected that answering the questionnaire and consequently thinking about cardiovascular risk before viewing actual risk, would itself encourage intention to change behaviours in order to reduce cardiovascular risk. See Figure 5.3 for diagrammatical representation of these comparisons.

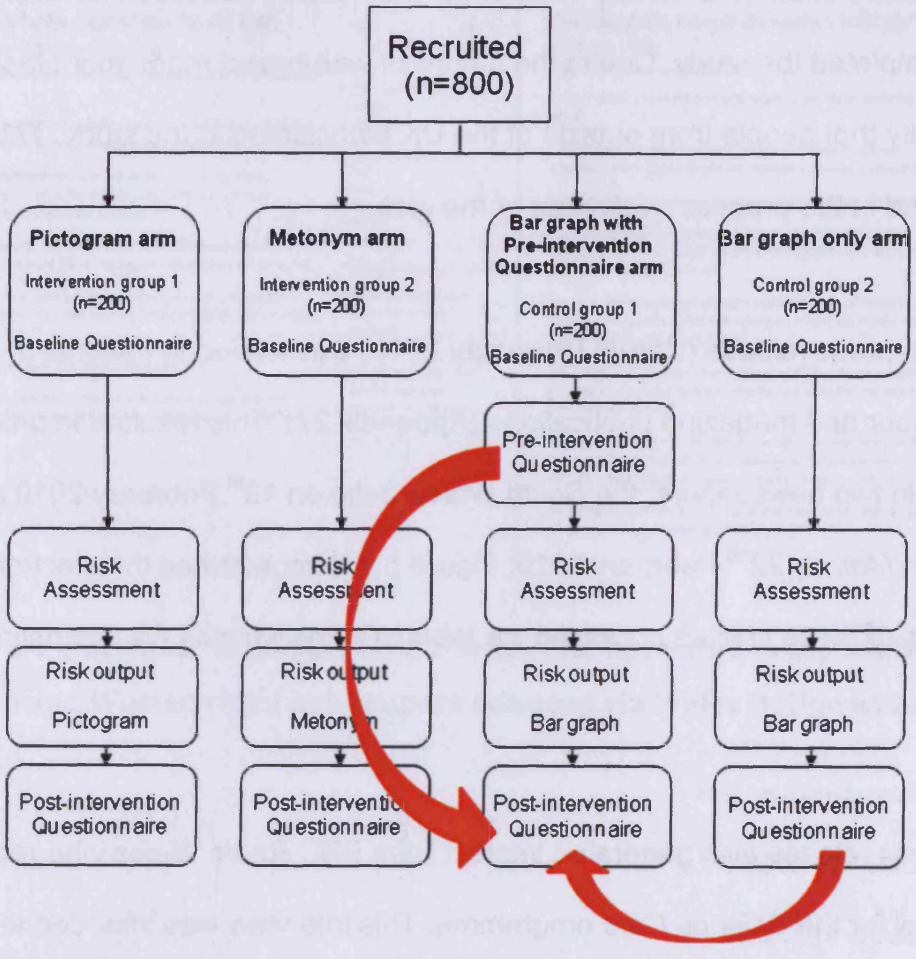


Figure 5.3 Comparison of Bar graph and pre-intervention questionnaire v. Bar graph only conditions.

5.10 Recruitment strategy

Respondents were invited to take part in the study using a number of methods: emails to educational institutions, co-operation with large organisations where the workforce has access to a computer; social networking websites (such as *Facebook),* emails to personal contacts and advertisements in the form of pocket sized cards and posters. In order to maximise publicity about the trial, it was promoted by offering to donate £1 to the British Heart Foundation for every person who completed the study. Due to the nature of web-based recruitment there was a possibility that people from outside of the UK participated in the study. This was examined in the process evaluation of the trial.

Firstly, a press release (Cardiff University 2010) was issued to national and local newspaper and magazine publications (Appendix 27). This resulted in articles being printed in two newspapers, the *South Wales Echo* on 13th February 2010 and the *Western Mail* on 22nd February 2010. Figure 5.4 demonstrates the electronic versions of these articles accessed via *Wales Online* website (Wales online.co.uk 2010).

The press release also generated interest from BBC Radio Wales who requested an interview for the *Science Cafe* programme. This interview was intended to promote the study and provide the website address. Figure 5.5 shows the Science Cafe programme synopsis, which included a hyperlink to the myHeartRisk website (BBC.co.uk 2010). The interview was aired on 21st February 2010. Additionally, a

web blog (Appendix 28) entitled *What's your Heart Risk? (Healthy 2010)* was written for *Healthy Magazine* (an on-line publication by the company *Holland and Barrett*, a health food retailer).

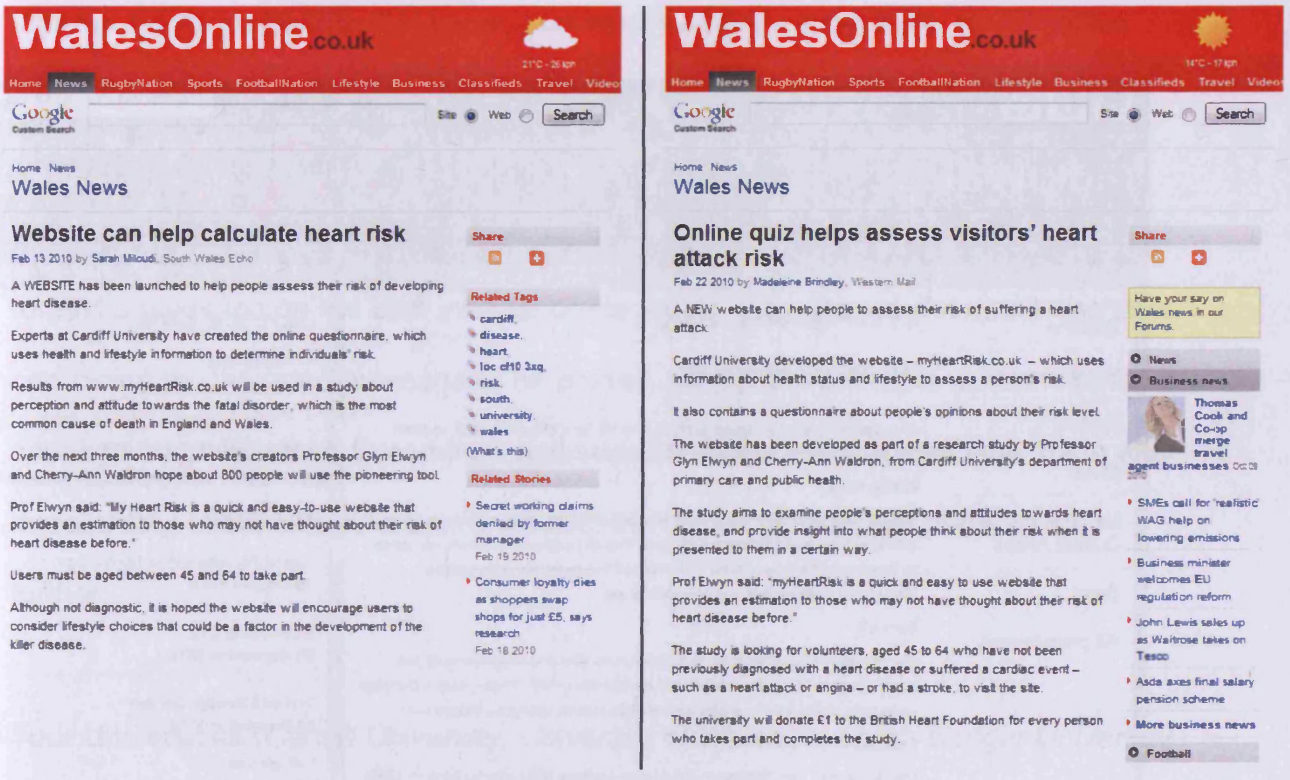


Figure 5.4 Electronic versions of the articles that appeared in the South Wales Echo and Western Mail newspapers accessed via Wales Online website.

Secondly, a mail shot of A5 sized posters and pocket-sized cards (Appendix 29) were sent to 21 Libraries and 20 Adult Learning and Community Centres in the local area, with a letter asking permission for them to be placed in display areas. It is not

possible to determine how many of the libraries and centres actually displayed the promotional material as no follow up was made. The posters and cards were also distributed in public places, including Leisure Centres, Gyms and a Football stadium.

Figure 5.5 BBC Radio Wales Science Cafe Programme Synopsis.

Furthermore, 14 Universities in Wales and South West / South East England were contacted to see if a message could be posted on the staff intranet notice boards (*Cardiff University; Swansea University; University of Glamorgan; Swansea Metropolitan University; Bangor University; University of Wales Institute Cardiff; Aberystwyth University; University of Wales Newport; Bristol University; University of West of England; Reading University; University of Gloucestershire; Buckingham New University and Thames Valley University*). A telephone call was made to the University switchboard asking to be put through to the IT or Information Services departments. The details of the study were explained and permission was requested to post a message on the staff intranet or electronic notice board. An email was sent containing the intended message to be posted. Numerous attempts were made to speak to the relevant staff members and departments. If no progress was made after three or four telephone calls and/or emails, the University was not perused any further.

Four Universities (*Cardiff University; University of Wales Newport; Bangor University and University of Glamorgan*) obliged and allowed a posting to be made. However, one University (*University of Glamorgan*) posted a message on their staff intranet but retracted it approximately three hours later, when it was suggested that the study would need ethical approval from their Ethics Committee before the message could be re-posted. Due to time constraints this was not sought. Upon assessing the responses to the question asking where respondents had heard about the study, there was no evidence of anybody participating from one of the Universities (Bangor University), so it cannot be certain that a message actually got posted on that notice board. Additionally, one University (*University of Gloucestershire*) did not allow a

message to be posted on their notice board, but did send an email to staff in their Public Relations department. An example of a posting on a University electronic notice board is shown in Figure 5.6.

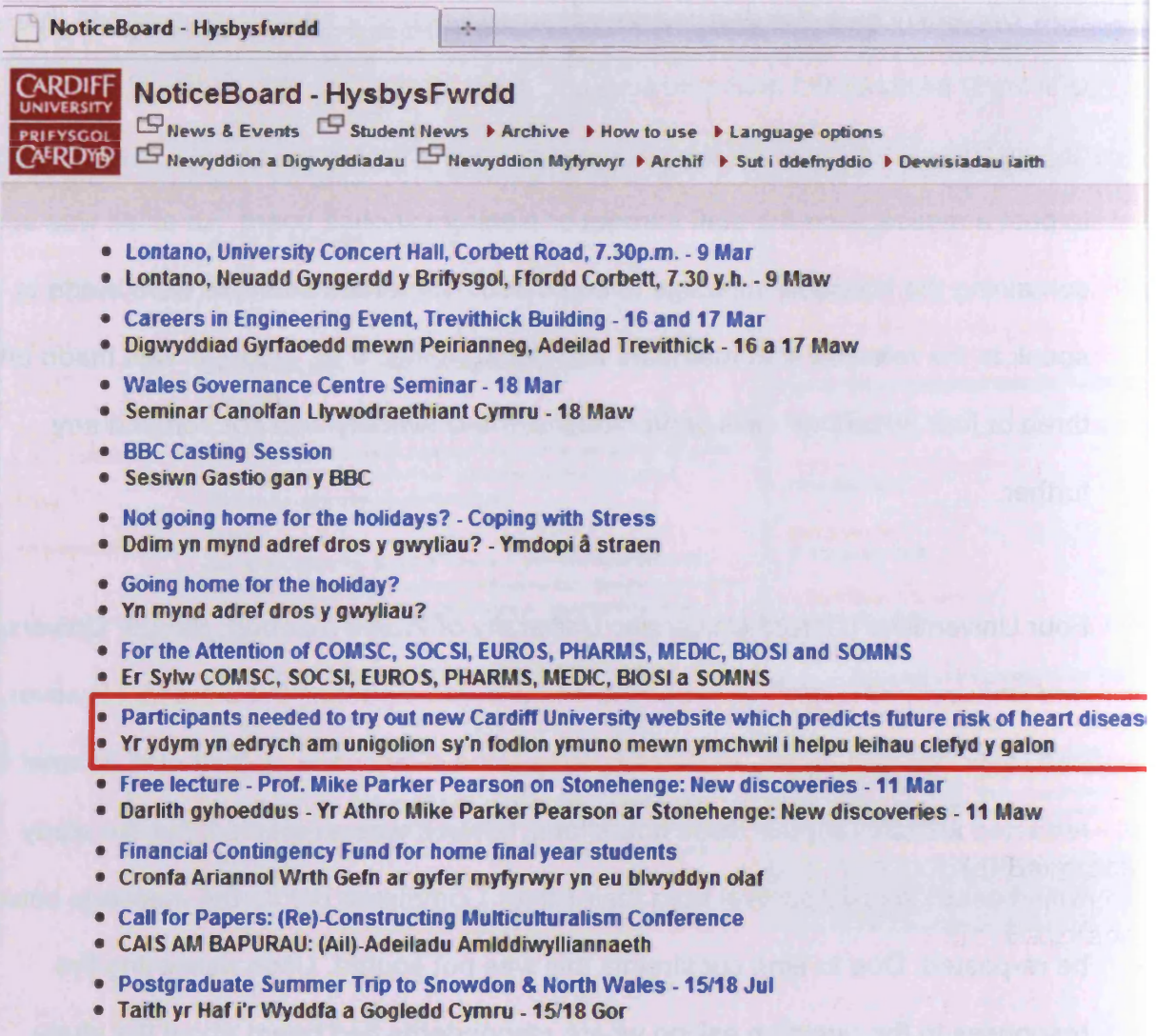


Figure 5.6 Posting on Cardiff University electronic notice board.

Another method of recruitment was Social Networking. This included *Facebook (www.facebook.com), Twitter (www.twitter.com),* on-line discussion forums dedicated to users over 50 years of age, and social bookmarking sites (where users save links to websites they wish to share with other users). MyHeartRisk *Facebook* group was created (Figure 5.7) which promoted the study and provided a hyperlink to the website. People were invited to join to group, who in turn invited their friends to join, raising awareness of the study and enabling interested users to participate. *Twitter* (where users communicate to their followers using 140 characters known as *Tweets*) was also used to promote the study. Known *Twitter* users were asked to *Tweet* about the study and requested their followers to re-*Tweet* the message, which disseminates the message to other users in a snowballing effect. An example of a *Tweet* posted by a *Twitter* user is shown in Figure 5.8. Figure 5.9 provides further examples of *Tweets* and re-*Tweets* made by a selection of *Twitter* users.

On-line discussion forums were also targeted, in particular those designed for an audience of people over the age of 50. In order to comment in the discussion boards, one must become a member. Once membership has been granted, a user is free to start a new discussion on a certain topic or comment on an existing thread of conversation. The discussion board is split into different sections such as health, money, chat, travel etc. Eight forums designed for users over 50 years of age were joined (*Age Concern Baby Boom Bistro; SagaZone; 50 Connect; Over50s forum; My Prime; Not Dead Yet; Caerphilly 50+ forum; I Don't Feel 50 forum*).

Figure 5.7 myHeartRisk Facebook group.

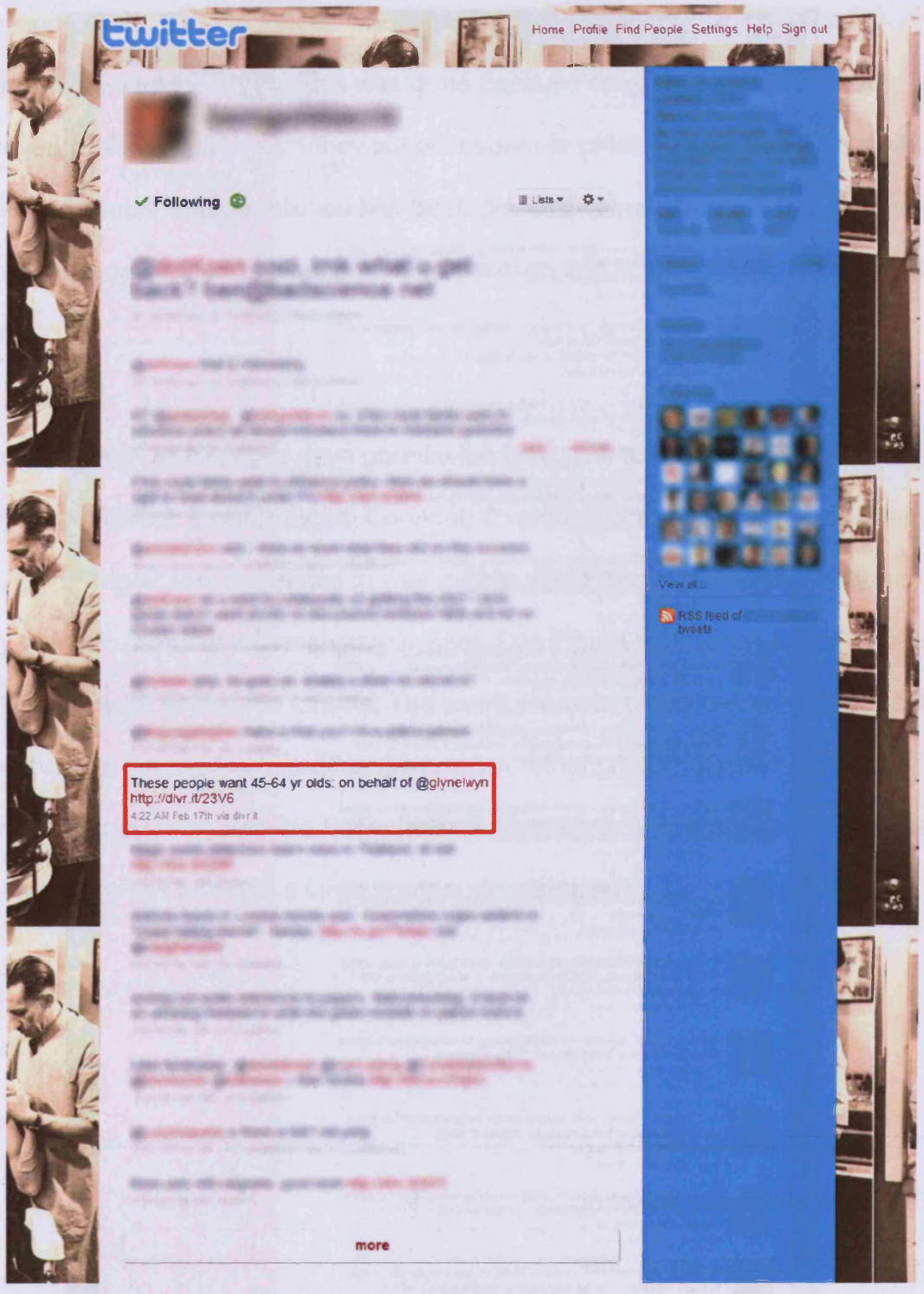


Figure 5.8 A *Tweet* from a *Twitter* user.

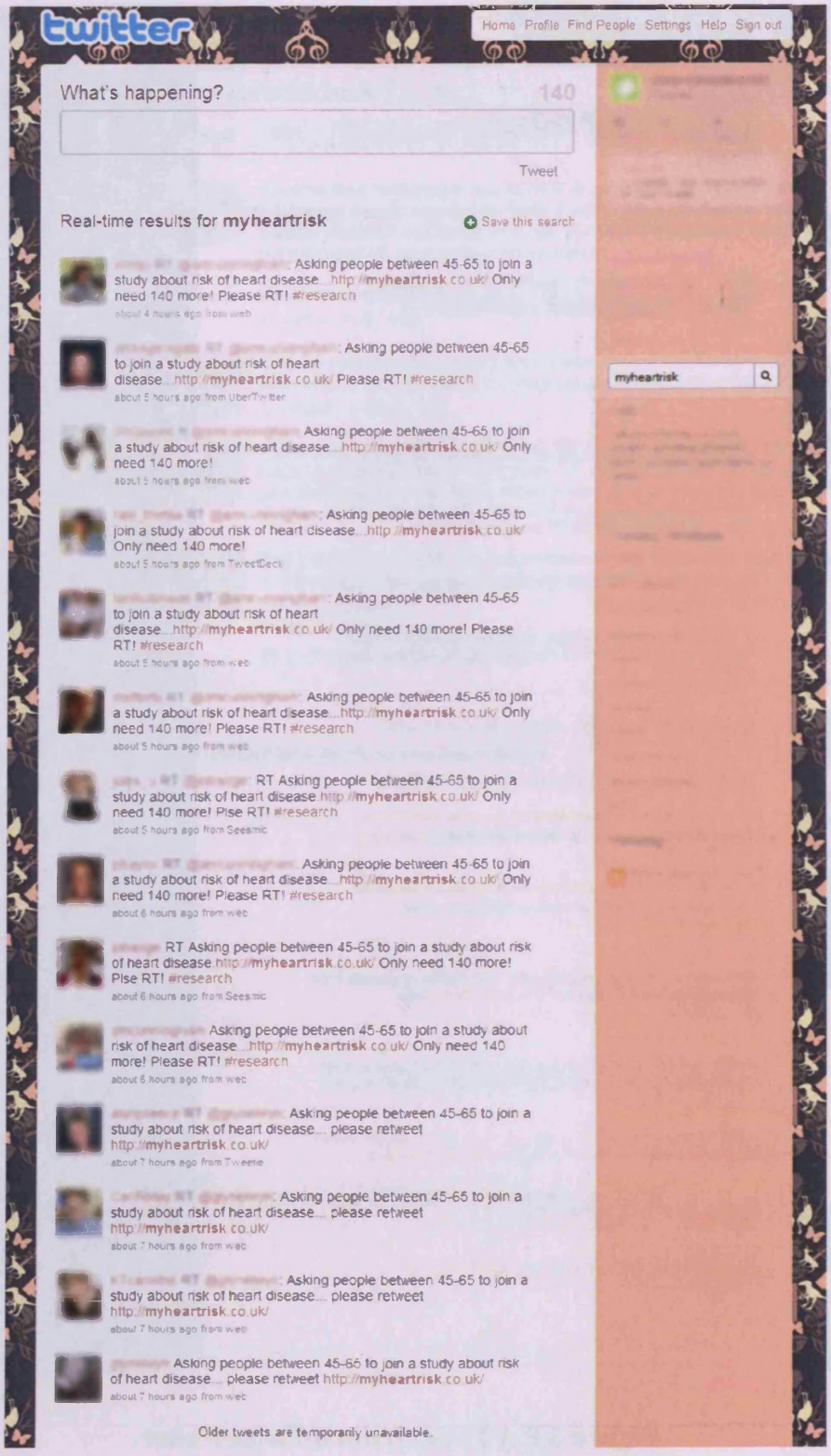
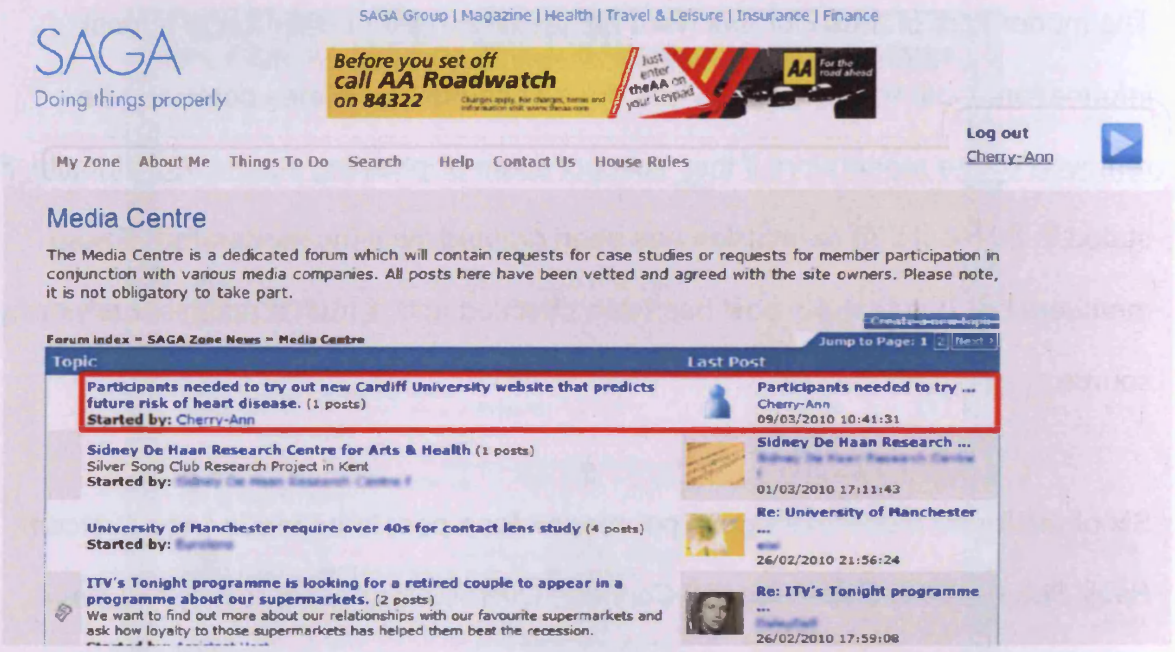


Figure 5.9 Further examples of Tweets and re-Tweets from *Twitter* users.

The moderators of these forums were contacted to ask for permission to post information about the study. This was done because sometimes posts can be removed by the moderators if they suspect spam or phishing scams. Additionally, if stated in the post that permission has been granted from the moderators, forum members can see that the post has been checked and is from a reliable trustworthy source.

Six of the forum moderators gave permission for a post to be made (*Age Concern Baby Boom Bistro; SagaZone; 50 Connect; Over50s forum; My Prime; Not Dead yet*). One (*SagaZone*) requested further details about the study, so an electronic copy of the Participant Information was sent. See Figure 5.10 for an example of a posting made on one of the forums. The same procedure was carried out for another three general forums (*Net Weather* (www.netweather.tv); *Big Soccer* (www.bigsoccer.com) and *Big Footy* (www.bigfooty.com)). These were chosen as they were popular and had a large number of members.



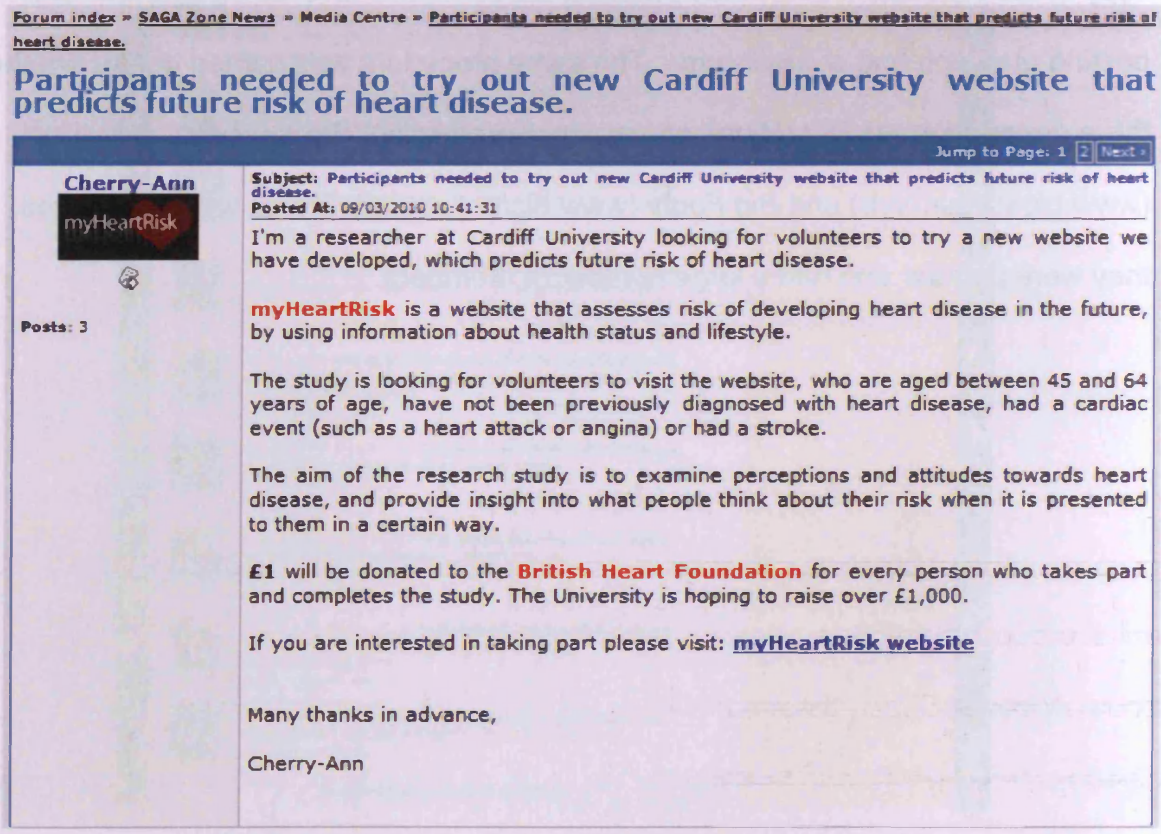


Figure 5.10 A posting on SagaZone.

A hyperlink to the study's website was placed on four Social Bookmarking websites (Digg (*www.digg.com*), Reddit (*www.redditt.com*), Delicious (www.delicious.com) and Stumble Upon (*www.stumbleupon.com*)). Figure 5.11 shows an example the bookmarks made on Delicious.com where the study's website was bookmarked by five different people (delicious.com 2010).

Figure 5.11 A social bookmark made on Delicious.com.

Another recruitment method involved contacting large organisations where employees had access to a computer. Four organisations (*Welsh Assembly Government, Driver and Vehicle Licensing Agency, HM Revenue and Customs Tax*

Office and *Cardiff Council)* were telephoned to ask whether they would be willing to send employees an invitation to participate in the study. A description was given about what the study entailed and the benefits of the on-line cardiovascular risk assessment. Upon trying to contact the Human Resources departments of three of the government based organisations, they were found to be managed by an independent company called *Shared Services*. *Shared Services* offered to send an invitation to their employees but were not authorised to send an invitation out to employees of the other organisations. Attempts were made to speak to the relevant people that would be able to authorise such action, however, this was not successful for two of the organisations (*Driver and Vehicle Licensing Agency* and *HM Revenue and Customs Tax Office).* The Occupational Health Department of the *Welsh Assembly* were contacted but they declined as they had recently performed a cardiovascular screening of their employees. However, *Cardiff Council* did send an invitation in their staff weekly email and posted a hyperlink to the study website on their staff intranet.

Lastly, a snowballing technique was employed where personal contacts were emailed the details of the study and website address, they were asked to forward this information to their friends and work colleagues who might have been interested in taking part in the study. It is not known how many people passed the email on or who it was passed on to; the only information that could be gained was from the questionnaire asking respondents to indicate where they heard about the study; which was examined in the process evaluation of the trial.

5.11 Conclusion

To conclude, this chapter has described the methods used in the RCT on the effects of cardiovascular risk representation formats on intention to change behaviour, understanding of risk information and affect (effect evaluation), and the use of the website by the respondents (process evaluation). It has described the design, procedure, plan of analysis and recruitment strategy. The following chapter describes the development and pilot testing of the web-based risk formatter used in this trial.

Chapter 6. Development and pilot testing of the myHeartRisk website.

6.1 Introduction

This chapter will present the development and pilot testing of the myHeartRisk website, comprising the web-based cardiovascular risk formatter and on-line questionnaires used in the RCT.

6.2 Development of the myHeartRisk website

The development of the website commenced in June 2009, a project specification document and storyboard of web pages were presented to a web developer (Appendix 30). Information was given to the web developer about who the website was intended for (e.g. people aged 45 to 64 years, of varying educational and computer literacy levels), and the considerations that needed to be made, such as making the website as user-friendly and self-explanatory as possible, simple layout, minimal text, use of plain language, clear instructions, use of colours that complement each other, and large sans serif font no smaller than size 14 that is easy to read (such as Veranda or Ariel). Additionally, the website needed to allow for easy navigation, with big easy-to-use buttons, check boxes and sliding scale response options. The project specification document also explained about the wide confidence intervals of the risk categories that needed to be depicted by the

graphical representation formats. The bar graph and pictogram formats needed to have an element of simple animation to show the range in the risk of future heart disease represented in each of the risk categories. For example, the bar graph needed to grow slowly from 0% to 9% in low risk category; 10% to 20% in moderate risk category and from 20% upwards in the high risk category. For the pictogram format, each heart symbol representing the frequency of risk needed to be highlighted or flash in succession. The web developer circulated the graphical formats and off-line versions of the web pages for approval, before constructing the website in *Adobe Acrobat Flash* software. A functional website was ready for pilot testing in December 2009.

6.2.1 Graphical Risk Representation formats

The two control groups in this trial consisted of vertical bar graphs depicting future risk of cardiovascular disease in percentages. This was animated (growing upwards) to demonstrate the wide confidence intervals of the risk categories in the Personal Risk Score (Mainous et al. 2007). Screenshots of the original bar graph formats for each of the risk categories (before pilot testing and refinement) are presented in Figures 6.1 to 6.3.

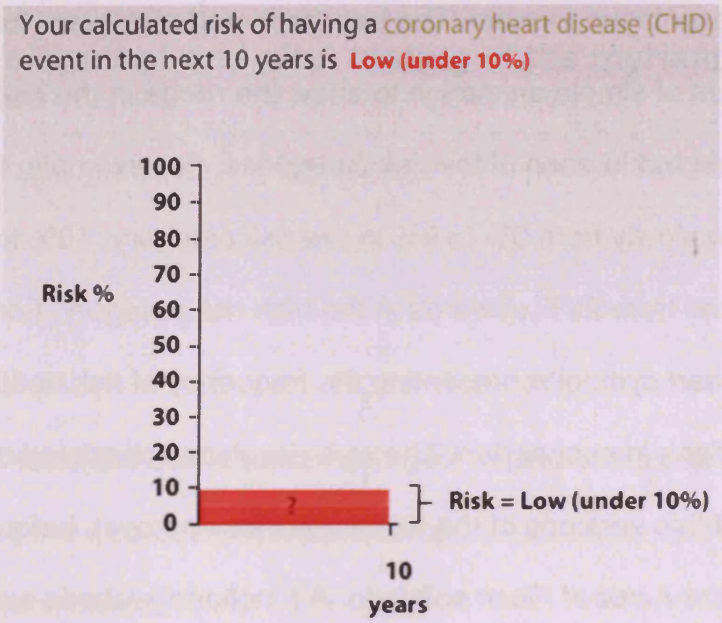


Figure 6.1 Original Bar graph format for Low risk category.

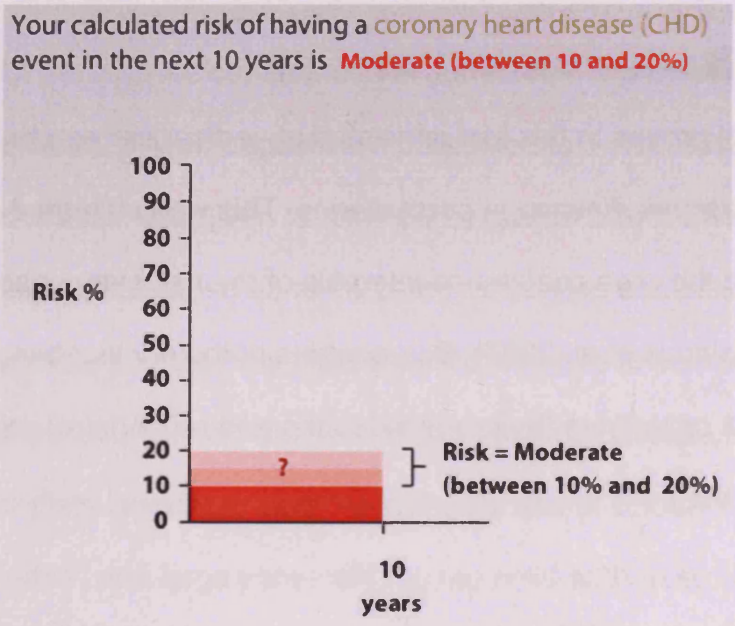


Figure 6.2 Original Bar graph format for Moderate risk category.

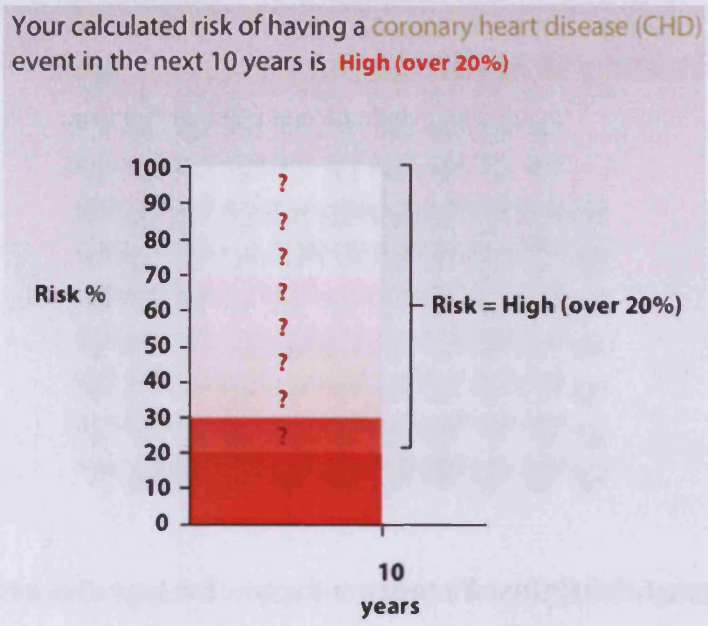


Figure 6.3 Original Bar graph format for High risk category.

For the first intervention group, future risk of cardiovascular disease was presented as a pictogram of 100 hearts depicting natural frequencies. This was animated, highlighting each affected heart in turn, to account for the range of numbers affected in the risk category. Screenshots of the original pictogram formats for each of the risk categories are presented in Figures 6.4 to 6.6.

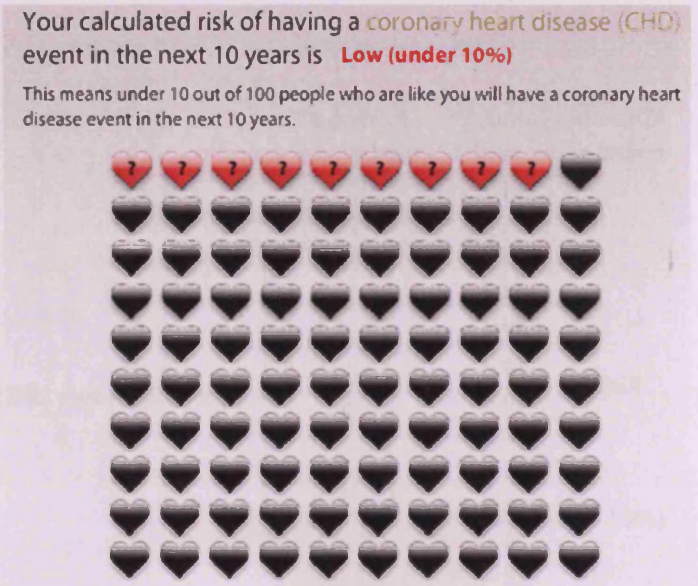


Figure 6.4 Original Pictogram format for Low risk category.

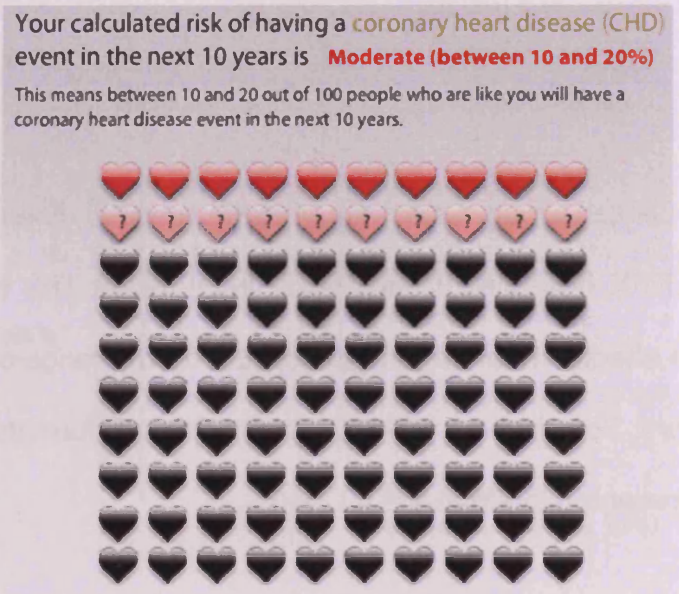


Figure 6.5 Original Pictogram format for Moderate risk category.

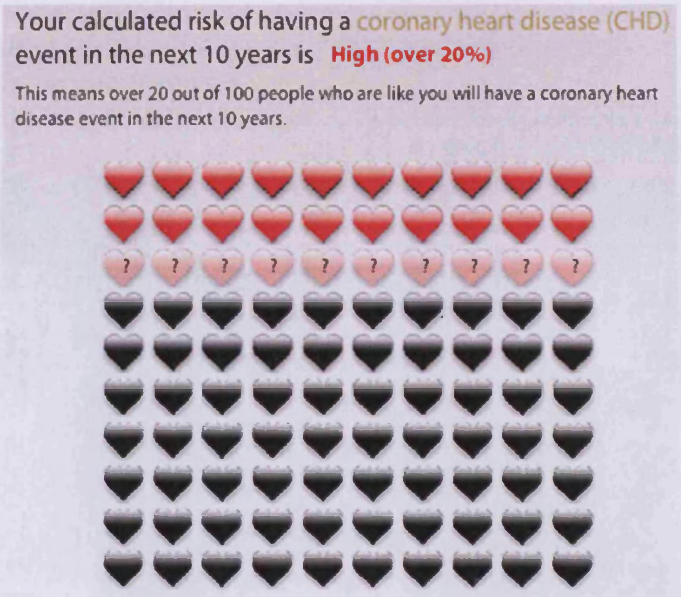


Figure 6.6 Original Pictogram format for High risk category.

The metonym format, used in the second intervention group, comprised an image that depicts the seriousness of an emergency admission for a myocardial infarction. This was chosen as heart disease is generally associated with having a myocardial infarction (Emslie et al. 2001). An animated image demonstrating healthy longevity was shown to those in the low risk category; the gentleman's foot slowly rocks back and forth and there is the sound of waves crashing in the background and birds cheeping. Those at moderate risk were presented with an ambulance travelling towards a person's house; the siren lights flash and the rain pours down, with the sound of thunder and lightning in the background. A person being defibrillated (with the appropriate sound effect) was shown to the high risk category. Screenshots of the original metonym formats for each of the risk categories are presented in Figures 6.7 to 6.9.

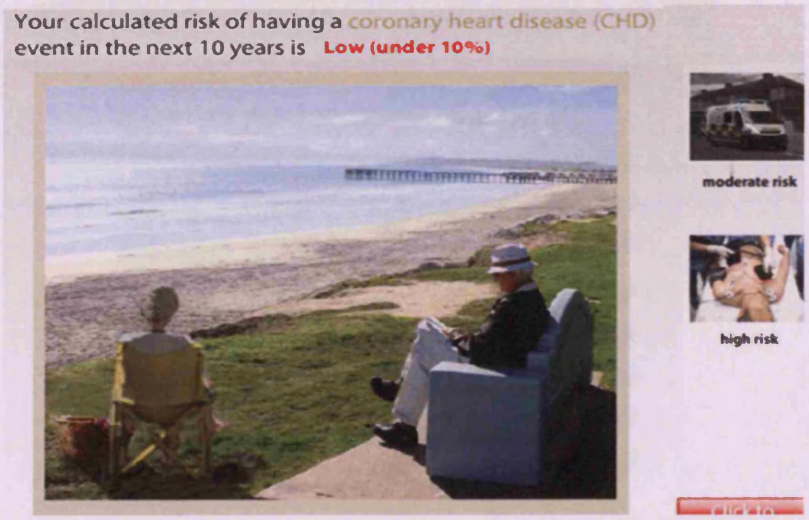


Figure 6.7 Original Metonym format for low risk category.

Figure 6.8 Original Metonym format for moderate risk category.

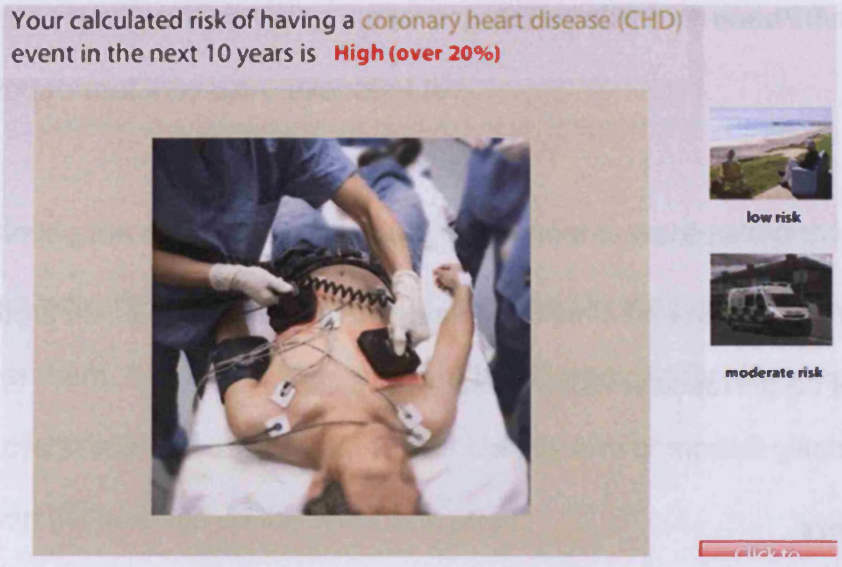


Figure 6.9 Original Metonym format for High risk category.

6.3 Pilot testing of the myHeartRisk website.

The aim of the pilot study was to assess the internal logic and usability of the website. It comprised two phases: the first, sought general feedback on the cardiovascular risk representation formats and wording of the questionnaires; the second phase was concerned with the functionality and internal logic of the site. Both phases indentified limitations and/or computer glitches.

6.3.1 Phase 1 of pilot testing

Design

An on-line evaluation and simulation study, using hypothetical risk profiles of varying degrees of cardiovascular risk (Appendix 31).

Participants

A convenience sample of peers invited to take part in the pilot study via University Departmental email.

Procedure

An email was sent to members of a Decision Laboratory research group at Cardiff University, asking whether they would be willing to take part in the piloting of the myHeartRisk website (Appendix 32).

Respondents agreeing to participate in phase 1 of the pilot testing were given a link to the pilot website (http://www.myheartrisk.co.uk/pilot.html) and instructions that comprised one of a selection of hypothetical risk profiles created to test the different risk categories (An example is given in Appendix 33). Respondents were asked to vividly imagine that they were the person in the profile with those particular risk factors. They were asked to navigate through the website, inputting the information from the hypothetical profile, view the output and complete the on-line

questionnaires. They were asked to comment on their opinions about the risk representation format they were allocated to.

When completing the on-line questionnaire, respondents were asked to answer the questions in a way they thought the person described in the hypothetical risk profile would answer them. They were also asked to highlight any difficulties they had in interpreting the wording of the questions and identify any computer glitches or limitations with the website on the feedback page.

The SQL database storage and transferring of data were assessed after respondents had visited the website, to make sure completed responses were successfully fed back to the host Server.

Results

Eleven respondents participated in the first phase of piloting. Comments from each of the reviewers are presented in Appendix 34. Comments were categorised into those regarding functionality of the website, layout of the web pages, risk representation formats or miscellaneous.

Functionality of the website

Reviewers assessed the functionality of the website to identify any computer glitches. They commented that they could not use the back button on the browser to view previous web pages. However, as the website was constructed using *Abode*

Acrobat Flash software, it was not possible to rectify this. Additionally, reviewers reported difficulty selecting their exact height and weight on the sliding height scale and weighing scales of the risk assessment page, and the progress bar did not continue to the end on the last page of the website. This was reported back to the web developer for amendment.

Additionally, reviewers had difficulty printing out a copy of their results for a number of reasons e.g. the print function would not work at all, the risk category on the printout would change from what was shown on their risk output results page, or the website would not print out the results and took users straight to the next page. The web developers attempted to rectify this, however it was not successful and an alternative method for respondents to obtain their results had to be implemented. This involved asking respondents to leave their contact details on the last page so an electronic copy could be emailed to them in *Adobe Acrobat Portable Document Format (pdf)*.

Layout of the web pages

Abnormalities with the layout of a questionnaire page were identified by the reviewers. For example, one of the questionnaire pages comprised anchors on the Likert scales that were negative on both sides. This was corrected. Smoking cessation questions were given to respondents who ticked that they were former smokers on the risk assessment page. This was amended so that only current smokers received these questions. In the original weighing scales the maximum weight was presented on the left, so users selected their weight by decreasing the

value on the weighing scale. It was felt this was counterintuitive, and was reversed so when the arrow was dragged upwards the weight increased.

Figure 6.10 demonstrates the revised layout of the risk assessment pages of the website. Additionally, a suggestion was made to change the colour of the hyperlinks from beige to a more recognisable format associated with hyperlinks (i.e. blue and underlined). This was done. Lastly, it was felt that users needed guidance on how they answered the question regarding family history when this information was not known to them. Therefore, wording was added to this question that suggested users should answer 'no' if this information was unknown.

Graphical risk representation formats

Four reviewers commented on the question marks being used in the bar graph and pictogram formats to represent the wide confidence intervals of the risk categories (see Figures 6.1 - 6.6). They were not understood as reviewers did not comprehend the message they were supposed to be conveying and did not see the purpose of them.

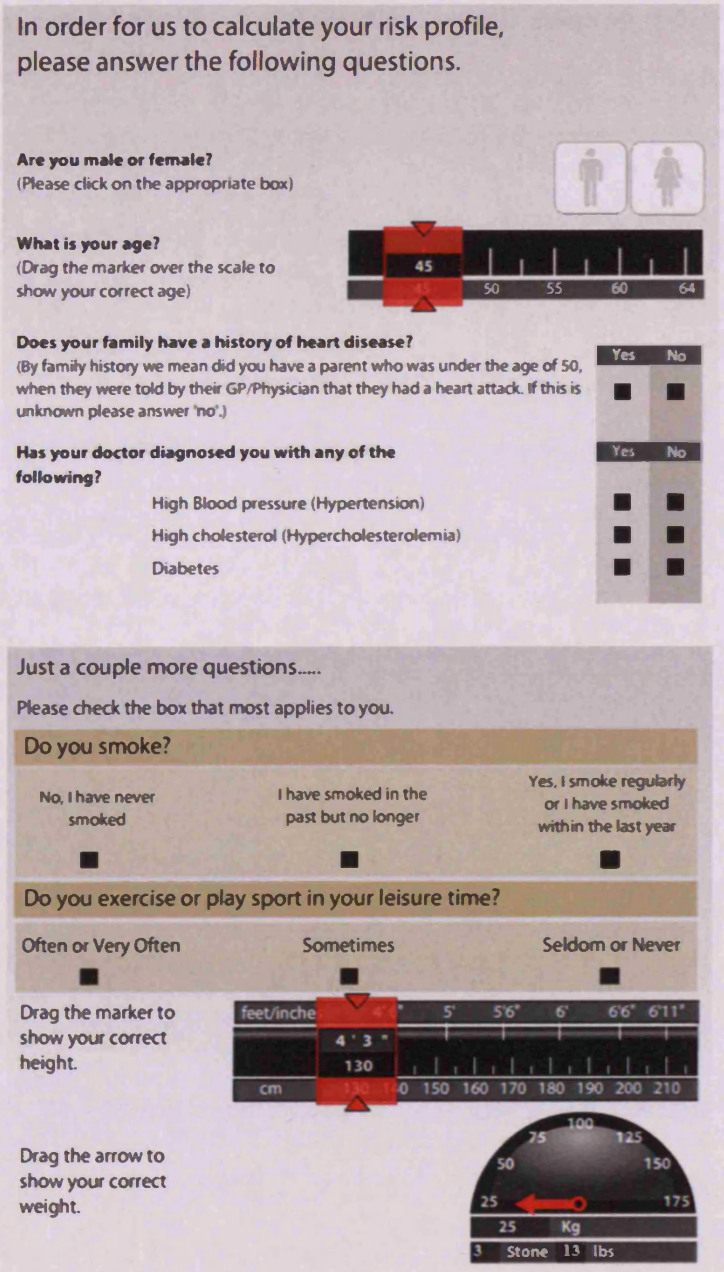


Figure 6.10 Revised cardiovascular risk assessment web page

A possible solution to representing the degree of uncertainly and wide confidence intervals was suggested (see Reviewer 10 in Appendix 34), where two colours should be used; a darker red to represent the people who will definitely be affected by a future coronary heart disease event and a lighter pink to represent the number of people who may be affected. For example, for moderate risk, 9 hearts would be a darkened colour as they represent the 'less than 10 people' who will be affected, whereas hearts 10-20 highlighted in a lighter pink to represent those who may be affected. A diagram key would be used to demonstrate what the two colours mean. The only alteration made to the metonym formats was changing the colour of the hyperlink of the CHD definition page. Figures 6.11 to 6.19 demonstrate the revised risk representation formats.

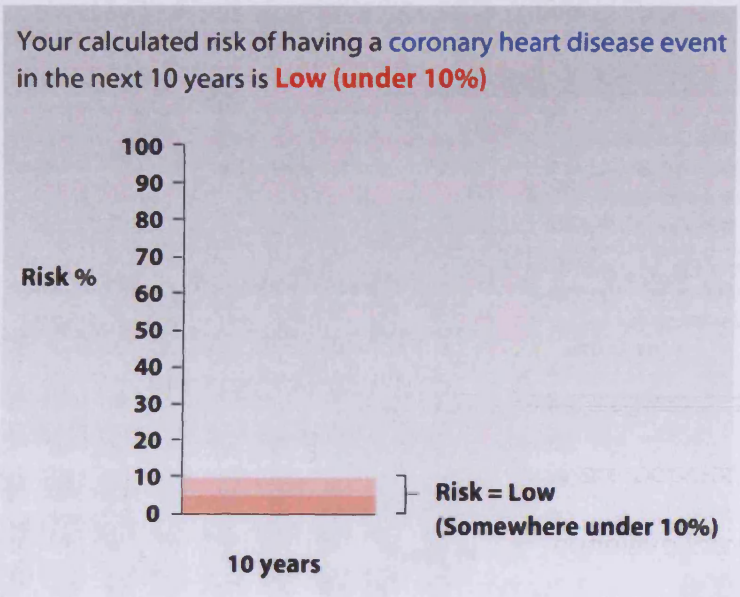


Figure 6.11 Revised Bar graph format for Low risk category.

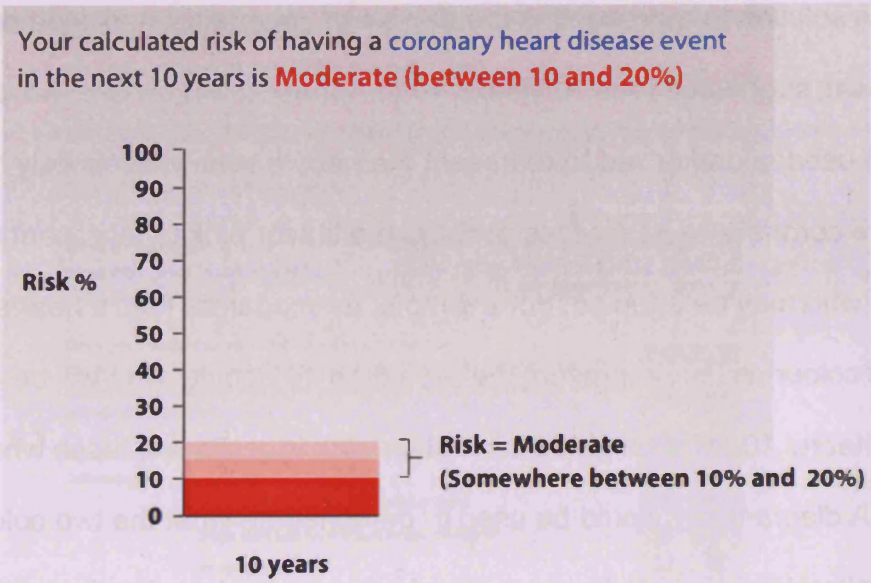


Figure 6.12 Revised Bar graph format for Moderate risk category.

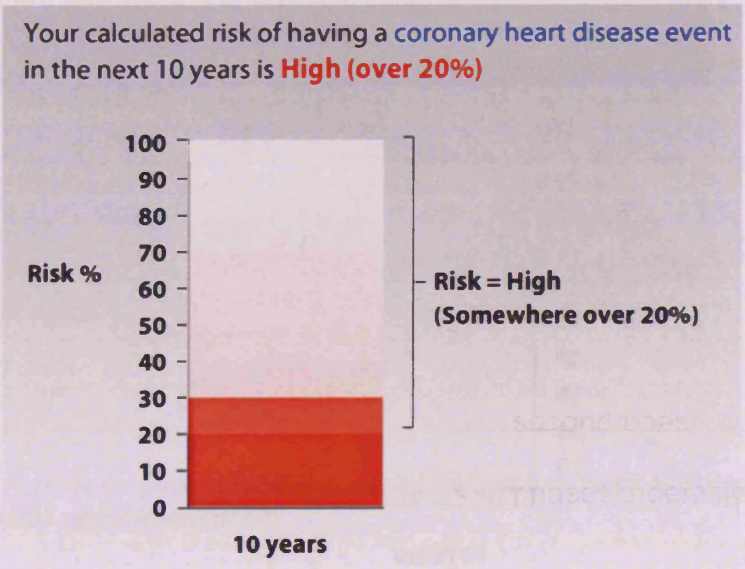


Figure 6.13 Revised Bar graph format for High risk category.

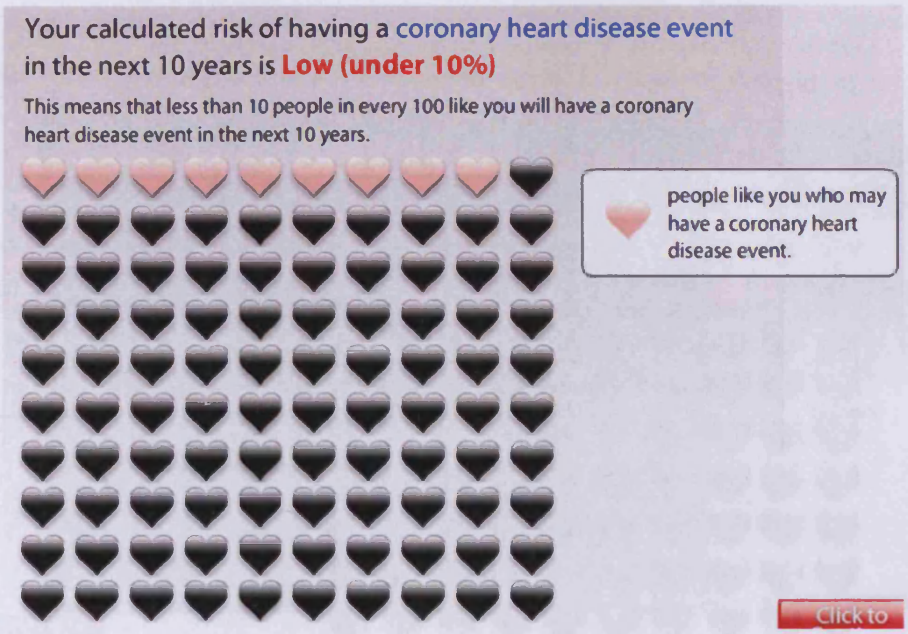


Figure 6.14 Revised Pictogram format for Low risk category.

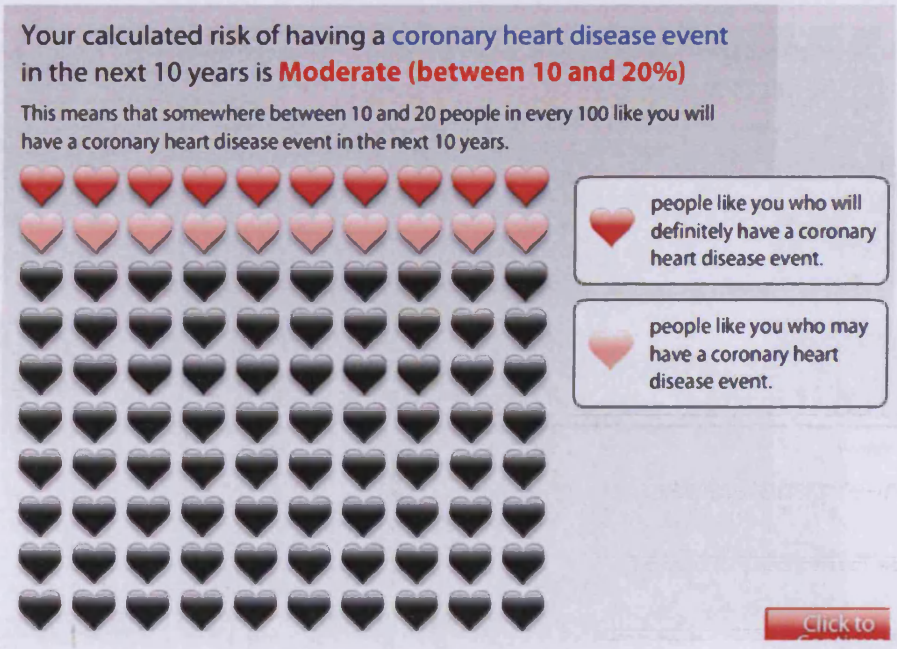


Figure 6.15 Revised Pictogram format for Moderate risk category.

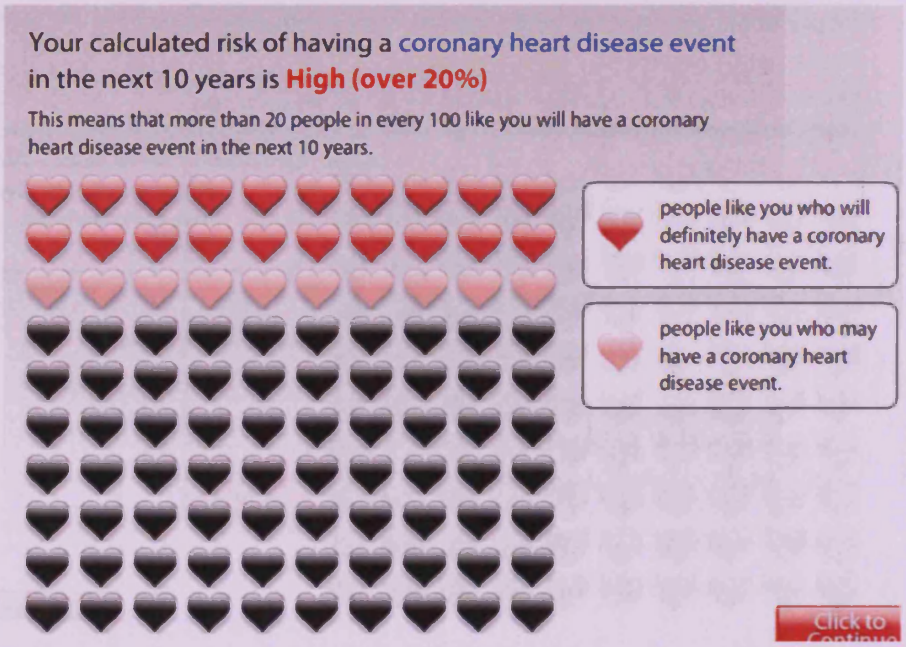


Figure 6.16 Revised Pictogram format for High risk category.

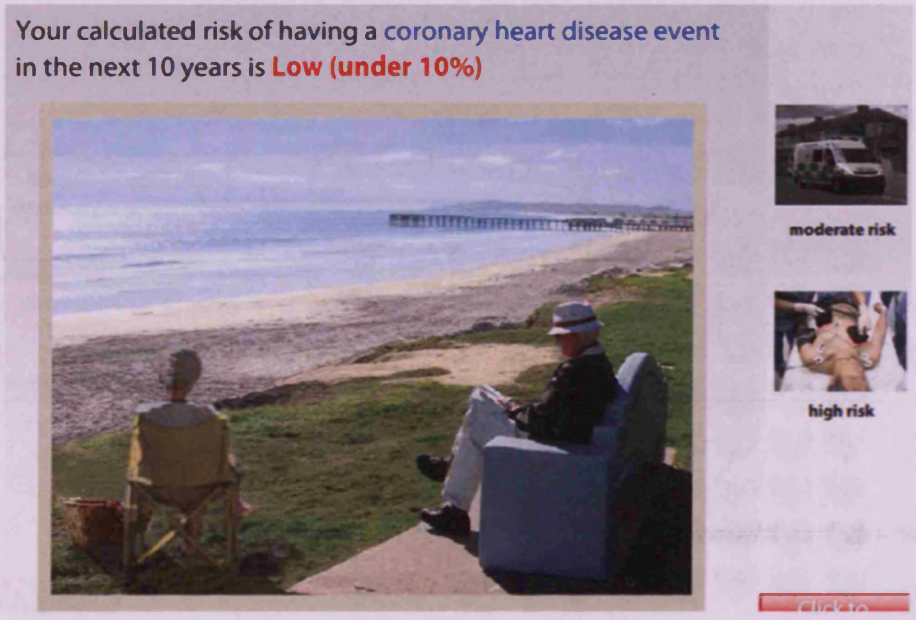


Figure 6.17 Revised Metonym format for Low risk category.

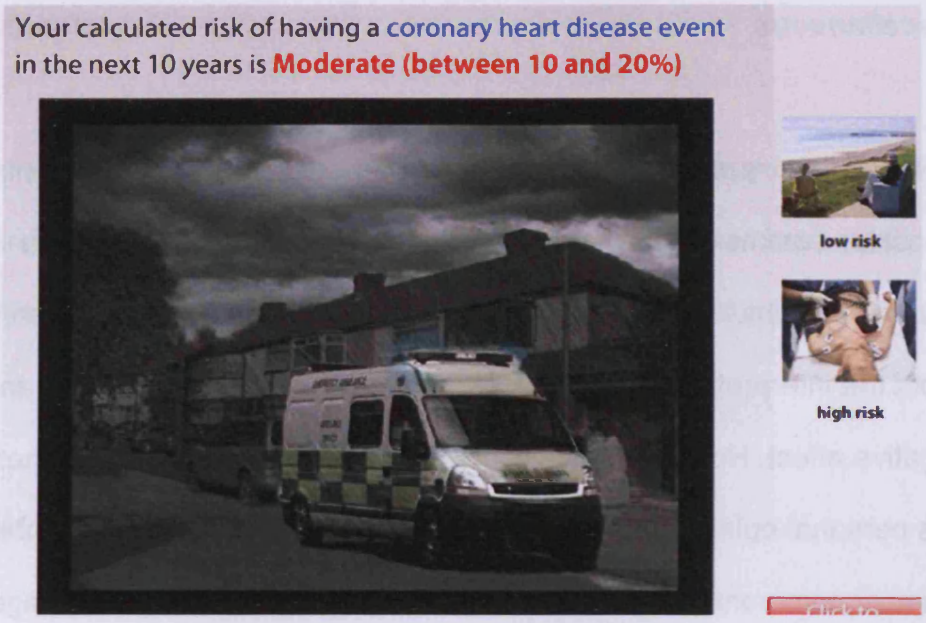


Figure 6.18 Revised Metonym format for Moderate risk category.

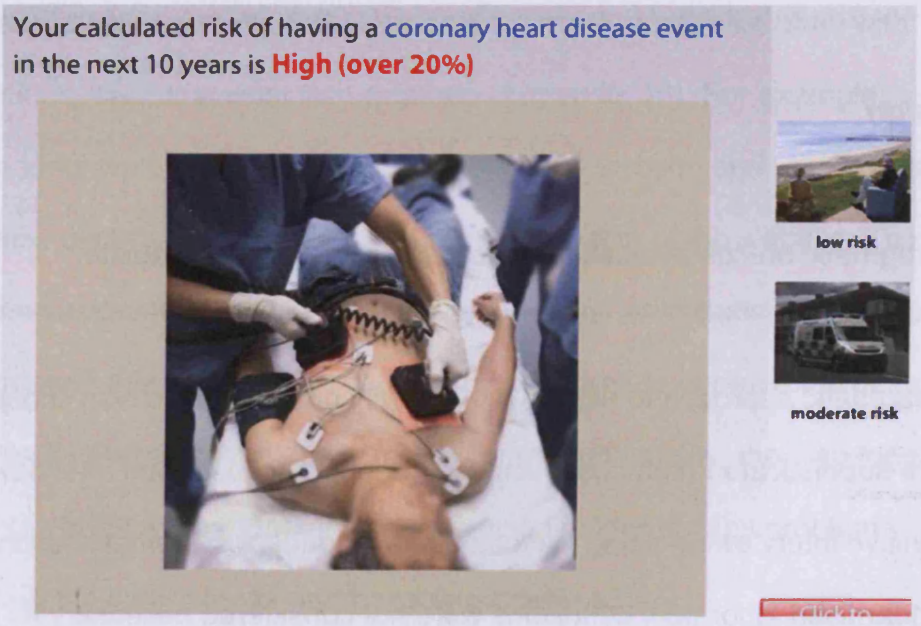


Figure 6.19 Revised Metonym format for High risk category.

Miscellaneous

Three reviewers provided comments that were categorised as miscellaneous. A positive comment was made about the website working well with a favourable opinion of the use of a progress bar. One reviewer was concerned about the interpretation of the PANAS-SF scale measuring positive and negative affect. However, no action was taken to address this comment as it was personal opinion and not reflected by the piloting group as a whole. One reviewer commented on the content of the participant information pages; amendments were made where necessary.

6.3.2 Phase 2 of pilot testing

Design

A pragmatic on-line evaluation to assess usability of the website.

A pragmatic approach to assess the usability of the website was chosen. More sophisticated methods, such as in-depth or focus group interviews, cognitive interviewing using think aloud technique, or systematic testing in standardised laboratory conditions were not considered necessary as navigation through the website was linear and straightforward.

Participants

Personal contacts and members of the Clinical Epidemiology Interdisciplinary Research Group at Cardiff University aged 45 to 64 years without existing heart disease (i.e. respondents who would be eligible to take part in the main RCT).

Procedure

Personal contacts and peers were invited by email to participate in a pilot study preceding the main trial (Appendix 35).

Respondents who replied to the invitation email were given a link to the myHeartRisk pilot website (http://www.myheartrisk.co.uk/pilot.html) with instructions regarding what was required (Appendix 36). For example, respondents were asked to navigate through the website and give free text feedback, comments and suggestions on all aspects of the website. They were also asked to identify any difficulties, glitches or limitations they found. It was stressed that the purpose of the pilot study was to improve the usability of the material and all comments were welcome. Additionally, the web-logs stored by the SQL host Server were assessed to identify any problems regarding the data storage and transfer processes.

Results

In total, there were 19 reviewers who took part in phase 2 of the pilot testing. Six were personal contacts, considered as non-experts or members of the general public, 13 were recruited from the Clinical Epidemiology Interdisciplinary Research Group and were considered to be 'experts' with experience of research and web-based studies.

Comments made by the reviewers were dichotomised into those that were positive and those that were negative. Appendix 37 shows reviewers responses of a positive nature. Generally, reviewers had favourable opinions regarding the layout, which they thought was attractive, easy to use and easy to navigate. They liked the use of graphics and the interactive tools with dragging options. They also commented that it did not take too much time to complete the post-intervention questionnaires.

Appendix 38 shows reviewers responses of a negative nature. These were categorised by the corresponding section of the website that they referred to: participant information, disclaimer, consent and eligibility assessment pages, baseline and pre-intervention questionnaires, risk assessment, risk output results, post-intervention questionnaires, end of study and contact details pages, and general comments. Tables 6.1 to 6.8 demonstrate the comments concerning the different sections of the website and the appropriate action that was taken. The feedback and comments regarding the functionality and

internal logic of the web-site were compiled into a list of alterations given to the web developer.

Participant information pages

Comments regarding the participant information pages (Table 6.1) mainly concerned its layout, such as inappropriate line-breaks, typographical errors, clickable hyperlinks not working etc. These were all amended. Additionally, four reviewers gave unfavourable opinions regarding how each question and answer was presented in the participant information page. In the original layout (Figure 6.20) users were required to roll their mouse over the question and click to open up a pop-up box displaying the answer. Reviewers commented that they would lose track of which questions they had visited and found it very long, 'off-putting' and intimidating. Therefore, the layout of this page was improved by displaying the questions and answers on one page that users scrolled down. The revised participant information page is presented in Figure 6.21.

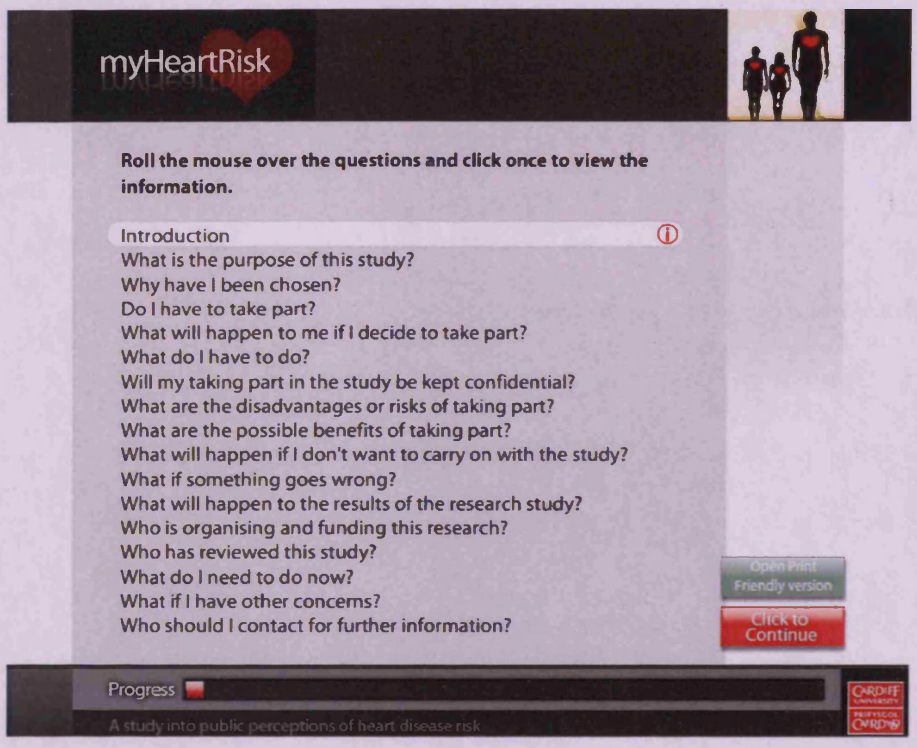


Figure 6.20 Original layout of the Participant Information page.

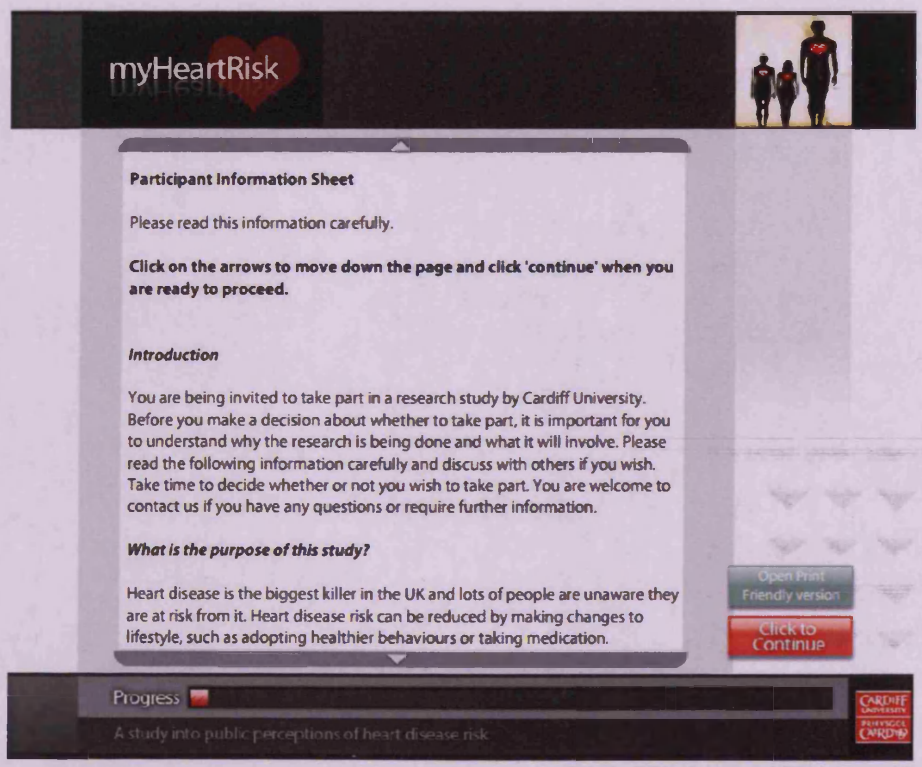


Figure 6.21 Revised layout of the Participant Information page.

Table 6.1 Comments regarding the participant information pages.

Reviewer	Comment	Action taken
Reviewer 3 (non-expert)	*'When I was reading through each of the information items from the list at the start, each time I closed a particular item it took me back towards the top of the list, not on the item I had just been on so I could move on to the next one.'*	The layout of this page has been improved.
Reviewer 6 (expert)	*'The introduction list, I seemed to have to step back and select each item, rather than flick forward through it, each one seemed clear and short, so I would have preferred that.'*	The layout of this page has been improved.
Reviewer 7 (expert)	*'What is the purpose of this study' you give the url of the website but it is not the same as the URL that displays in the browser status bar.*	The pilot website had a different website address to the main study. No action was taken.
	'Will my taking part be kept confidential' you say '..at an agreed period' rather than '..after an agreed period.	This has been amended.
	'What do I need to do now?' you instruct to navigate to the electronic consent page, yet the only button available is a 'continue' button. It would be better to say press continue button which will take you to the consent page.	This has been amended.
Reviewer 8 (expert)	*'Scrolling is still a pain'.*	The layout of this page has been improved.
	'This really needs to retain and indicate where the participant has visited; otherwise they won't know where they have been. A 'next' option would be handy, but there is a lot to wade through.'	The layout of this page has been improved.
	'What are the disadvantages or risks of taking part? Typo: 'we recognise that viewing you risk...'	This has been amended.
	'What if something goes wrong? – professor Glyn Elwyn, line break'	This has been amended.

Reviewer	Comment	Action taken
Reviewer 10 (expert)	*Under disadvantages, in line 1 it should be your, not you.*	This has been amended.
	In the 'what if something goes wrong, the formatting of Glyn is a bit odd.	This has been amended.
	In the 'what will happen to the results', the punctuation is a bit odd in the second paragraph.	This has been amended.
	In the 'what do I need to do now?' you instruct to navigate to the electronic consent page, yet the only button available is a 'continue' button. It would be better to say press continue button which will take you to the consent page.	Wording instructing users to click on the continue page to get to the consent page has been added.
Reviewer 13 (expert)	*Long list of questions was off-putting. Was I supposed to read them all, or just click on the ones of interest, or ignore and continue?*	The layout of this page has been improved.
	The subjects should have to work through each question to get to the next page- at least the then the content is in front of them if only for a few seconds. If people are sufficiently interested to go on the site, they should be sufficiently interested to read information sheet.	The layout of this page has been improved.
Reviewer 14 (expert)	*'Would be helpful to have some links here.* *-What do I need to do now – maybe a link to take you straight to the consent screen?* *-what if you have other concerns – clickable email link to Prof Elwyn, or a link to the Contact details screen.*	Wording has been amended instructing users to click on the continue button to go to the consent page.
	The email on the contact details doesn't work.	This has been amended.
Reviewer 15 (expert)	*List at beginning very long and a bit intimidating – is this necessary- it almost made me turn off.*	The layout of this page has been improved.

Reviewer	Comment	Action taken
Reviewer 16 (expert)	*'What will happen if I don't want to carry on with the study? You can withdraw from the study at any point by closing the web browser.' Is this really what you want to happen? There are various reasons why a web browser can close without implying intention to withdraw - crashes, navigating away and not being able to get back, being called away and the kids then start using the computer etc. Better for the system to require deliberate withdrawal, and allow return after interruption -* *though detect if they never return within a specified time frame and count that as a withdrawal.*	Due to the nature of the website being constructed in Adobe Flash, users cannot return to the page in which they exited previously.
Reviewer 17 (expert)	*There is a risk that people might be mislead regarding the source of this website, which is Cardiff University and not Br Heart Foundation*	The participant information page clearly states that Cardiff University is the source.
	Grammatical amendments needed on participant information. See email.	This has been amended.
Reviewer 18 (expert)	*Change 'Why have I been chosen? To 'Why am I eligible'*	This has been amended.
	Change what if something goes wrong to 'What If I have concerns/ What if I become worried?'	This has been amended.

Disclaimer, consent and eligibility assessment pages

Reviewers commenting on the disclaimer, consent and eligibility assessment pages (Table 6.2) said they would like a back button on the browser in case users wanted to view the participant information pages again before consenting, or in case they changed their minds about participating. As the website was created in *Adobe Acrobat Flash* software, it was not possible to implement this into the website. Comments that were able to be addressed resulted in adding a title heading to the consent page and providing a reference to the published algorithm used by the website, e.g. the Personal Heart Score (Mainous et al. 2007).

Baseline and pre-intervention questionnaires

Three comments were made regarding the baseline and pre-intervention questions given to those in the first control group (Table 6.3). Two of these were personal opinions about wording of one of the scales used in the questionnaires, PANAS-SF (Thompson 2007). As this is a published scale that has been validated, and the opinions were not reflected by the group of reviewers as a whole, these comments were not addressed and no action was taken.

Table 6.2 Comments regarding disclaimer, consent and eligibility assessment pages.

Reviewer	Comment	Action taken
Reviewer 13 (expert)	*Language is a bit high brow (published prediction tool, self-reported information)*	This is a personal opinion. No action was taken.
Reviewer 14 (expert)	*Consent – a 'back' button would be helpful in case the person wants to review the participant options again before consenting.*	This is a feature of the website being constructed in Adobe Flash, it cannot be changed.
	We are sorry you do not wish to take part – a 'back' button might be helpful as well in case the person decides to change their mind. A 'quit' button to confirm their decision and take them out of the website.	It was not possible to do this.
	Disclaimer – this mentions a published prediction tool. It would be nice if this were referenced, or if there was a link to it, for anyone who wants further info.	This has been done.
Reviewer 17 (expert)	*Once on the consent page, I don't think I actually saw it labelled as a 'consent page'. Possible to give it that heading?*	It has been made sure that the consent page is labelled.

Table 6.3 Comments regarding the baseline affect/worry and pre-intervention questionnaires.

Reviewer	Comment	Action taken
Reviewer 9 (expert)	*I didn't like being asked if I was ashamed or nervous (I assume that was for personality type) it seemed irrelevant and intrusive.*	This is a personal opinion; these questions form part of the PANAS (a published and validated scale).
Reviewer 13 (expert)	*Q16 suddenly has numbers -3,-2,-1,0,1,2,3 rather than previous 1,2,3,4,5,6,7 which was a bit confusing. Also, the minus end was sometimes associated with the most positive response (easy/rewarding).*	The questionnaire format is recommended by published guidelines on constructing TPB questionnaires. No action was taken.
Reviewer 16 (expert)	*Page 'Before we calculate your risk': are we asking how worried they feel, or how concerned? I'm concerned re my heart disease risk - but not worried. I realise that this is my most likely pathway of death. I am taking reasonable steps to minimise my risk. I have plenty else of more immediate concern.*	This is personal opinion, not a website issue. No action was taken.

Risk assessment pages

Table 6.4 demonstrates the comments made by the reviewers about the risk assessment pages of the website. The 'expert' reviewers commented on the questions asking whether users had ever been told by their GP that they had high cholesterol, one expected a definition of what constitutes high, another would have liked to have seen the option to request more information. Furthermore, the definition of family history (e.g. first degree relative diagnosed under the age of 50) surprised one reviewer, as they reported that other algorithms use 60 years of age. However, no action was taken to address these comments as they related to the risk factors used by the published algorithm not with the functionality of the website. The sensitivity of the weight scales and height ruler were reduced after two reviewers commented that it was still very sensitive and difficult to get the arrow to their exact weight and height. A computer glitch was sorted out after a reviewer reported that they had proceeded to the next webpage without answering some of the risk assessment questions. Lastly, one reviewer thought that aesthetically, the line joining the response options boxes on the smoking question should be removed, therefore, this was done.

Risk output results

Five reviewers commented on the risk output results page (Table 6.5). The hyperlinks were amended so that the text did not disappear when highlighted and the definition of a coronary heart disease event was improved in

response to comments from two reviewers. One reviewer reported that they did not understand the purpose of the thumbnails given in the metonym format (See Figures 6.17 to 6.19). However, no action was taken to address this as it was felt that the thumbnails provided context, as they showed how the metonym was used to represent a user's risk category compared to the metonyms used to represent other risk categories. If these were removed, the metonym image on its own would not be easily interpreted or understood. Additionally, one reviewer commented on the lack of anonymity when requesting a copy of the risk output result by entering contact details for a copy to be emailed to you. As described previously, it was not possible to provide a function that enabled a printout straight from the website. This limitation is acknowledged and will be discussed in Chapter 9.

Post-intervention questionnaires

A statement clarifying why the post-intervention questionnaire pages ask about a user's intentions to stop smoking, lose weight and exercise more was added to this page, in response to the comments from two reviewers: one who suggested that the questions had no real introduction and an unclear purpose, and another who said that they thought these questions were asked because of the responses they gave on the risk assessment pages, i.e. that the website was recommending that they should exercise more or lose weight.

Five reviewers commented on the different numerical values on the response sets, suggesting that they should be kept the same because the scales are confusing and caused hesitation in how to interpret the sudden switch to the answer format, which numerically challenged users' may find 'off-putting'. However, no action was taken to amend this because the post-intervention questionnaire was constructed using the published guidelines on constructing Theory of Planned Behaviour Questionnaires (Francis et al. 2004). According to Francis et al (2004) it is suggested that bipolar items with an evaluative component (where the respondent is required to make a judgement about the probability that the item is true) should have positive and negative values, such as -3 to +3. This determines the direction of the opinion, e.g. a negative score represents an opinion that is against the behaviour in question, a positive score represents an opinion that is favourable towards the behaviour and zero score represents a neutral opinion.

Additionally, two reviewers commented on the items that were reversed scored, suggesting they seemed to be intuitively the wrong way round and asked whether the numerical values were meant to be showing, where there were negative scores for positive items and positive scores for negative items. No action was taken to address these comments as the reversal of some items was deliberately done to reduce the possibility of response set bias; as recommended when constructing questionnaires and surveys (Oppenheim 2001).

It was also suggested that the response options should comprise all the same response option anchors such as '*strongly agree* to *strongly disagree*'. However, no action was taken in response to this comment, as the questionnaire was designed to have a variation in response option anchors to reduce the possibility of response set bias (Oppenheim 2001), and this was a comment suggested by one reviewer only.

Lastly, one reviewer felt the questionnaire was repetitive. However, no action was taken as the number of items was kept to an absolute minimum so not to cognitively overload the respondents and thus reducing drop-out /attrition rates.

End of study and contact details pages

Four reviewers provided comments about the end of study and contact details pages (Table 6.7). Two commented that the progress bar had not gone all the way to the end when the study was complete and users were on the last webpage. This was amended. Additionally, one reviewer reported that they would have liked to have clicked on a 'close' button when leaving the site, rather than just closing the web browser. This was not able to be addressed due to the software used to develop the website (e.g. *Abode Acrobat Flash*).

Table 6.4 Comments regarding risk assessment pages.

Reviewer	Comment	Action taken
Reviewers 1 & 2 (non-experts)	*The only problem we both encountered was setting our weight on the gauge. We had to leave it as close as, as it was very sensitive to movement.*	The sensitivity of the height ruler and weighing scales has been reduced.
Reviewer 6 (expert)	*Dials with moving needles – could perhaps be bigger.*	This has been done.
Reviewer 8 (expert)	*Do you smoke? – if this question is missed and 'click to continue' clicked, the 'please answer all questions' message is displayed. If smoking is answered and 'click to continue' clicked, the survey goes to the next page, even if the other 3 qs (exercise, height and weight) are missed. I had a very good result, presumably because it thought I was 130cm high and weighed 25kg! I have not checked all combinations on all pages.*	This has been amended.
Reviewer 9 (expert)	*Would have liked to see stones and pounds rather than kilos*	There are already both imperial and metric measurements on display.
Reviewer 10 (expert)	*Question about high cholesterol – I don't think that is very clear. How high does it have to be to be counted as high? Does the total have to be 5.5? 6? 7? What about the ratio of low hdl to high? I'm not sure that will get clear answers. And clearly the risk does depend on whether it is 6 or 10?*	This comment relates to the responses options of the algorithm that is used in the risk assessment. It is not a website issue.
Reviewer 13 (expert)	*The line joining 3 boxes for do you smoke and exercise questions suggested a visual analogue scale. Why have it? The boxes alone would be clearer.*	This has been amended.
Reviewer 14 (expert)	*Weight adjustable pointer is very sensitive and a bit fiddly.*	The sensitivity of the height ruler and weighing scales has been reduced.

Reviewer	Comment	Action taken
Reviewer 15 (expert)	*Family history – you have risk as being event below 50 – most other assessment make it 60.* *I was a bit surprised that although I ticked box for raised cholesterol there was no further details requested here – I came out as low risk but surely if my cholesterol was high this would not be accurate.*	These comments relate to the algorithm that is used in the risk assessment. It is not a website issue.
Reviewer 18 (expert)	*The questions on exercise or play sport; Shouldn't you define what is exercise? Is regular walking or cycling, e.g. to work, exercise?*	The definitions came from the Personal Heart Score paper by Mainous et al.

Table 6.5 Comments regarding the risk output results pages.

Reviewer	Comment	Action taken
Reviewer 6 (expert)	*I wonder whether there should be some comparators to the risk statistic- perhaps the difference from average, or the percentage of improvement if lifestyle is changed. Something to improve the understanding of the message.*	This is beyond the scope of the study. No action was taken.
Reviewer 7 (expert)	*I don't understand the purpose of the two buttons marked 'moderate risk' and 'high risk'*	This comment refers to the small thumbnails on the metonym format designed for users to see where their category fits in along the risk category scale of low, moderate and high. Displaying only the relevant risk category will not allow users to put the metonym representing their risk into context. No action was taken.
Reviewer 8 (expert)	*Blue link text on the basic calculated display disappears when highlighted.*	This has been amended.
Reviewer 10 (expert)	*Explanation of CHD event – don't think MI or cardiac procedure were as helpful to a layperson as it could be.*	This has been amended.
Reviewer 14 (expert)	*Would be nice to be able to print off your risk profile at the end, not just request it by email – it would also preserve your anonymity.*	Although, this is preferable, it was beyond the scope of the web-developers to achieve this. No action was taken.

Table 6.6 Comments regarding the post-intervention questionnaires.

Reviewer	Comment	Action taken
Reviewers 1 & 2 (non-experts)	*The only bit I wasn't sure of was the section at the end about exercise and weight. I wondered if this had been calculated from the information that I'd given and it was recommended that I exercise more and lose weight.*	This has been addressed by adding wording at the start of the post-intervention questionnaire that address why the study asks about intentions to stop smoking, losing weight and exercising more.
Reviewers 3 & 4 (non-experts)	*Questionnaire was a bit repetitive.*	This is a personal opinion. No action was taken.
Reviewer 6 (expert)	*I don't think I understood some of the option about fear and exercise fully, so may have flipped through without giving them enough attention, so perhaps reducing their value.*	This is personal opinion, no a website issue. No action was taken.
Reviewer 7 (expert)	*In Qs 51-54 the numbers attributed to each level of difficulty. Etc. seem intuitively to be the wrong way around. I would expect to select -3 for difficult for example rather than +3. Ditto for 66-69.*	The questionnaire format has different response endpoints to reduce the possibility of response bias. No action was taken.
	Q60 asks if I am prepared to lose weight. Is it asking me if I am ready to try losing weight or if I am willing to try losing weight, which are not the same thing.	More than one item measuring each component of the TPB was used to assess the internal reliability/ consistency of user's responses. No action was taken.
Reviewer 8 (expert)	*If question 56 is missed it is highlighted. If it is subsequently filled in but something else is missed, it is still highlighted.*	This has been amended.

Reviewer	Comment	Action taken
Reviewer 10 (expert)	*Wasn't clear why we had to go through the first set of questions again, about being angry, anxious etc. – some explanation might help. It was tempting to just give the same answers as before without thought.*	Wording has been added to this page to address this point.
	Q 69 was hard to answer – forgot to write it down.	This is personal opinion. Not a website issue.
Reviewer 11 (expert)	*Q 48-51 – isn't entirely clear what you are supposed to read here – it may be that patients might be confused and think the question has been missed off.*	This has been amended.
	Also, the scale on Qs 51-54 is confusing given what has gone before, why not just use 1-7 as above?? Same with other questions using this scale.	The questionnaire format is recommended by published guidelines on constructing TPB questionnaires. No action was taken.
	Page with Q60-65 – programme got stuck after complete all qs and I couldn't move on.	It is not possible to determine the cause of this, as only one reviewer has mentioned it, to action has been taken and the cause attributed to a computer glitch.
Reviewer 13 (expert)	*I don't consider I need to lose weight and so all the losing weight section seemed irrelevant and a bit irritating. Is it not better to exclude this if BMI below 24?*	The appropriateness of responses regarding intention to lose weight and actual BMI will be assessed.
Reviewer 14 (expert)	*Weight reduction – q69. 'difficult' is mis-spelt.*	This has been amended.

Reviewer	Comment	Action taken
Reviewer 15 (expert)	*The questions at the end here have no real introduction – so their purpose is not clear – I think a few introductory words 'Now we'd like to check out your views on taking more exercise and losing weight...' or similar.*	Wording has been added to this page to address this point.
Reviewer 16 (expert)	*Click to continue after questions 31-33 didn't work, first, but then it jumped to questions 47-54.Maybe I clicked twice, thinking the first click didn't register. Though one isn't allowed to move forward from other pages that require responses - ???*	It is not possible to determine the cause of this, as only one reviewer has mentioned it, to action has been taken and the cause attributed to a computer glitch.
	Questions 51-54 are appropriately scored as -3 to +3 for analysis - but this might be off-putting to numerically challenged respondents - why switch from using 1 to 7? Ditto 66-69.	The questionnaire format is recommended by published guidelines on constructing TPB questionnaires. No action was taken.
	Are questions 60-65 appropriate to ask of someone for whom there would be no great advantage to losing weight? I don't like my trousers being tight around my waist, but I don't feel inclined to actively lose weight for health reasons - I don't think you do either.	The appropriateness of responses regarding intention to lose weight and actual BMI will be assessed.
Reviewer 17 (expert)	*Q33 – didn't know what to answer here, my indicated risk was very low but of course 'do as much as you can' is the only answer possible even when you're at low risk.*	The question is designed to measure instances like this.
	Similar for Q60: of course I am prepared to lose weight but how does this fit in with weight not being an issue in some cases? Guess the problem is that I don't quite see what these answers would tell you.	The appropriateness of responses regarding intention to lose weight and actual BMI will be assessed.
	Q51: hesitated a long time here as to how to interpret the sudden switch to the -3,-2,-1,0.1,2,3 answer format..numbers are not my strong point and even now I'm not quite sure if I gave the answers I intended to give.	The questionnaire format is recommended by published guidelines on constructing TPB questionnaires. No action was taken.
Reviewer 18 (expert)	*I was confused by the difference in answering scales. It was all 7-point, which is fine. But sometimes the scale was -3, to +3 (e.g. in questions 51-54) instead of 1 to 7. I would opt for the latter format only.*	The questionnaire format is recommended by published guidelines on constructing TPB questionnaires. No action was taken.

Reviewer	Comment	Action taken
Reviewer 19 (expert)	*Why don't you change all questions to strongly agree- strongly disagree?*	The questionnaire format has different response endpoints to reduce the possibility of response bias, where users do not read all of the questions properly. No action was taken.
	Some of the questions do not make sense.	This is personal opinion, the questions were piloted previously. As only one reviewer mentioned this, no action was taken.

Table 6.7 Comments regarding the end of study and contact details pages.

Reviewer	Comment	Action taken
Reviewers 1 & 2(non-experts)	*We both wanted to check 2 boxes on education.*	The question asks for the highest level of education attained. No action is taken.
Reviewer 9 (expert)	*Progress bar still had a way to go once I'd finished.*	This has been amended.
Reviewer 13 (expert)	*Last page told me I could close the browser, yet progress line was only 90% complete.*	This has been amended.
Reviewer 17 (expert)	*I would have loved a 'close' button of some kind on the very last page instead of just the advice to close the browser. A psychological thing, I guess, I want to know I've rounded off something, completed something. Closing the browser just means I'm moving on to something else and leaving something 'open' behind me. It's all in the mind, I know, but it does make a difference, I think.*	A message informing users that they may close the web-browser has been added.

General comments

Two reviewers commented on the lack of a functional back button and one reviewer reported that they had to zoom out (decrease the size of the webpage) to view all of the webpage. However, due to the *Adobe Acrobat Flash* software it was not possible to address these comments. It was suggested that an indication should be given at the beginning of the website about how long it is likely to take to complete the study. This was added to the participant information page. One reviewer commented on the fact that the wording throughout the website appeared in different sized fonts which could be distracting to users. Therefore, this was amended so that the important information of the page appeared in the biggest font with information of less importance in a smaller font.

Functionality of data storage

The data storage of the server was also assessed. No problems were found with the database of respondent's answers or the web-logs of the times each web page was visited.

Table 6.8 General comments made about the website.

Reviewer	Comment	Action taken
Reviewer 5 (non-expert)	*'No back button, couldn't see if I'd filled in the last question on a page and there was no way to go back and see'.*	This is a feature of the website being constructed in Adobe Flash, it cannot be changed.
Reviewer 8 (expert)	*'At whom is this aimed? The language used appears to be above 9 –year-old/sun reader literacy level'.*	This is a personal opinion, The author does not agree with this comment.
Reviewer 13 (expert)	*'Font sizes differed and the information in largest font did not always seem most important. This seemed a bit of a distraction – maybe better all the same size?'*	The font for all web-pages was assessed to make sure important info appeared in bigger font.
Reviewer 16 (expert)	*'The back button on the browser doesn't work with this site - is this deliberate? Desirable? I would have liked to go back, if only to see the pages I missed. Obviously we don't want people to be able to alter what they responded before seeing their risk - but I'm not sure that, after this stage, it is appropriate to prevent them doing so.'*	This is a feature of the website being constructed in Adobe Flash, it cannot be changed.
Reviewer 18 (expert)	*'Should give info about responding time (about 10 mins) at the beginning.'*	This has been added.
	'There was no escape during the process. Does this mean that you will only generate data on participants who have gone through all pages? Will you not file non- or incomplete responders?'	Every visit to the website will be logged.
	'I had to zoom out to view the complete home page'.	This is due to the size of the website pages and cannot be changed.

Internal reliability of the Theory of Planned Behaviour questionnaire

It is best practice to assess the internal reliability of a newly developed questionnaire at the piloting stage (Oppenheim 2001), so that inconsistent items can be identified and addressed, e.g. items not meeting the reliability requirements can be eliminated from the final questionnaire. However, due to the small sample size of the second phase of the pilot testing, it was not possible to assess the internal reliability of the Theory of Planned Behaviour questionnaire at this stage. An assessment of Cronbach's Alpha Coefficient was made in the analysis of the main trial data. Appendix 39 shows screenshots of the final versions of the web pages to be used in the main trial.

6.3 Summary

To summarise, this chapter has described the development of the website to be used in the web-based RCT; and the results of the two phase pragmatic pilot study that assessed the layout, usability and functionality of the website.

Chapter 7. Primary results of a web-based randomised controlled trial of cardiovascular risk representation formats.

7.1 Introduction

This chapter describes the primary results of the web-based randomised controlled trial of cardiovascular risk representation formats. The chapter is divided into sections according to the research objectives and/or hypotheses. This chapter also presents the data screening procedures, assumption testing, sample characteristics and summary statistics of the outcome measures.

The main statistical analyses are presented in the appendices. The syntax and full SPSS outputs are presented in an on-line Google document, accessible by using the following link:

https://docs.google.com/viewer?a=v&pid=explorer&chrome=true&srcid=0B0ZzQPPd5mfKZTQ0MjliMDgtMjE3MS00MGVlLWIyMmItMTQzZjMwZGIyMzlk&hl=en_GB.

The primary objectives described in this chapter are outlined below:

- Assessment of the effects of the cardiovascular risk representation formats to assess which format leads to the greatest *intention to change behaviour*, best

facilitates *understanding of risk information* and alters *positive and negative affect* and *worry about future heart disease*.

- Multiple regression analysis to determine which variables predict *intention to change behaviour*.
- Assessment of within group changes in *positive and negative affect* and *worry about future risk of heart disease* after viewing cardiovascular risk.
- Analysing the correlational validity between *intention to change behaviour*, and *understanding of risk information*, to find out if understanding results in more appropriate intentions to change behaviour to reduce cardiovascular risk.
- Examination of the level of *worry about future risk of heart disease* that increases *intention to change behaviour*.
- Determining whether responses are mediated by a respondent's risk category, by conducting sub-group analyses on responses.

7.2. Data screening

This section explains the initial data screening preceding the main analyses, including how a violation in the condition allocation randomisation was rectified. The trial commenced on 11th February 2010 and ended on 7th June 2010. The flow of participants through each stage of the recruitment process is also described.

7.2.1 Randomisation violation

The distribution of respondents allocated to each condition made by the website's randomiser was examined when just over 100 respondents had been recruited to the study. It was evident that the original algorithm was biased towards two of the four conditions (Conditions 2 and 3). The reason behind this is demonstrated in Appendix 40. Unfortunately, due to the small sample this issue was not identified in the pilot study. An alternative algorithm was suggested (Appendix 41). Before incorporating the alternative algorithm into the site a demonstration file (demo.swf) created a dummy run to look at the distribution of random numbers generated over time. Screenshots of the dummy runs using both algorithms are presented in Appendix 42.

Two goodness of fit Chi-square tests were conducted to ensure that the alternative algorithm was working correctly, and producing an equal chance of the four conditions being selected (Appendix 43). With 90 randomisations, the expected chi-square would be 10, corresponding to a power of just under 90% (i.e. a 10% risk that there would be a failure in detecting that the new algorithm was still wrong). The first goodness of fit Chi-square test looked at whether there were any consistent differences between the numbers allocated to the four conditions, which were all treated on an equal footing. Therefore, the resulting Chi-square statistic was interpreted as having 3 degrees of freedom. There was a significant difference between the total number of times each condition was selected in the randomisation using the original algorithm (Chi square = 94.83, df=3, p=.000). Conversely, when the alternative algorithm was assessed, there were no significant differences

between the conditions in terms of the number of times they were selected for randomisation (Chi square = 4.21, df=3, p=.240).

The second goodness of fit Chi-square test compared the total number in conditions 1 and 4 with the total number in conditions 2 and 3. Again, a significant difference between conditions was found for the original algorithm (Chi square = 94.39, df=1, p=.000) and no significant differences were found for the alternative algorithm (Chi square = 2.20, df=1, p=.138). Therefore, as both types of analyses agreed, it was concluded that the original algorithm produced a clear discrepancy well beyond the limits of chance variation, whereas, the differences between the group frequencies with the alternative algorithm were within chance variation.

The alternative algorithm was installed into the site and a clear distinction between the respondents randomised using the original algorithm and those randomised using the alternative algorithm was made.

A number of options could have been employed to rectify the randomisation violation. Firstly, all the responses that were randomised according to the original algorithm could have been discarded. This option was not optimal, as a large sample size was needed for the trial. Second, it could have been ensured that the next 120 respondents got allocated to the four conditions in the ratio of 40: 20: 20: 40, and equally thereafter as this does not 'waste' any respondents' data. However, this option was rejected due to the confounding between group allocation and position in the recruitment sequence. Lastly, a random half of the data from conditions 2 and 3

could be discarded, which had the risk of decreasing the sample size and hence reducing the power. This was thought to be more favourable compared to group allocation confounding. Therefore, the latter option was chosen and a random half of the responses from conditions 2 and 3 in the first phase were discarded from the first 100 recruits. A simple coin toss determined whether responses 1, 3, 5 etc. were excluded over 2, 4, 6 etc. In accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Schulz et al. 2010), the trial flowchart (Figure 7.1) demonstrates this protocol violation. 53 cases were excluded in total.

7.2.2 Cleaning of database

An SQL database stored the responses of visitors to the website. This database was queried and exported via comma separated variables (CSV), into an Excel spreadsheet. Partially completed responses were excluded, as were entries made by spy bots and crawlers (i.e. non-human activity). Non-human activity was identified by analysing the database for instances where a webpage had been completed, but no randomisation had occurred, meaning that the homepage had not been visited and no consent given.

Flow of participants through the trial

The CONSORT diagram (Figure 7.1) demonstrates the flow of participants through each stage of the trial. There were 2463 visits to the homepage in total; 342 respondents did not meet the inclusion criteria of being between 45 to 64 years of age and not having existing heart disease. 31 did not consent, so did not proceed with the study. However, this figure is only an approximation as it cannot be determined how many respondents were not eligible or did not consent, and exited the website by closing the web browser instead of checking the appropriate boxes on the eligibility assessment and consent pages.

There were 144 incomplete responses and 18 cases that contained some missing data. As the website required all responses to be completed before proceeding to the next page, it is likely that this was due to a technical glitch involving the storing of data by the host Server. Cases that were not fully completed were excluded. Because there were only a small number of affected cases and the missing values were randomly distributed through the data, a listwise deletion (where an entire record is excluded from the analysis if any single value is missing) was chosen, as opposed to a pairwise deletion (which excludes missing data cases only from the calculations that involve variables with missing data) (Allison 2001; Statsoft 2010).

The fully completed responses were imported into SPSS version 16. Cleaning the dataset revealed three duplicate responses, thought to be due to a database bug. The duplicates were excluded, leaving a total of 908 completed responses.

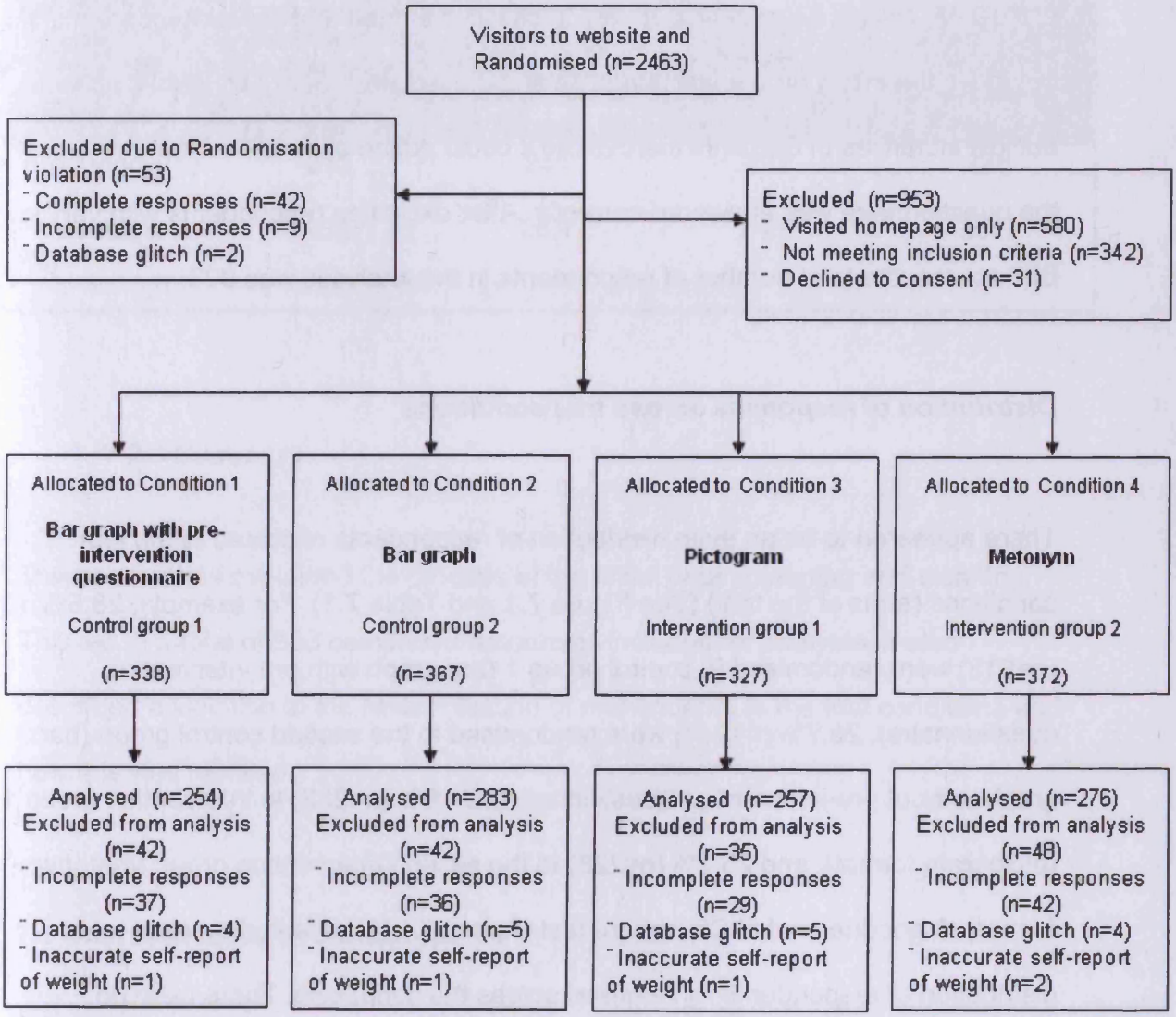


Figure 7.1 CONSORT diagram of flow of participants through each stage of the Randomised Controlled Trial.

Values were screened for plausibility. When the 'Weight' variable was analysed, 5 cases were identified where respondents reported they weighed 25kg (3 stone 13 lbs). As this is highly unlikely in an adult, it was assumed that these respondents did not move the arrow on the weighing scales. These cases were excluded by filtering out low instances of BMI less than 15, as it could not be ascertained that the rest of the questionnaire was answered correctly. After excluding respondents with very low BMI socres, the total number of respondents in the analyses was 903.

Distribution of responses across trial conditions

There appeared to be an even distribution of respondents allocated to the four conditions (arms of the trial) (See Figure 7.1 and Table 7.1). For example, 23.5% (n=212) were randomised to control group 1 (bar graph with pre intervention questionnaire), 26.7% (n=241) were randomised to the second control group (bar graph without pre-intervention questionnaire), 24.6% (n=222) to intervention group 1 (pictogram format), and 25.2% (n=228) to the second intervention group (metonym format). A goodness of fit Chi-square test (Appendix 44) revealed an even distribution of respondents randomised across the conditions. There were no significant differences between the number of respondents allocated to the four conditions (Chi square = 1.965, df = 3, p=.580).

Table 7.1 Distribution of responses across trial conditions.

Condition	Bar graph with pre-intervention questionnaire Control group 1	Bar graph Control group 2	Pictogram Intervention group 1	Metonym Intervention group 2
Frequency (n)	212	241	222	228
Percentage (%)	23.5	26.7	24.6	25.5

7.2.3 Summary

This section has explained the process of the initial data screening and cleaning. This led to a total of 903 completed responses included for analysis. It also described a violation in the randomisation of respondents to the trial conditions and how this was rectified.

7.3 Characteristics of the sample

This section describes the characteristics of the sample who participated in the trial. Frequencies of the sex, age, level of education and risk factor information are reported.

7.3.1 Sex and Age of respondents

Of the 903 fully completed responses included in the analysis, 61.7% (n=557) were female. Table 7.2 presents the frequencies of the characteristics of the sample. 34.9% (n=315) were between 45 and 49 years and 19.8% (n=179) were between 60-64 years. The frequencies of individual ages were analysed (Figure 7.2), the mean age was 53 (SD 6.06) years (Appendix 45). An over representation of 45-year olds was found (n=119, 13.2%), the most plausible explanation is that respondents who were too young to participate wanted an assessment of future cardiovascular risk projected at age 45, and therefore indicated that they were within the eligible age range. However, this cannot be determined for certain. It was decided to include these respondents as this was unlikely to impact on the main aim of the study, which was to investigate the effects of cardiovascular risk representation formats. Exclusion would have reduced the power of the sample to detect differences between the formats.

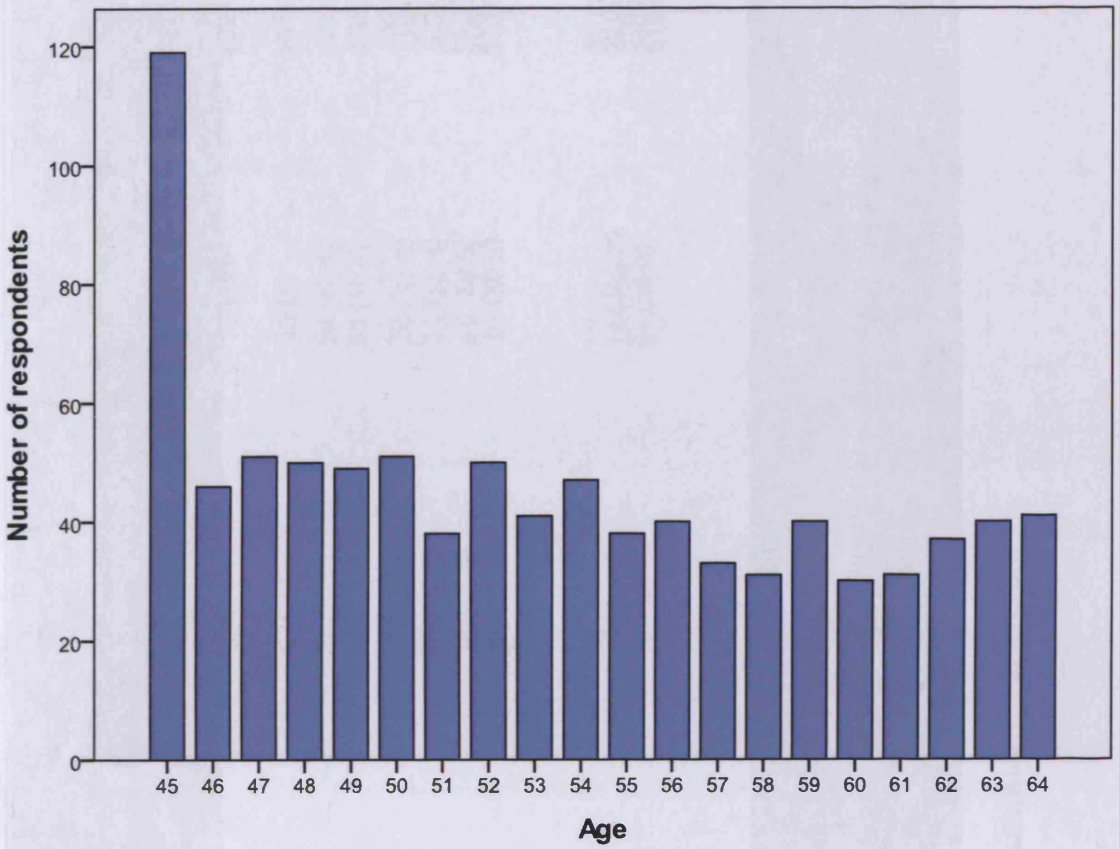


Figure 7.2 Age of respondents.

Table 7.2 Characteristics of sample.

Characteristic	Bar graph with pre-intervention questionnaire Control group 1 n (%)	Bar graph Control group 2 n (%)	Pictogram Intervention group 1 n (%)	Metonym Intervention group 2 n (%)	Total n (%)
Sex					
Male	82 (38.7)	101 (41.9)	79 (35.6)	84 (36.8)	346 (38.3)
Female	130 (61.3)	140 (58.1)	143 (64.4)	144 (63.2)	557 (61.7)
Age					
45-49	76 (35.8)	92 (38.2)	86 (38.7)	61 (26.8)	315 (34.9)
50-54	42 (19.8)	64 (26.6)	55 (24.8)	66 (28.9)	227 (25.1)
55-60	48 (22.6)	45 (18.7)	38 (17.1)	51 (22.4)	182 (20.2)
60-64	46 (21.7)	40 (16.6)	43 (19.4)	50 (21.9)	179 (19.8)
Highest level of Education					
Left school before age 16 (no formal qualifications)	10 (4.7)	8 (3.3)	6 (2.7)	16 (7)	40 (4.4)
Left school at 16 (GCSE, CSE, O level or equivalent)	19 (9)	22 (9.1)	32 (14.4)	32 (14)	105 (11.6)
Left school *at 18 (A levels or equivalent)*	14 (6.6)	13 (5.4)	12 (5.4)	3 (1.3)	42 (4.7)

Characteristic	Bar graph with pre-intervention questionnaire	Bar graph	Pictogram	Metonym	Total
	Control group 1	Control group 2	Intervention group 1	Intervention group 2	
	n (%)	n (%)	n (%)	n (%)	n (%)
Risk factors					
Family history of heart disease	37 (17.5)	38 (15.8)	47 (21.2)	39 (17.1)	161 (17.8)
Hypertension	31 (14.6)	45 (18.7)	45 (20.3)	35 (15.4)	156 (17.3)
Hypercholesterolemia	41 (19.3)	58 (24.1)	39 (17.6)	48 (21.1)	186 (20.6)
Diabetes	8 (3.8)	9 (3.7)	8 (3.6)	9 (3.9)	34 (3.8)
BMI <30	159 (75)	184 (76.3)	177 (79.7)	175 (76.8)	695 (77)
BMI >30	53 (25)	57 (23.7)	45 (20.3)	53 (23.2)	208 (23)
Smoking status					
Current	19 (9)	20 (8.3)	26 (11.7)	16 (7)	81 (9)
Former	66 (31.1)	90 (37.3)	71 (32.0)	82 (36)	309 (34.2)
Never	127 (59.9)	131 (54.4)	125 (56.3)	130 (57)	513 (56.8)
Level of physical activity					
Seldom/ never	60 (28.3)	72 (29.9)	58 (26.1)	54 (23.7)	244 (27)
Sometimes	80 (37.7)	82 (34)	80 (36)	94 (41.2)	336 (37.2)
Often/ very often	72 (34)	87 (36.1)	84 (37.8)	80 (35.1)	323 (35.8)

7.3.2 Level of education

Respondents were asked to indicate their highest level of education attained. 40 (4.4%) left school before the age of 16; 105 (11.6%) were educated to GCSE level, and 42 (4.7%) were educated to A level. Over half the sample (53%, n=479) were educated to university degree level or higher (Table 7.2). This is higher than the estimated 20 per cent of the adult population who are educated to university degree level or higher in the UK, according to Census data (Office for National Statistics 2001). 13% (n=117) of respondents in the sample did not wish to disclose information on their level of education, perhaps this was due to privacy fears. A Chi-square test (Appendix 46) revealed no significant differences in the level of education of respondents across conditions (Chi square = 24.544, df = 18, p=.138).

7.3.3 Risk factor information

To predict the risk of a future coronary heart disease event, respondents were asked questions about their risk factors. This information comprised age, sex, family history of heart disease, diagnosis of hypertension, hypercholesterolemia or diabetes, smoking status, level of physical activity and BMI (Mainous et al. 2007).

Family history of heart disease was reported by 17.8% (n=161) of respondents. This was defined as a parent who was under the age of 50 when told by a clinician that they had heart disease. 17.3% (n=156) stated that a clinician had diagnosed them

with high blood pressure, and 20.6% (n=186) stated they had been diagnosed with high cholesterol. 34 respondents (3.8%) reported they had diabetes. Of these, 3.1% of the sample were female and 4.9% were male. This is similar to the estimated overall prevalence rate of diabetes in England in 2006 in people aged 45 to 54 years of age, which was 3.6% for women, but lower than the 6% prevalence rate in men (Diabetes UK 2010).

Respondents were asked to input their height and weight to calculate their BMI score. The mean BMI score was 27 (SD 5.76). 23% of respondents (n=208) reported a BMI of 30 and over which is considered as being obese/ morbidly obese (Appendix 45). This is the same as the estimated percentage of adults in the UK classed as overweight/obese in 2009 (The NHS Information Centre for Health and Social Care 2009).

When asking about smoking status, there were three response categories for respondents to chose from: *current smoker, former smoker* (i.e. smoked in the past but no longer) and *never smoked*. 81 respondents (9%) reported that they were current smokers and 309 (34.2%) were former smokers. This is lower than the national average of current smokers reported to be 21% in 2008 (Robinson and Bugler 2010). Additionally, respondents were asked to report their level of physical activity. Response options were: *seldom or never*, *occasionally* and *often or very often*. 35.8% (n= 323) exercised or played sport often or very often, 27% (n=244) reported that they seldom or never exercised or played sport (Table 7.2).

7.3.4 Risk category

Once the risk factor information had been obtained, the cardiovascular risk calculator provided respondents with their risk category. The calculator provides a predetermined classification of the risk of having a coronary heart disease event in the next 10 years (i.e. low, moderate and high). It uses conventions of under 10% to define low risk, 10-20% to define moderate risk and over 20% to define high risk. This trial adopts these conventions as used in the Personal Heart Score (Mainous et al. 2007). However, it is acknowledged that there is discussion in the literature regarding risk category thresholds (Graham 2007; Joint British Societies 2005). The majority of respondents fell into the low risk category (82.8%, n=748). 127 (14.1%) were at moderate risk and 28 (3.1%) were categorised as high risk. The number of respondents at moderate and high risk was lower than expected, when considering that CVD is the main cause of death in the UK (Scarborough et al. 2010).

7.3.5 Requesting copy of risk assessment results

At the end of the study, respondents indicated whether or not they wanted a copy of their risk output. Respondents wanting a copy of their output left their contact details, for their results were emailed to them. 143 respondents (15.8%) in total requested a copy of their risk output.

The *Bar graph* condition had the highest proportion of respondents requesting a copy of their risk output (n=40) and the *Metonym* condition had the lowest proportion of respondents requesting a copy of their risk output (n=31). A Chi-square (Appendix 47) revealed no significant differences across conditions between those who requested a copy of their risk output and those that did not (Chi square = 2.163, df = 3, *p*=.539).

Table 7.3 Frequencies of respondents who request a copy of their risk output results for each of the trial conditions.

Condition	Bar graph with pre-intervention questionnaire Control group 1	Bar graph Control group 2	Pictogram Intervention group 1	Metonym Intervention group 2	Total
Frequency (n)	39	40	33	31	143
Percentage (%)	18.4	16.6	14.9	13.6	15.8

7.3.6 Summary

This section has reported the characteristics of the sample who participated in the trial. To summarise, the sample recruited was different to the expected cohort of respondents participating in this trial in this age group. Over half of the sample were female, there was an over representation of 45 year olds (the lower end of the age

range for study inclusion), and the sample was highly educated. They smoked less, but reported similar BMI scores those of the general population. However, there was an even spread of respondents across physical activity levels. The majority of respondents were categorised as low risk, and there were fewer moderate and high risk respondents than expected.

7.4 Variables measured

This section describes the primary and secondary outcome measures that were used in this trial. It also provides summary statistics of each outcome measure.

7.4.1 Primary and Secondary Outcome Measures

The primary and secondary outcome measures are described in Table 7.4. The primary outcome measure comprised *intention to change behaviour* (e.g. exercising more, losing weight and stopping smoking). The secondary outcome measures comprised *understanding of risk information* (comprising *level of understanding* and *confidence in understanding*), *affect* (*positive* and *negative)* and *worry about future risk of heart disease*.

Table 7.4 Description of primary and secondary outcome measures.

Outcome Measure	Components	Example of item	Scoring
Intention to change behaviour	Intention to exercise more	I intend to exercise more.	7-point Likert scales indicating higher scores indicate greater intentions
	Intention to lose weight	How likely are you to lose weight?	
	Intention to stop smoking	To what extent are you prepared to stop smoking?	
Understanding of risk information	Absolute probability perception	*What are your chances of having heart disease in the next 10 years?*	3 pre-defined response options: • Low • moderate • high
	Subjective understanding of the risk information	*What should someone in your risk category do to reduce their risk of heart disease?*	3 pre-defined response options: • Do nothing to reduce risk • Try and do a little bit to reduce risk • Do as much as you can to reduce risk
	Confidence in understanding	*How confident are you that you have understood the risk information given to you?*	7-point Likert Scale indicating degree of confidence in understanding
Affect Positive and Negative Affect Schedule- Short Form (PANAS-SF) (Thompson 2007)	Positive affect	*Thinking about yourself right now at this present to what extent do you feel inspired?*	5-point Likert response scale anchored 'not at all' to 'extremely'
	Negative affect	*At this present moment to what extent do you feel upset?*	5-point Likert response scale anchored 'not at all' to 'extremely'
Worry about future heart disease	-	*After viewing your results, how worried do you feel about developing heart disease in the future?*	7-point Likert response scale from very worried' to 'not at all worried'

Intention to change behaviour

Items measuring *intention to change behaviour* (e.g. exercising more, losing weight and stopping smoking) were summed and a mean *intention to change behaviour* score was calculated. Higher scores represented greater intentions to change behaviour.

Understanding of risk information

Understanding of risk information was measured using *level of understanding* and *confidence in understanding* components. *Level of understanding* assessed the appropriateness of *absolute probability perception* (i.e. recalling the risk category) and *subjective understanding* (i.e. what a person with the same risk category should do about their cardiovascular risk) responses. *Absolute probability perception* and *subjective understanding* responses were assessed for accuracy. Respondents who correctly answered both of these items scored two and were said to have *complete understanding.* Those answering one item correctly scored one and were said to have *partial understanding.* Those with no correct items scored zero and were deemed to have *no understanding.* These aggregate scores represented the variable *level of understanding. Confidence in understanding* was measured by asking respondents how confident they were that they had understood the risk information. A 7-point Likert Scale indicated the degree of confidence in understanding.

Affect

Affect was measured at baseline as well as post-intervention, in order to assess changes after viewing the different representations of cardiovascular risk. Scores from the *positive and negative affect* items were summed separately, giving total scores out of 25. Higher scores indicated a greater degree of positive or negative affect.

Worry about future risk of heart disease

Worry about future risk of heart disease was measured at baseline and post-intervention to assess within-group changes after viewing the different representations of cardiovascular risk. Higher scores indicated a greater level of worry about the future risk of heart disease.

Summary statistics

Table 7.5 provides baseline and post-intervention summary statistics for the primary and secondary outcome measures. Mean *intention to change behaviour* scores were above the mid-point of the scales, indicating high intentions to *exercise more* (M=5 SD=1.22), *lose weight* (M=4.65, SD=1.6) and *stop smoking* (M=4.06, SD=1.61).

Mean *level of understanding* was 1.09 (SD=.41) which represents *partial understanding* of the risk information presented. This means they either answered the *absolute probability* item correctly (suggesting they accurately recalled their risk category) or the *subjective probability* item correctly (suggesting they understood the appropriate degree of action that needed to be taken by someone of the same risk category). A high degree of *confidence in understanding* (M= 6.07, SD=1.24) was demonstrated by the respondents.

At baseline, respondents had greater *positive affect* (M=18.11, SD=2.99) than *negative affect* (10.68, SD=2.78). These both decreased post-intervention (i.e. after viewing cardiovascular risk), *positive affect* decreased to 17.64 (SD=3.86) and *negative affect* decreased to 7.59 (SD=3.35). *Worry about future risk of heart disease* had a mean of 2.8 (SD=1.04) at baseline and 2.15 (SD=0.98) post-intervention, indicating that respondents generally possessed low levels of *worry about the future risk of heart disease,* which further reduced after viewing cardiovascular risk. Statistical analysis on within-group changes are described in section 7.8 of this chapter.

Table 7.5 Baseline and post-intervention summary statistics for the primary and secondary outcome measures.

Outcome Measures	Intention to Change Behaviour			Baseline and post-intervention Positive affect		Baseline and post-intervention Negative Affect		Baseline and post-intervention worry about future risk of heart disease		Understanding of risk information	
	Intention to Exercise More	Intention to Lose Weight	Intention to Stop Smoking	Baseline Positive affect	Post-intervention Positive affect	Baseline Negative affect	Post-intervention Negative affect	Baseline Worry	Post-intervention Worry	Level of understanding	Confidence in understanding
n	903	903	81	903	903	903	903	903	903	903	903
Mean	5	4.65	4.06	18.11	17.64	10.68	7.59	2.8	2.15	1.09	6.07
SD	1.22	1.6	1.61	2.99	3.86	2.78	3.35	1.04	0.98	0.41	1.24
Median	5	5	4	18	18	10	6	3	2	1	6
Mode	5	5	4	19	20	10	5	3	2	1	7
Min	1	1	1	5	5	5	5	1	1	0	1
Max	7	7	7	25	25	23	25	5	5	2	7

7.4.2 Tertiary Outcome Measures

The tertiary outcome measures (Table 7.6) included the sub-components of the Theory of Planned Behaviour (Ajzen 1991), measuring the three risk reducing options (exercise more, lose weight and stop smoking). The mean scores were determined by summing the items and dividing by the number of items measuring each sub-component.

Attitudes

Attitudes comprise *evaluative* (e.g. evaluation using bipolar opposites), *instrumental* (e.g. whether the behaviour achieves something) and *experiential* (e.g. how it feels to perform the behaviour) items. A higher attitude score indicated a more positive attitude to perform the behaviour.

Perceived behavioural control

Perceived behavioural control represents self-efficacy about performing the behaviour and the degree that the respondents feel control over performing the behaviour. Higher scores indicate greater self-efficacy and controllability over the behaviour.

Table 7.6 Description of tertiary outcome measures.

Tertiary outcome measure	Components	Example of item	Scoring
Attitudes	Evaluative	*For me stopping smoking would be... Bad/ Good.*	7-point Likert scale
	Instrumental	– *For me losing weight would be...* the wrong thing to do / the right thing to do.	
	Experiential	*For me exercising more would be...* Unenjoyable / Enjoyable.	
Perceived behavioural control	Self-efficacy	*I am confident that I can exercise more.*	7-point Likert scale
	Controllability of the behaviour	*Whether I lose weight or not is entirely up to me.*	
Subjective norms	-	*I feel under social pressure to lose weight.*	7-point Likert scale
Indirect measure of intention to change behaviour	-	Measured by examining whether respondents requested a copy of their risk output results.	

Subjective norms

Subjective norms relate to the perceptions of significant others' preferences about whether one should or should not engage in a specific behaviour. A higher score indicates a greater influence of subjective norms.

Indirect measure of intention to change behaviour

Lastly, an indirect measure of *intention to change behaviour to reduce cardiovascular risk* was measured by whether respondents requested a copy of their risk output results, which it was suggested that they could take it to their GP.

Summary statistics

Table 7.7 shows the baseline and post-intervention summary statistics for the tertiary outcome measures. Mean *attitude* scores ranged from 1.45 (SD= 1.21) to 1.79 (SD=1.14) indicating a low positive attitude towards exercising more, losing weight and stopping smoking. The influence of *subjective norms* was less for *losing weight* (M=3.38, SD=1.62) than it was for *exercising more* (M=5.63, SD=1.06) and *stopping smoking* (M=5.19, SD=1.33). Lastly, mean *perceived behavioural control* for all behaviours ranged from 4.62 (SD=1.08) to 5.22 (SD=1.09), indicating respondents

felt a high degree of self-efficacy and control over exercising more, losing weight and stopping smoking.

7.4.3 Summary

This section has summarised the primary, secondary and tertiary outcomes of this trial. The summary statistics across all trial conditions for each outcome measure have been reported. *Intentions to exercise more, lose weight and stop smoking*, *positive affect* and *confidence in understanding* after viewing cardiovascular risk were all reasonably high. This was despite the majority of respondents demonstrating only a *partial level of understanding* of their risk information. Conversely, *worry about future risk of heart disease* was low at baseline, and further decreased after viewing cardiovascular risk. *Positive affect* was higher than *negative affect* at baseline, both decreased post-intervention.

The tertiary outcome measures (sub-components of the TPB), *attitudes*, *subjective norms* and *perceived behavioural control* were similar across the three behaviours (exercising more, losing weight and stopping smoking).

Table 7.7 Summary statistics for the post-intervention tertiary outcome measures and pre-intervention questionnaire given to control group 1.

	Pre-intervention Questionnaire items given to Control group 1.				Attitudes			Subjective norms			Perceived behavioural control		
	Intention to reduce risk of heart disease	Attitudes towards reducing risk of HD	Subjective norms to reducing risk of HD	PBC over reducing risk of heart disease	Exercise more	Lose weight	Stop smoking	Exercise more	Lose weight	Stop smoking	Exercise more	Lose weight	Stop smoking
n	211	211	211	211	903	903	81	903	903	81	903	903	81
Mean	6.25	2.21	5.15	5.14	1.78	1.52	1.41	5.63	3.37	5.16	5.22	5.06	4.59
SD	1.26	0.92	1.89	1.17	1.14	1.71	1.21	1.06	1.62	1.33	1.092	1.041	1.067
Median	7	2.33	6	5.50	2	2	1.33	5.67	3.33	5.34	5.25	5.25	4.50
Mode	7	3	7	5.50	3	3	3	6	2	6.33	6	6	4.25
Min	1	-1	1	1	-3	-3	-2	2	1	2	1	1	2
Max	7	3	7	7	3	3	3	7	7	7	7	7	7

7.5 Assumption testing

This section reports the assumptions that needed to be tested before the data were analysed to examine the hypotheses proposed. This included the assessment of normal distributions suitable for parametric tests and identification of univariate outliers.

7.5.1 Normality testing

To assess normality of the variables, the distributions on histograms and normal probability plots were examined (Appendix 48). An alternative way of assessing normal distribution is to look at the Kolmogorov-Smirnov statistic, where normality is assumed if this statistic is significant. However, it is not suitable for use in this trial, as it is common for this statistic to be significant in large samples (Tabachnick and Fidell 2001).

There was deviation from the Gaussian distributional form for two variables (*post-intervention negative affect* and *confidence in Understanding*). *Post negative affect* had extreme positive skewness. It was decided to apply a logarithmic transformation to alter the distribution and remove outliers, making it acceptable to apply parametric statistical tests (Tabachnick and Fidell 2001). It was also necessary to do the same transformation to the data from the variable *Baseline negative affect,* as these data were related to the *post negative affect* variable.

Confidence in understanding was negatively skewed; therefore, scores needed to undergo a process known as 'reflection', to make them positively skewed before they could be transformed. Reflection is done by identifying the highest score in the distribution and adding 1, this creates the 'constant'. Scores are then subtracted from this constant (Tabachnick and Fidell 2001). As the maximum score in the distribution was 7, the constant became 8. A log transformation was performed on the reflected scores. When interpreting a reflected variable, the direction of the interpretation needs to be reversed, or the log transformations can be reflected back keeping the interpretation of the results in the original direction (Tabachnick and Fidell 2001). In this instance, the scores were reflected back. The transformed variables were checked for normality (Appendix 49). The transformed distributions were considered to be normal, and therefore suitable for parametric analysis.

7.5.2 Identification of univariate outliers

The variables were assessed for the presence of univariate outliers. This was done by examining the box plots for each of these variables (Appendix 50). Seven of the variables had outliers (*baseline positive affect, baseline negative affect, baseline worry about future risk of heart disease, post positive affect, confidence in understanding, level of understanding* and *intention to exercise*). The values of these variables were checked for plausibility (assessing whether they were within the range of possible scores and not an error in the dataset). The means of these

variables were compared to the 5% trimmed means (e.g. mean with the top and bottom 5% of cases omitted) before deciding whether to exclude the outliers from subsequent analyses. The 5% trimmed means were almost identical to the means (Table 7.8) and therefore, outlier scores did not need to be omitted from the analysis.

Table 7.8 Means and 5% trimmed means of the variables with univariate outliers.

Variable	Baseline positive affect	Baseline negative affect (log transformed)	Baseline worry	Post positive affect	Confidence in understanding (log transformed, reflected back)	Level of understanding	Intention to exercise more
Mean	18.11	1.01	2.80	17.63	8.21	1.09	5.01
Trimmed 5% mean	18.19	1.06	2.78	17.76	8.20	1.09	5.04

7.5.3 Ratio of cases to independent variables

There are statistical recommendations that relate to the ratio of cases to the number of independent variables measured. To examine this assumption, the number of cases and independent variables in this study was compared with the recommended minimum number of cases per variable needed to satisfy the assumption. This study had a sample of 903 with seven independent variables, giving a ratio of 129 cases

per independent variable. This exceeded the minimum requirement of 111 for testing individual predictors (calculated by the formula =104 + # of independent variables), and 106 for testing multiple correlations (calculated by the formula = N> 50 + 8* # of independent variables) (Tabachnick and Fidell 2001). However, this assumption was violated for the *intention to stop smoking* variable, as only 81 respondents reported that they smoked and answered items relating to smoking cessation. It was decided to proceed with the analyses using this variable but to interpret the results with caution.

7.5.4 Internal reliability of the Theory of Planned Behaviour questionnaire

The internal reliability of items measuring the components of the Theory of Planned Behaviour (TPB) was examined. It was not possible to assess this in the pilot study due to the small sample size. Firstly, the appropriate items were re-coded and/or reverse scored in the SPSS database (Appendix 25). Then, Cronbach's Alpha coefficient was calculated to assess the internal reliability of the TPB components: *attitudes, perceived behavioural control* and *subjective norms* (Appendix 51). For items to possess satisfactory internal reliability, the alpha level should exceed 0.7 (Tabachnick and Fidell 2001). The Cronbach's alpha for the components for each of the three behaviours (*exercising more, losing weight* and *stopping smoking*) were assessed separately (see Table 7.9).

Table 7.9 Cronbach's alpha for the components of Theory of Planned Behaviour.

Component of TPB	Pre- intervention questionnaire	Exercise more	Lose weight	Stop smoking
Intention	**n/a**	**0.54**	**0.90**	**0.88**
Improved to:	-	**0.90** if item Q54 is removed	-	-
Attitudes	**0.56**	**0.74**	**0.96**	**0.58**
Improved to:	**0.76** if item Q17 is removed	-	-	**0.63** if item Q39 is removed
Subjective norms	**n/a**	**0.42**	**0.82**	**0.94**
Improved to:	-	cannot be improved	-	-
Perceived behavioural control	**0.81**	**0.53**	**0.528**	**0.56**
Improved to:	-	**0.65** if item Q55 is removed	**0.56** if item Q68 is removed	**0.62** if item Q42 is removed

There were seven instances where the alpha level was less than 0.7, meaning the items measuring the components of the TPB were not internally reliable. For two of the components (*pre-intervention attitudes* and *intention to exercise more*) a satisfactory alpha level could be achieved by the removal of an item. However, multicollinearity would be caused if this was done for the *intention to exercise more* component, where the other items correlate too highly with each other making one of the items superfluous. Internal consistency is only one aspect of validity; therefore, it

was decided to include all items, with acknowledgment of the lower than ideal alpha level when interpreting results.

It is thought that the poor internal reliability of the components of the TPB may be due to the direct measure of the TPB components (e.g. assessing intention by using three generalised intention items and three predictor variables) as recommended by a manual for constructing TPB questionnaires (Francis et al. 2004). A direct measure of the TPB was chosen as it keeps the number of items to a minimum, thus reducing the cognitive demand on respondents and avoiding attrition. The items appeared to have face validity, where it could clearly be seen which component they were supposed to be measuring. It was decided to proceed with the data analysis without removing any of the items, but to interpret the findings with caution.

7.5.5 Internal reliability of the PANAS questionnaire

Cronbach's alpha coefficient was calculated to assess the internal reliability of the PANAS scale (Thompson 2007). Internal reliability checks were made to PANAS presented at baseline and after respondents had received their results (post-intervention). Positive and negative items were assessed separately (Appendix 52). The alpha levels were satisfactory for the components measuring positive and negative affect at baseline (baseline positive affect $\alpha = 0.78$, baseline negative affect $\alpha = 0.73$), and post-intervention (post-intervention positive affect $\alpha = 0.85$, post-intervention negative affect $\alpha = 0.88$). This means that the components measuring

both baseline and post-intervention positive and negative affect were all internally reliable and all items could be included.

7.5.6 Summary

This section has described the assumptions that were tested to assess the suitability of the data for parametric analysis. Variables that were not normally distributed were log transformed and univariate outliers were identified. These did not have any significant impact on the overall means and were not omitted. There were fewer cases in the *intention to stop smoking* variable than the required ratio of cases per independent variable, due to having a small sample of current smokers. It was decided to proceed and interpret the results with caution. Internal reliability of the TPB was not reached in seven out of fourteen instances. However, this was not rectified due to the limited number of items in the questionnaire and to prevent multicollinearity. This will be acknowledged when interpreting results. Conversely, the internal reliability of the PANAS was measured, and acceptable Cronbach's alpha levels were reached for the positive and negative items that were presented both at baseline and post-intervention.

7.6 The effect of cardiovascular risk representation formats

This section reports the analysis conducted to assess the effects of cardiovascular risk representation formats on the primary and secondary outcome measures. This was to determine which format led to the greatest intention to change behaviour; best facilitated understanding of risk information and appropriately increased/decreased affect and worry about future heart disease. All cardiovascular risk representation formats were compared on an equal footing first for each of the primary and secondary outcome measures separately (i.e. *intention to change behaviour*, *understanding of risk information*, *affect* and *worry about future risk of heart disease*).

Planned comparisons were conducted using three pairwise contrasts (*Bar graph with pre-intervention questionnaire* versus *Bar graph*; *Bar graph* versus *Pictogram*; *Bar graph* versus *Metonym*). The analyses were split by risk category, where risk was dichotomised into two categories: (a) low risk and (b) moderate or high risk. This was to determine whether a person's calculated risk category had any influence on their responses.

7.6.1 Comparing cardiovascular risk representation formats on an equal footing

Analyses of variance (ANOVA) were conducted to explore the impact of cardiovascular risk representation formats on *intention to change behaviour, level of understanding, positive and negative affect* and *worry about future risk of heart disease*. The four conditions were first compared on an equal footing using one-way ANOVAs (e.g. the four risk representation formats: bar graph with pre-intervention questionnaire, bar graph, pictogram and metonym). An advantage of the ANOVA is that it is robust when parametric test assumptions are not entirely met, providing that the cell sizes are equal (Brace et al. 2006). Table 7.10 summaries the ANOVA results for these variables.

The subsequent four tables (Tables 7.11 – 7.14) show the summary statistics for each of the primary outcomes (*intention to change behaviour, understanding of risk information, affect and worry about future risk of heart disease*) across the conditions respectively.

Table 7.10 Results of ANOVAs examining the effects of risk representation formats on intention to change behaviour, understanding of risk information, affect and worry about future risk of heart disease.

Effect	d.f.	*F*	*p*	partial η^2
Intention to exercise more	3	0.655	0.580	0.002
Intention to lose weight	3	0.710	0.546	0.002
Intention to stop smoking	3	1.436	0.239	0.053
Level of understanding	3	0.944	0.419	0.003
Confidence in understanding	3	1.108	0.345	0.004
Positive affect	3	1.595	0.189	0.005
Negative affect	3	0.776	0.507	0.003
Worry about future risk of heart disease	3	0.021	0.996	0.000

Intention to change behaviour to reduce cardiovascular risk

Table 7.11 demonstrates the summary statistics for *intention to exercise more, lose weight* and *stop smoking* across the four conditions. The results were not displayed in bar graphs as these are not helpful when displaying small amounts of variation. Intentions to stop smoking were lower across all the conditions than intentions to exercise more and lose weight.

Table 7.11 Summary statistics for intention to change behaviour by condition.

Condition	Bar graph with pre-intervention questionnaire *(Control group 1)*			Bar graph *(Control group 2)*			Pictogram *(Intervention group 1)*			Metonym *(Intervention group 2)*		
	Intention to... Exercise more	Lose weight	Stop smoking	Exercise more	Lose weight	Stop smoking	Exercise more	Lose weight	Stop smoking	Exercise more	Lose weight	Stop smoking
n	212	212	19	241	241	20	222	222	26	228	228	16
Mean	**5.06**	**4.75**	**4.28**	**5.02**	**4.65**	**4.56**	**5.03**	**4.68**	**3.64**	**4.91**	**4.53**	**3.85**
SD	1.20	1.56	1.64	1.21	1.61	1.45	1.18	1.62	1.83	1.27	1.61	1.27
Median	5	5	4	5	5	4.50	5	5	3.50	5	4.67	3.83
Mode	5	5	4	5.33	5	4	5	5	2.33	4.33	4	3.67
Min	1	1	1.33	1	1	1.67	1	1	1	1	1	1
Max	7	7	7	7	7	7	7	7	7	7	7	6.33

One-way ANOVAs were performed on the difference between the conditions in the means of the post-intervention *intention to exercise more, intention to lose weight and intention to stop smoking* scores(see Table 7.10). The variances were equal across groups as the Levene's test of homogeneity of variance was not significant (Appendix 53).

Scores did not significantly differ across the conditions for *intention to exercise more* ($F(3,899) = .655$, $p = .580$, partial $\eta^2 = .002$). The estimated effect size indicates that .02% of the overall variance in *intention to exercise more* was accounted for by cardiovascular risk representation. Furthermore, scores did not significantly differ for *intention to lose weight* ($F(3,899) = .710$, $p = .546$, partial $\eta^2 = .002$) and *intention to stop smoking* ($F(3,77) = 1.436$, $p = .239$, partial $\eta^2 = .053$). This means that there was no statistically significant main effect of risk representation format on intention to change behaviour.

Understanding of risk information

As described previously, *level of understanding* was determined by the correctness of the *absolute probability perception* and *subjective understanding* items. Respondents who answered both items correctly were said to have *complete understanding*. One correct answer was determined to be *partial understanding*. If both items were answered incorrectly, this was taken as having *no understanding* of the risk information. *Confidence in understanding* was also measured.

Table 7.12 shows the mean *level of understanding* scores and *confidence in understanding* for each of the four groups representing the different cardiovascular risk representation formats. There was little difference in *level of understanding* across all conditions. The mean scores indicated a *partial level of understanding*. *Confidence in understanding* was reasonably high regardless of which cardiovascular risk representation formats was presented, however it was lower in the metonym condition (M=5.98, SD=1.27).

One-way between-groups ANOVA (Table 7.10) found no statistically significant effect of cardiovascular risk representation format on *level of understanding* ($F(3,899) = .944$, $p = .419$, partial $\eta^2 = .003$). Nor was there a statistically significant effect of representation format on how confident respondents felt that they understood their risk information ($F(3,899) = 1.108$, $p = .345$, partial $\eta^2 = .004$) (Appendix 54).

Affect

The mean post-intervention *positive* and *negative affect* scores are shown in Table 7.12. *Positive affect* scores were consistently higher than the *negative affect* scores across the conditions. General linear models were used with baseline *positive* and *negative affect* set as covariates (Table 7.10). There was no significant main effect of cardiovascular risk representation format on *positive affect* ($F(3,898) = 1.595$, $p = .189$, partial $\eta^2 = .005$) or *negative affect* ($F(3,898) = .776$, $p = .507$, partial $\eta^2 = .003$) (Appendix 55).

Worry about future risk of heart disease

There was little variation in *worry about future risk of heart disease* across the four conditions demonstrated in Table 7.14. A general linear model, with baseline *worry about future risk of heart disease* scores set as a covariate (Table 7.10), revealed no significant main effect of cardiovascular risk representation format on respondents' worry about future risk of heart disease ($F(3,898)=.021$, $p=.996$, partial $\eta^2=.000$) (Appendix 56).

Sub group analysis split by risk category

Responses were split and analysed separately according to risk category (Appendices 57-60). This was to determine whether responses differed according to the cardiovascular risk level of respondents. Due to an uneven distribution of respondents in each of the low, moderate and high categories, the moderate and high risk categories were combined and compared against the low risk category.

Table 7.12 Summary statistics for understanding by condition.

Condition	Bar graph with pre-intervention questionnaire *(Control group 1)*			Bar graph *(Control group 2)*			Pictogram *(Intervention group 1)*			Metonym *(Intervention group 2)*		
	Understanding...			Understanding...			Understanding...			Understanding...		
	Level	Confidence	*Confidence	Level	Confidence	*Confidence	Level	Confidence	*Confidence	Level	Confidence	*Confidence
n	212	212	212	241	241	241	222	222	222	228	228	228
Mean	**1.06**	**6.13**	**8.20**	**1.09**	**6.10**	**8.20**	**1.09**	**6.08**	**8.22**	**1.12**	**5.98**	**8.24**
SD	.39	1.26	.24	.42	1.28	.24	.42	1.16	0.23	.42	1.27	0.24
Median	1	7	8	1	7	8	1	6	8.30	1	6	8.30
Mode	1	7	8	1	7	8	1	7	8	1	7	8
Min	0	1	8	0	1	8	0	2	8	0	1	8
Max	2	7	8.85	2	7	8.85	2	7	8.78	2	7	8.85

* *Confidence in understanding* log transformed and reflected back

Table 7.13 Summary statistics for affect by condition.

Condition	Bar graph with pre-intervention questionnaire *(Control group 1)*			Bar graph *(Control group 2)*			Pictogram *(Intervention group 1)*			Metonym *(Intervention group 2)*		
	Positive affect	Affect Negative affect	*Negative affect	Positive affect	Affect Negative affect	*Negative affect	Positive affect	Affect Negative affect	*Negative affect	Positive affect	Affect Negative affect	*Negative affect
n	212	212	212	241	241	241	222	222	222	228	228	228
Mean	**17.49**	**7.53**	**0.84**	**17.86**	**7.53**	**0.85**	**17.36**	**7.51**	**0.84**	**17.82**	**7.65**	**0.85**
SD	3.68	3.46	0.17	3.72	3.46	0.16	3.95	3.18	0.16	4.06	3.47	0.17
Median	18	6	0.78	18	6	0.78	18	6	0.78	18	6	0.78
Mode	20	5	0.70	18	5	0.70	20	5	0.70	20	5	0.70
Min	5	5	0.70	5	5	0.70	6	5	0.70	5	5	0.70
Max	25	20	1.30	25	20	1.40	25	23	1.36	25	20	1.30

**Negative affect* log transformed

Table 7.14 Summary statistics for worry about future risk of heart disease by condition.

Condition	Bar graph with pre-intervention questionnaire *(Control group 1)*	Bar graph *(Control group 2)*	Pictogram *(Intervention group 1)*	Metonym *(Intervention group 2)*
	Worry about future risk of heart disease	Worry about future risk of heart disease	Worry about future risk of heart disease	Worry about future risk of heart disease
n	212	241	222	228
Mean	**2.17**	**2.14**	**2.17**	**2.12**
SD	0.99	1.01	0.90	1.03
Median	2	2	2	2
Mode	2	2	2	2
Min	1	1	1	1
Max	5	5	5	5

There were no significant differences across the conditions for *intention to change behaviour* (i.e. exercise more, lose weight and stop smoking), *understanding of risk information* (i.e. level of understanding and confidence in understanding), *positive and negative affect* or *worry about future risk of heart disease* for those of low cardiovascular risk or those of moderate/high risk. The *p*-values and estimated effect sizes for the ANOVAs split by risk category are summarised in Table 7.15.

7.6.2 Planned comparisons between conditions

Planned comparisons were carried out as they are more sensitive to detecting differences and the overall main effect does not have to be significant to test specific differences. Three pairwise contrasts were conducted: *Bar graph* versus *Pictogram*; *Bar graph* versus *Metonym* and *Bar graph* versus *Bar graph with pre-intervention Questionnaire*.

As more than one planned comparison was performed on the same set of data, it needed to be checked that the comparisons were orthogonal, meaning they were independent of one another and not over-lapping (Brace et al. 2006). This was done by ensuring that the products of the coefficients assigned to each level for each pair of comparisons sum to zero. The conditions were assigned the appropriate coefficients (weights) so that the sum of the weights equalled zero (Table 7.16).

Table 7.15 Results of ANOVAs examining the effects of risk representation formats on intention to change behaviour, understanding of risk information, affect and worry about future risk of heart disease split by risk category.

Effect		d.f.	*F*	*p*	partial η^2
Intention to exercise more	Low risk	3	1.095	0.350	0.004
	Moderate / High risk	3	0.596	0.618	0.012
Intention to lose weight	Low risk	3	1.178	0.317	0.005
	Moderate / High risk	3	1.314	0.272	0.025
Intention to stop smoking	Low risk	3	0.752	0.527	0.048
	Moderate / High risk	3	2.047	0.130	0.180
Level of understanding	Low risk	3	1.022	0.382	0.004
	Moderate / High risk	3	1.743	0.161	0.033
Confidence in	Low risk	3	1.359	0.254	0.005
understanding	Moderate / High risk	3	1.229	0.301	0.024
Positive affect	Low risk	3	1.503	0.231	0.006
	Moderate / High risk	3	1.569	0.199	0.030
Negative affect	Low risk	3	0.866	0.458	0.003
	Moderate / High risk	3	0.005	1.000	0.000
Worry about future risk of	Low risk	3	0.117	0.950	0.000
heart disease	Moderate / High risk	3	0.999	0.395	0.000

The planned comparisons tested the hypotheses that the *Pictogram* would lead to greater intentions to change behaviour and be better understood compared to the *Bar graph* format; the *Metonym* would lead to greater intentions compared to the *Bar graph*, and the *Bar graph with pre-intervention questionnaire* would lead to greater intentions compared to the *bar graph* only format, as a result of thinking about cardiovascular risk before viewing actual risk.

Table 7.16 Coefficients assigned to conditions for the planned comparisons.

	Bar graph with preQ	Bar graph	Pictogram	Metonym	Total coefficie
Comparison 1 ***Bar graph* vs. *Pictogram***	0	1	-1	0	0
Comparison 2 ***Bar graph* vs. *Metonym***	0	1	0	-1	0
Comparison 3 ***Bar graph vs. Bar graph* + preQ**	1	-1	0	0	0

Bar graph versus Pictogram

Planned comparisons between the *Bar Graph* and *Pictogram* conditions (Appendix 61) revealed that respondents who received their risk in the pictogram format did not significantly differ in *intention to exercise more* (t=-.110, df=899, p=.913); *intention to*

lose weight (t=.856, df=899, *p*=.856); *intention to stop smoking* (t=1.915, df=77, *p*=.59); *level of understanding* (t=.040, df=899, *p*=.968); *confidence in understanding* (t=-.735, df=899, *p*=.462); *positive affect* (t=1.402, df=899, *p*=.161); *negative affect* (t=.463, df=899, *p*=.644) and *worry about future risk of heart disease* (t=-.324, df=899, p=.746) compared to those who received the bar graph format.

Bar graph versus Pictogram split by risk category

Subgroup analyses of risk categorised into low or moderate / high were conducted (Appendix 62). Respondents in the low risk category who received the pictogram format did not differ in terms of: *intention to exercise more* (t=.015, df=744, *p*=.988); *Intention to lose weight* (t=-.150, df=744, *p*=.881); *intention to stop smoking* (t=.361, df=45, *p*=.720); *level of understanding* (t=1.372, df=744, *p*=.171); *confidence in understanding* (t=-1.547, df=744, *p*=.122); *positive affect* (t=-1.817 df=744, *p*=.070); *negative affect* (t=.465, df=744, *p*=.642) and *worry about future risk of heart disease* (t=-1.080, df=744, *p*=.273) than those who received the bar graph format.

Likewise, no significant differences were found between the *Bar graph* and *Pictogram* conditions in the moderate/high risk category in terms of: *intention to exercise more* (t=-.219, df=151, *p*=.827); *intention to lose weight* (t=-.039, df=81.475, *p*=.969 equal variances not assumed); *intention to stop smoking* (t=2.018, df=28, *p*=.053); *level of understanding* (t=-1.651, df=151, *p*=.101); *confidence in understanding* (t=1.297, df=83.426, *p*=.198 equal variances not assumed); *positive affect* (t=-.400, df=151,

p=.690); *negative affect* (t=-.096, df=151, *p*=.923) and *worry about future risk of heart disease* (t=.951, df=71.676, *p*=.345 equal variances not assumed).

Bar graph versus Metonym

No significant differences were found in the planned comparisons for the *Bar graph* and *Metonym* conditions (Appendix 63). Those who received their risk in the metonym format did not significantly differ in *intention to exercise more* (t=1.003, df=899, p=.316); *intention to lose weight* (t=.807, df=899, *p*=.420); *intention to stop smoking* (t=1.300, df=77, *p*=.197); *level of understanding* (t=-.932 df=899, *p*=.352); *confidence in understanding* (t=-1.522, df=899, *p*=.128); *positive affect* (t=.109, df=899, *p*=.913); *negative affect* (t=.185, df=899, *p*=.853); *worry about future risk of heart disease* (t=.203, df=899, *p*=.839) compared to those who received the bar graph format.

Bar graph versus Metonym split by risk category

A subgroup analysis of risk categorised into low or moderate / high were conducted (Appendix 64). For the low risk category, respondents who received the bar graph format did not differ compared to those who received the pictogram format in terms of: *intention to exercise more* (t=1.549, df=744, *p*=.122); *intention to lose weight* (t=1.473, df=744, *p*=.141); *intention to stop smoking* (t=-.142, df=45, *p*=.887); *level of*

understanding (t=.267, df=744, *p*=.789); *confidence in understanding* (t=-1.691, df=744, *p*=.091); *positive affect* (t=-.921, df=744, *p*=.357); *negative affect* (t=.015, df=744, *p*=.988) and *worry about future risk of heart disease* (t=-.390, df=744, *p*=.697).

No significant differences were found between the groups for the moderate/high risk category. For example: *intention to exercise* (t=-.980, df=151, *p*=.329), *intention to lose weight* (t=-1.361, df=80.334, *p*=.177 equal variances not assumed), *intention to stop smoking* (t=1.781, df=28, *p*=.086), *level of understanding* (t= -2.002, df=151, *p*=.047), *confidence in understanding* (t= -.408, df=79.938, *p*=.684 equal variances not assumed), *positive affect* (t= -1.528, df=151, *p*=.129), *negative affect* (t= -.060, df=151, *p*=.952) and *worry about future risk of heart disease* (t= .338, df=57.498, *p*=.737 equal variances not assumed).

Bar graph versus Bar graph with pre-intervention questionnaire

Planned comparisons revealed no significant differences between the *Bar graph* and *Bar graph with pre-intervention questionnaire* conditions. Respondents who received the bar graph format did not differ from those who completed a pre-intervention questionnaire before viewing the bar graph format. The scores of the two groups did not significantly differ in *intention to exercise more* (t=-.301, df=899, *p*=.764); *intention to lose weight* (t=.651, df=899, *p*=.515); *intention to stop smoking* (t=-.527,

df=77, *p*=.600); *level of understanding* (t=-.782 df=899, *p*=.434); *confidence in understanding* (t=-.112, df=899, *p*=.911); *positive affect* (t=-1.015, df=899, *p*=.311); *negative affect* (t=-.732, df=899, *p*=.464) and *worry about future risk of heart disease* (t=.354, df=899, *p*=.723). This suggests that the questionnaire did not seem to have had an intervention effect (Appendix 65). This will be explored more in Chapter 8 when determining the existence of a Hawthorne effect (Adair 1984).

Bar graph versus Bar graph with pre-intervention questionnaire by risk category

A subgroup analyses of risk categorised into low or moderate / high were conducted (Appendix 66). For the low risk category respondents who received the bar graph format did not differ compared to those who received the bar graph with pre-intervention questionnaire in terms of: *intention to exercise more* (t=-.196, df=744, *p*=.854); *intention to lose weight* (t=.055, df=744, *p*=.956); *intention to stop smoking* (t=.891, df=45, *p*=.378); *level of understanding* (t=-1.340, df=744, *p*=.181); *confidence in understanding* (t=.446, df=744, *p*=.656); *positive affect* (t=-1.094, df=744, *p*=.275); *negative affect* (t=-.933, df=744, *p*=.351) and *worry about future risk of heart disease* (t=.669, df=744, *p*=.504).

For the moderate/high risk category no significant differences were found between those who received the bar graph format and those who received the bar graph format with pre-intervention questionnaire in terms of: *intention to exercise more* (t=1.108, df=151, *p*=.270); *intention to lose weight* (t=1.691-, df=76.116, *p*=.095 equal

variances not assumed); *intention to stop smoking* (t=-1.752, df=28, *p*=.091); *level of understanding* (t=.470, df=151, *p*=.639); *confidence in understanding* (t=-.904, df=77.999, *p*=.369 equal variances not assumed); *positive affect* (t=-.595, df=151, *p*=.553); *negative affect* (t=.723, df=151, *p*=.471) and *worry about future risk of heart disease* (t=.528, df=58.589, *p*=.599 equal variances not assumed).

7.6.3 Summary

This section has described the analyses conducted to examine the effects of cardiovascular risk representation formats on intention to change behaviour, understanding of risk information, affect and worry about future risk of heart disease. Firstly, all conditions were compared on an equal footing using one-way ANOVAs. Secondly, planned comparisons using three pairwise contrasts (*Bar graph* versus *Pictogram*; *Bar graph* versus *Metonym* and *Bar graph* versus B*ar graph with pre-intervention questionnaire*) were conducted. No significant differences were found in the scores across the conditions (even when responses were dichotomised into low or moderate/high risk), meaning there were no main effects of cardiovascular risk representation formats on *intention to exercise more*, *intention to lose weight*, *intention to stop smoking*, *level of understanding*, *confidence in understanding*, *positive affect*, *negative affect* and *worry about future risk of heart disease.*

7.7 Predicting intention to change behaviour

This section describes the multivariate analyses determining which variables predict intention to change behaviour. Firstly, assumptions were tested to assess the suitability of the data for multivariate analyses. Then, multiple regression models for *intention to exercise more, intention to lose weight* and *intention to stop smoking* were conducted. These models indicate which variables influence intention to change behaviour by assessing how much variance in the intention to change behaviour scores are attributed to *understanding, affect, worry about future risk of heart disease* or the risk category of respondents.

7.7.1 Assumption Testing for Multivariate Analyses

A number of assumptions were checked before proceeding with the multiple regression models. Some of the necessary assumptions checks were assessed previously, e.g. the ratio of cases to independent variables, normality and presence of univariate outliers (Appendices 48-50). However, further checks needed to be conducted to ensure the suitability of the data for multivariate analyses. The assumptions that were tested are reported below.

Linearity and homoscedasticity of residuals

The assumptions of normality, linearity and homoscedasticity between predicted dependent variable scores and errors of prediction are assessed by a residual

scatterplot. This checks whether the residuals are normally distributed about the predicted dependent variable scores, that the residuals have a straight-line relationship with the predicted dependent variable scores, and that the variance of the residuals about predicted dependent variable scores is the same for all predicted scores (Tabachnick and Fidell 2001).

Scatterplots of residuals against predicted values were assessed for the dependent variables of *intention to exercise more*, *lose weight* and *stop smoking*. For normality, linearity and homoscedasticity assumptions to be satisfied, the residual in the scatterplots should resemble a rectangular shape distribution with a concentration of scores around the centre along the zero point. This is demonstrated in Figures 7.3 to 7.5. Therefore, these assumptions were not violated.

The scatterplots can also be used to identify outliers. A standardised residual of less than -3.3 or more than 3.3 is considered to be an outlier (Tabachnick and Fidell 2001). As seen in the scatterplot for *intention to lose weight* (Figure 7.5) there appeared to be residuals with a standardised predicted value of around -4 and 4. However, before the decision was made whether to take action, the presence of outliers was investigated further.

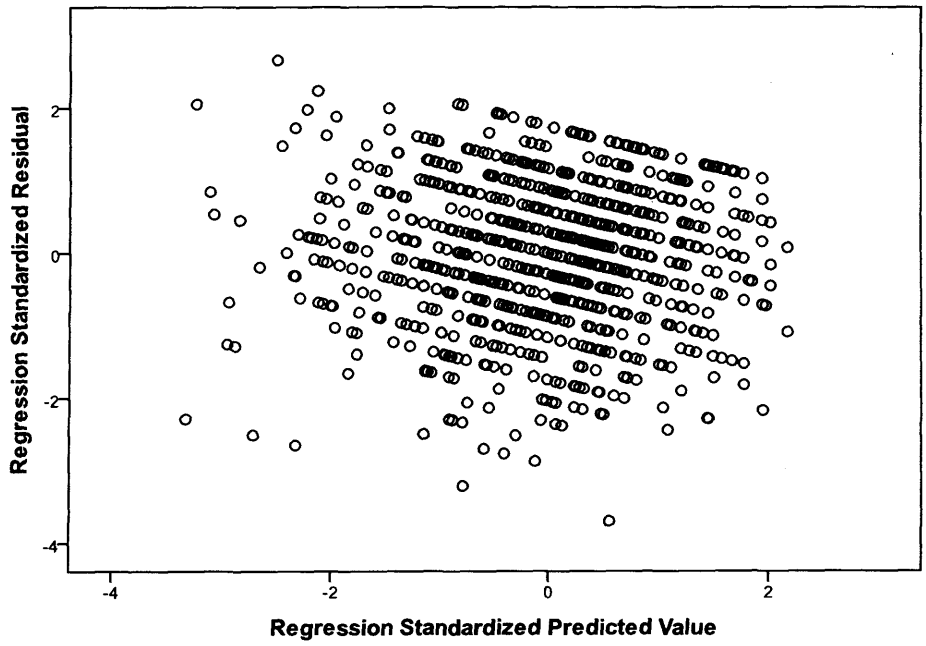


Figure 7.3 Scatterplot of the residuals against predicted values for Intention to exercise more.

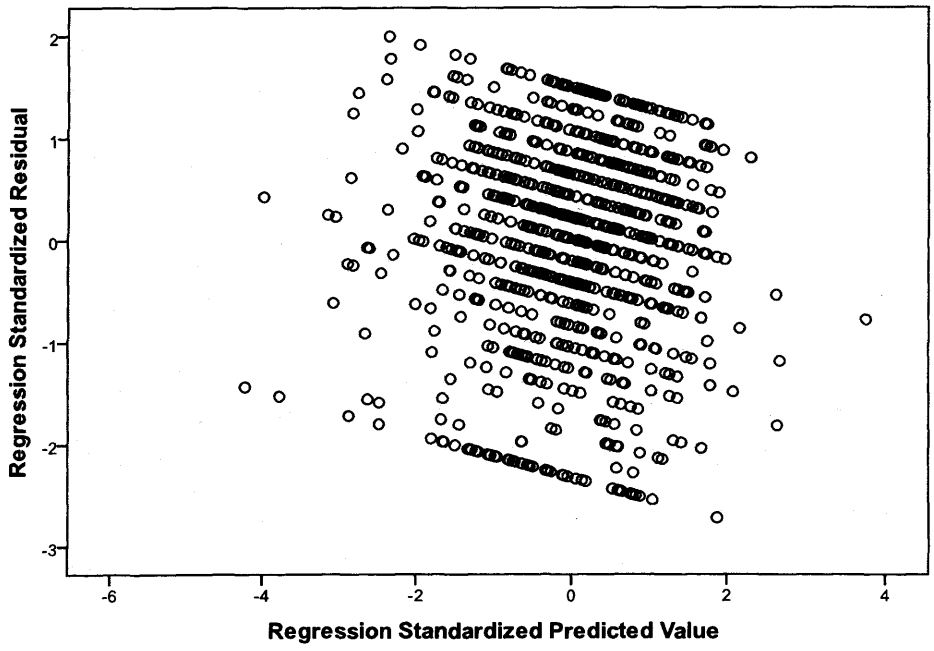


Figure 7.4 Scatterplot of the residuals against predicted values for Intention to lose weight.

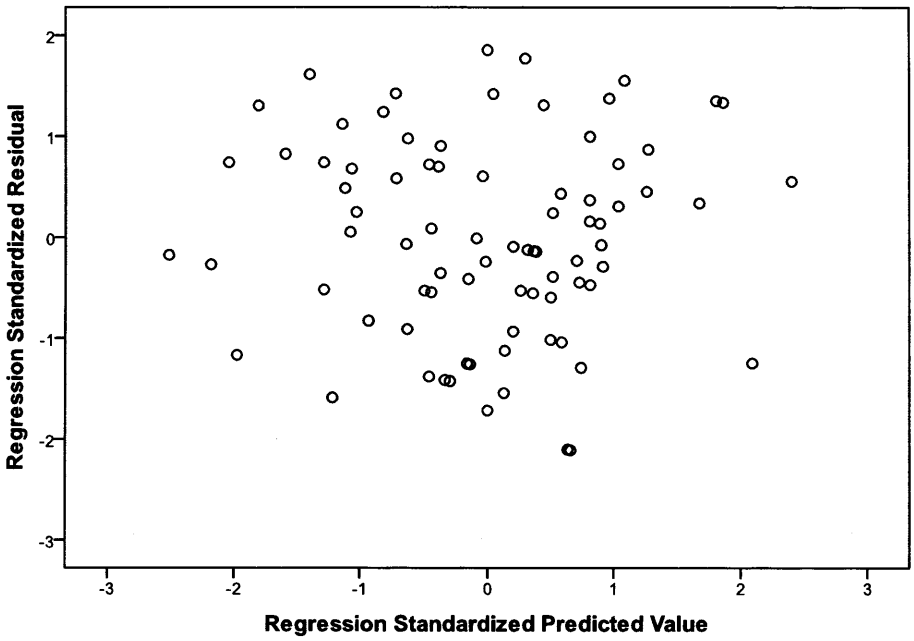


Figure 7.5 Scatterplot of the residuals against predicted values for intention to stop smoking.

Multivariate outliers

Mahalanobis distance (i.e. distance of a case from the means of the predictor variables) was calculated to identify multivariate outliers. A critical chi square table was consulted to obtain the critical chi square value at $\alpha = 0.001$, where the number of independent variables equals the degrees of freedom (Tabachnick and Fidell 2001). In this instance, the degrees of freedom equalled 7 and the critical value was 24.32 at $p<0.001$. One multivariate outlier (case 28) was found among the independent variables as its value was greater or equal to the critical chi square value. However, it is suggested that a few multivariate outliers are not unusual in

large samples, and one case should not cause concern (Pallant 2006). Therefore, it was felt that no action needed to be taken to omit this from the regression model.

Additionally, the Cook's distance was calculated. Cook's distance is the change in regression coefficients when a case is deleted to measure its influence on the other cases. Influence scores greater than 1 are suspected of being outliers (Tabachnick and Fidell 2001). As the maximum value in this instance was 0.164, this assumption was not violated.

Multicollinearity and Singularity

The correlation matrix between variables was assessed for multicollinearity (Appendix 67). This assumption looks at correlations between the independent variables, as presence of high or perfect correlations (over 0.7) between the independent variables make it difficult to interpret the relationships between them and attribute variance in the dependent variables to one of independent variables. None of the variables correlated above 0.7. The highest correlation was 0.43 (between *negative affect* and *worry about future risk of heart disease*). Therefore, the assumption of multicollinearity was not violated.

The coefficients tables (Appendix 68) were consulted to look for possible problems with multicollinearity that may not be evident in the correlation matrix. The tolerance value (calculated using the formula $1-R^2$ for each variable) is an indication of how much of the variability of the specified independent variable is not explained by the

other independent variables in the model. Values less than 0.10 are considered to be of concern. Additionally, the VIF (Variance inflation factor) values, which are the inverse of the tolerance values, of above 10 would be of concern indicating mulitcollineary (Pallant 2006). As the tolerance values are all above 0.10 and the VIF values are all less than 10 for the three independent variables (*intention to exercise more, lose weight and stop smoking*), the multicollinearity assumption was not violated. Furthermore, as there was no perfect linear relationship between any of the independent variables, the assumption of singularity was not violated.

7.7.2 Multiple Regression Models to predict intention to change behaviour

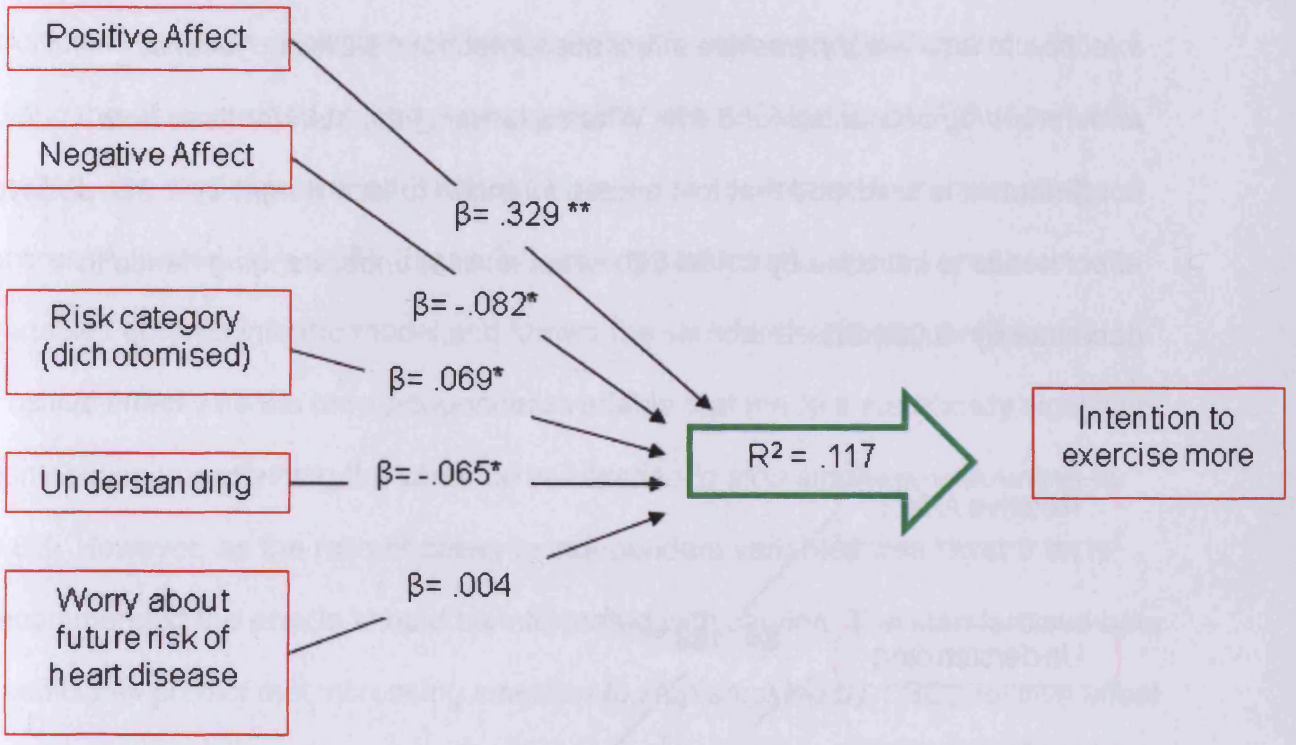
Three multiple regression models were conducted, where the dependent variables were represented by each of the behavioural intentions (*exercising more*, *losing weight* and *stopping smoking*). A simultaneous method was chosen which specifies the set of predictor variables that make up the model (Brace et al. 2006). The success of the model in predicting the criterion variable (i.e. *intention to exercise more, lose weight and stop smoking*) was assessed. The predictor variables comprised *level of understanding*, *positive affect*, *negative affect*, *worry about future risk of heart disease* and the risk category of respondents

Intention to exercise more

Multiple regression analysis examined *intention to exercise more* (Appendix 69). A significant model emerged: $F(5,897)= 24.851$, $p=.000$. The model explained 11.7% of the variance in *intention to exercise more* scores (Adjusted $R^2 = .117$). Figure 7.6 provides information for the predictor variables entered into the model and shows the standardised beta coefficients.

Four independent variables made the largest statistically significant contribution in explaining the variance in *intention to exercise more*; *positive affect* accounted for 32.9%, *negative affect* accounted for 8.2%, the risk category of the respondent accounted for 6.9% and *level of understanding* accounted for 6.5%. The standardised beta coefficients measure the contribution of each variable to the model in terms of standard deviations. Beta is the predicted change in standard deviation of the criterion variable, for a change in 1 standard deviation in the predictor whilst controlling for the other predictors (Brace et al. 2006).

Therefore, the model suggests that in order to increase *intention to exercise more* by 1 SD, *positive affect* needs to be increased by 0.329 SD. Whilst *negative affect* needs to be decreased by -0.082 and *level of understanding* needs to be decreased by - 0.065 SD.



* Significant correlation at $p<0.05$
** Significant correlation at $p<0.001$

Figure 7.6 Standardised beta coefficients for Intention to exercise more.

Intention to lose weight

Multiple regression analysis examined *intention to lose weight* (Appendix 70). Using the enter method, a significant model emerged: $F(5,897)= 8.175$, $p=.000$. The model explained 3.8% of the variance in *intention to lose weight* scores (Adjusted R^2 = .038). Figure 7.7 provides information for the predictor variables entered into the

model and shows the standardised beta coefficients. Two independent variables made the largest statistically significant contribution in explaining the variance in *intention to lose weight*; *positive affect* accounted for 18.8% and *level of understanding* accounted for 8.4%. When assessing the standardised beta coefficients it is predicted that to increase *intention to lose weight* by 1 SD, *positive affect* needs to increase by 0.188 SD, whilst *level of understanding* needs to decrease by -0.084 SD.

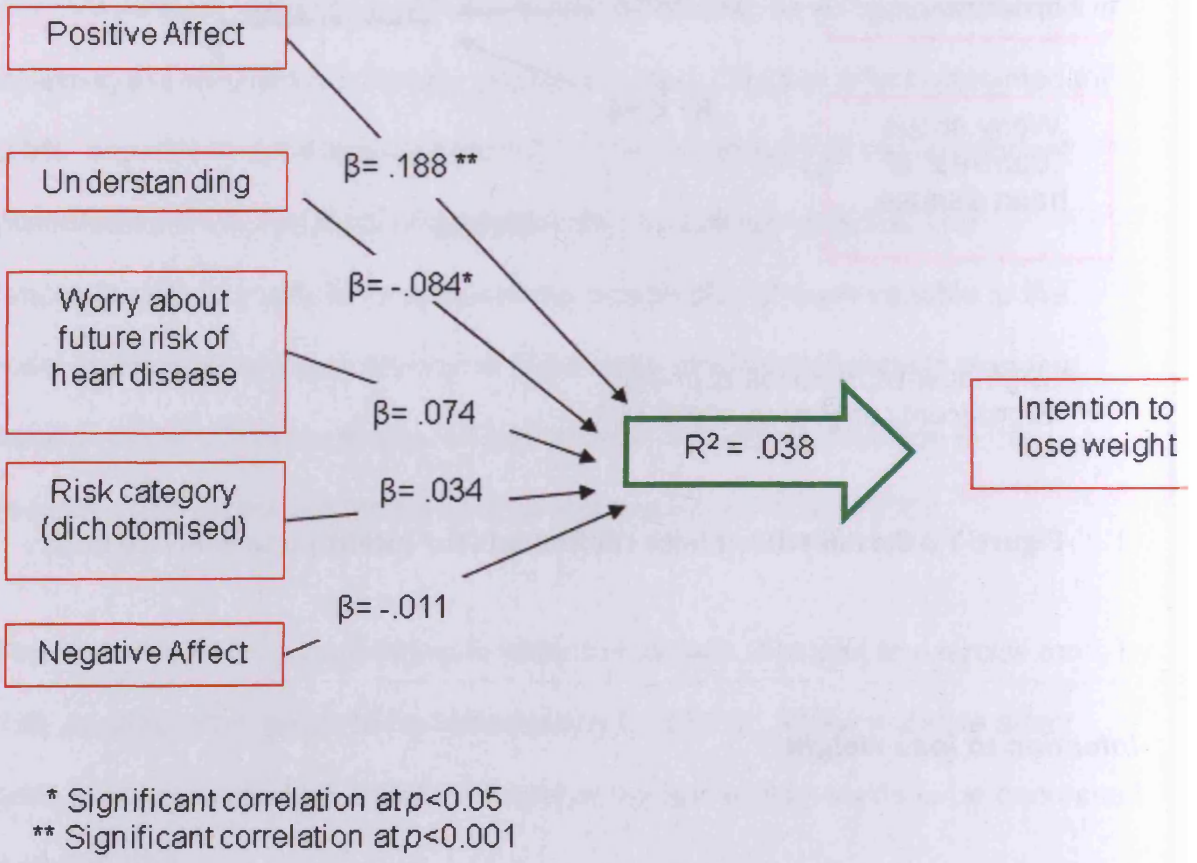
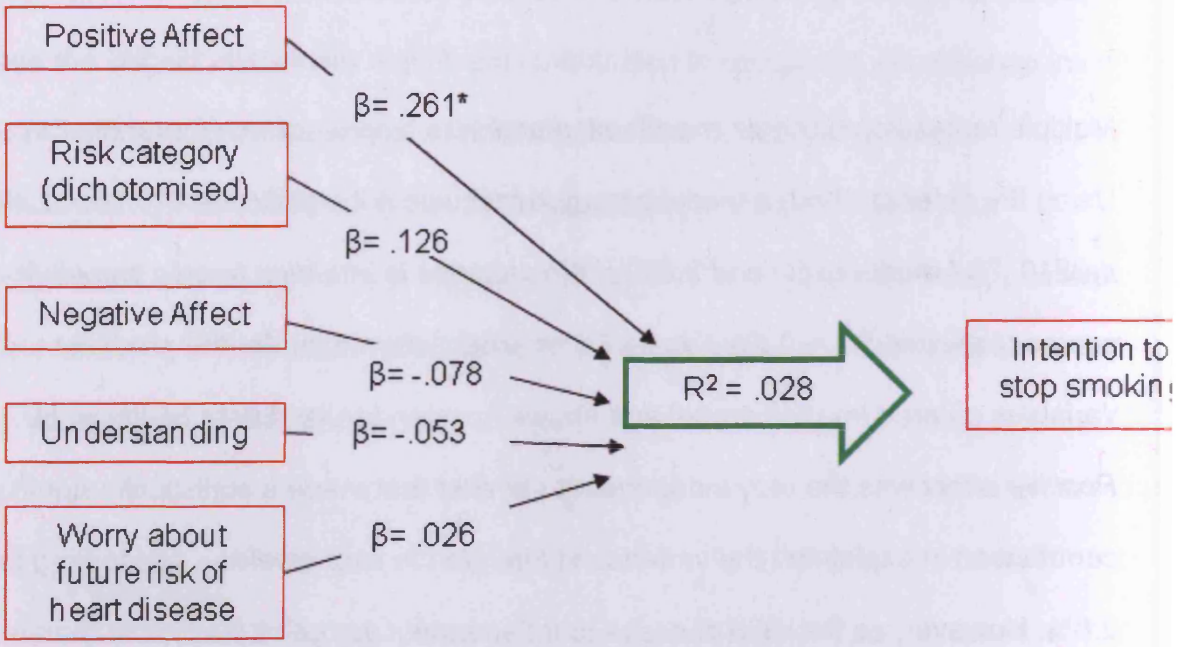


Figure 7.7 Standardised beta coefficients for Intention to lose weight.

Intention to stop smoking

Multiple regression analysis examined *intention to stop smoking* (Appendix 71). Using the enter method, a model emerged that was not significant: $F(5,75)= 1.469$, $p=.210$. The model explained 2.8% of the variance in *intention to stop smoking* scores (Adjusted $R^2 = .028$). Figure 7.8 provides information for the predictor variables entered into the model and shows the standardised beta coefficients. *Positive affect* was the only independent variable that made a statistically significant contribution in explaining the variance in *intention to stop smoking*, accounting for 2.8%. However, as the ratio of cases to independent variables was lower than is recommended the results should be interpreted with caution. The standardised beta coefficients predict that increasing *intention to stop smoking* by 1 SD, *positive affect* should increase by 0.261 SD.



* Significant correlation at $p<0.05$

Figure 7.8 Standardised beta coefficients for Intention to stop smoking.

7.7.3 Summary

This section reports the multivariate analyses conducted to determine which variables predict intention to change behaviour. The appropriate assumption testing preceding the multivariate analyses were described. Three multiple regression models were conducted for *intention to exercise more, intention to lose weight* and *intention to stop smoking*. The *intention to exercise more* and *intention to lose weight* models were statistically significant, and explained 11.7% and 3.8% of the variance

in intention scores respectively. It is concluded that the small sample size of those who completed the items on smoking cessation resulted in the non-significant multiple regression model for *intention to stop smoking.*

Intention to exercise more was significantly predicted by *positive affect, negative affect, level of understanding* and risk category of respondents. This suggests that increasing physical activity and exercise levels can be achieved by increasing positive emotions, decreasing negative emotions and the level of understanding a person has regarding their cardiovascular risk. Also, exercising is partly dependent on the risk magnitude of the individual.

Intention to lose weight was significantly predicted by *positive affect* and *level of understanding.* Although, the *intention to stop smoking* model was not significant overall, *positive affect* significantly predicted *intention to stop smoking.*

Positive affect was the only variable to significantly predict all three behavioural intentions (*exercise more, lose weight* and *stop smoking)* and was consistently the largest contributor to the variance in intention scores. This suggests that positive emotions have an influence on decisions to change behaviour. Therefore, developers of health interventions should focus on increasing a person's positive emotions to effectively increase health protective behaviours.

7.8 Changes in affect and worry about future risk of heart disease after viewing cardiovascular risk.

This section will report the analysis conducted to assess changes to affect and worry about future risk of heart disease resulting from viewing cardiovascular risk. Paired analysis using paired t-tests were conducted to compare baseline and post-intervention scores for *positive* and *negative affect* and *worry about future risk of heart disease* (Appendix 72), to examine whether they decreased or increased after viewing cardiovascular risk. Additionally, subgroup analyses splitting responses into low or moderate/high risk were conducted to see if there were differences between scores depending on the risk category of respondents (Appendix 73). Subgroup analysis of the four conditions of the trial was also carried out to determine whether the changes in baseline and post-intervention scores differed according to the cardiovascular risk representation formats viewed by respondents (Appendix 74).

7.8.1 Paired analysis of baseline and post-intervention positive affect

Figure 7.9 shows the baseline and post-intervention *positive affect*. A decrease in *positive affect* scores can be seen. The mean score at baseline was 18.11 (SD=2.99) and 17.64 (SD=3.86) post-intervention. The mean difference between baseline and post-intervention scores was 0.47 (95% CI=0.03-0.64). Paired t-tests showed that this decrease in *positive affect* scores after viewing cardiovascular risk

was significant (t=5.313, df=902, p=.000). This suggests that when people find out their risk of CVD, a decrease in their positive emotion results.

Subgroup analysis by risk category

The subgroup analysis split responses into low or moderate/high risk. For the low risk category, *positive affect* reduced by 0.4 (95% CI=0.22-0.59) after viewing cardiovascular risk (baseline M= 18.27, SD=2.96 compared to post-intervention M= 17.87, SD=3.86). Paired t-tests showed that this difference was significant (t=4.279, df=747, p=.000).

For the moderate/ high risk category, *positive affect* was reduced by 0.78 (95% CI=0.34-1.26) after viewing cardiovascular risk (baseline M= 17.32, SD= 2.99 compared to post-intervention M= 16.54, SD=3.63). Paired t-tests showed that this difference was significant (t=3.288, df=154, p=.001).The greater reduction in positive emotions found in those of moderate and high risk respondents compared to those of low risk is logical and in the direction that would be expected, because someone finding out that they are of elevated risk of CVD is likely to be less reassuring and cause more concern, than finding out that they are at low cardiovascular risk.

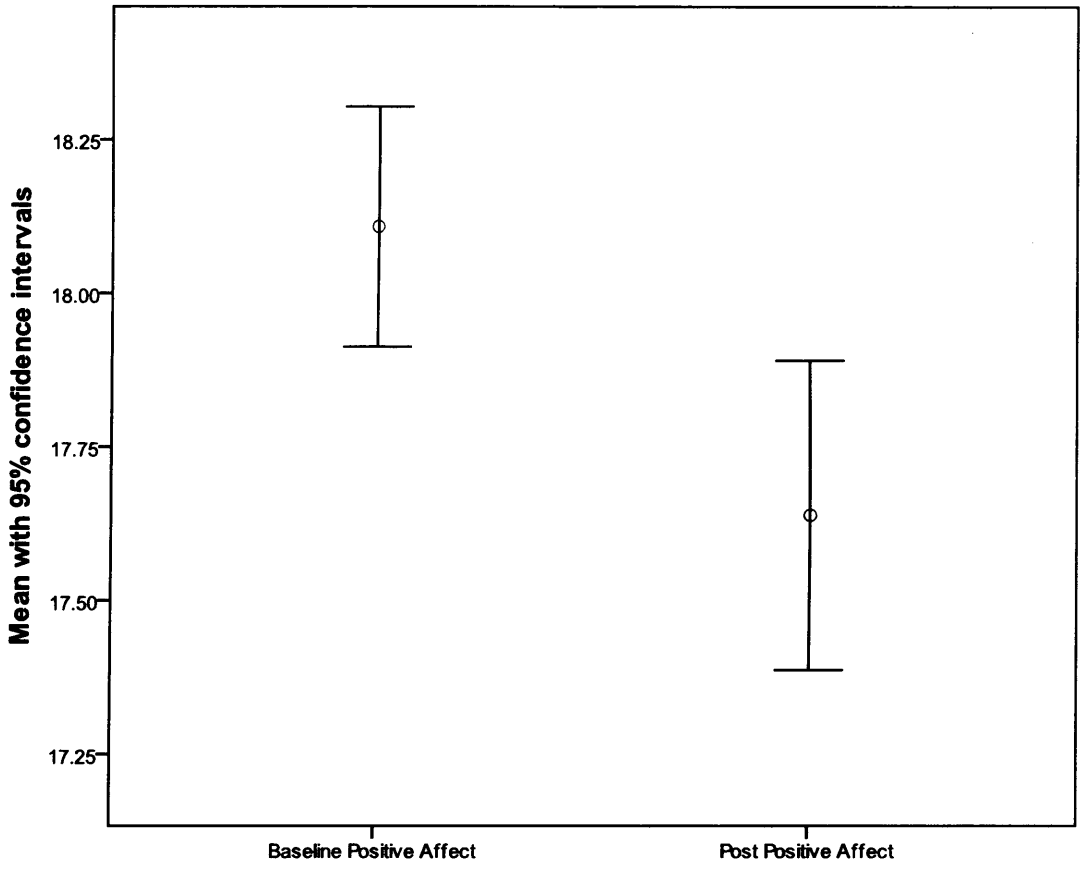


Figure 7.9 Error bar plots of mean and 95% confidence intervals of baseline and post-intervention positive affect.

7.8.2 Paired analysis of baseline and post-intervention negative affect

As shown in Figure 7.10, *negative affect* decreased after viewing cardiovascular risk (baseline M= 1.10, SD=0.11 compared to post-intervention M= 0.85, SD=0.16, log transformed). The mean difference between conditions was 0.17 (95% CI=0.16-0.18). Paired t-tests showed that this decrease was significant (*t*=34.449, df=902,

p=.000). This suggests that when people find out their risk of CVD, their negative emotions decrease. However, this finding is likely to be due to the majority of respondents being of low cardiovascular risk and thus, they did not need to be overly concerned about their risk result.

Subgroup analysis by risk category

A subgroup analysis dichotomised responses into low or moderate/ high risk. For the low risk category, the baseline mean *negative affect* score was 10.70 (SD= 2.74) compared to post-intervention mean 7.27 (SD=3.11) log transformed. *Negative affect* reduced by 3.43 (95% CI= 3.22-3.63) after viewing cardiovascular risk. Paired t-tests showed that this difference was significant (*t*=32.718, df=747, *p*=.000).

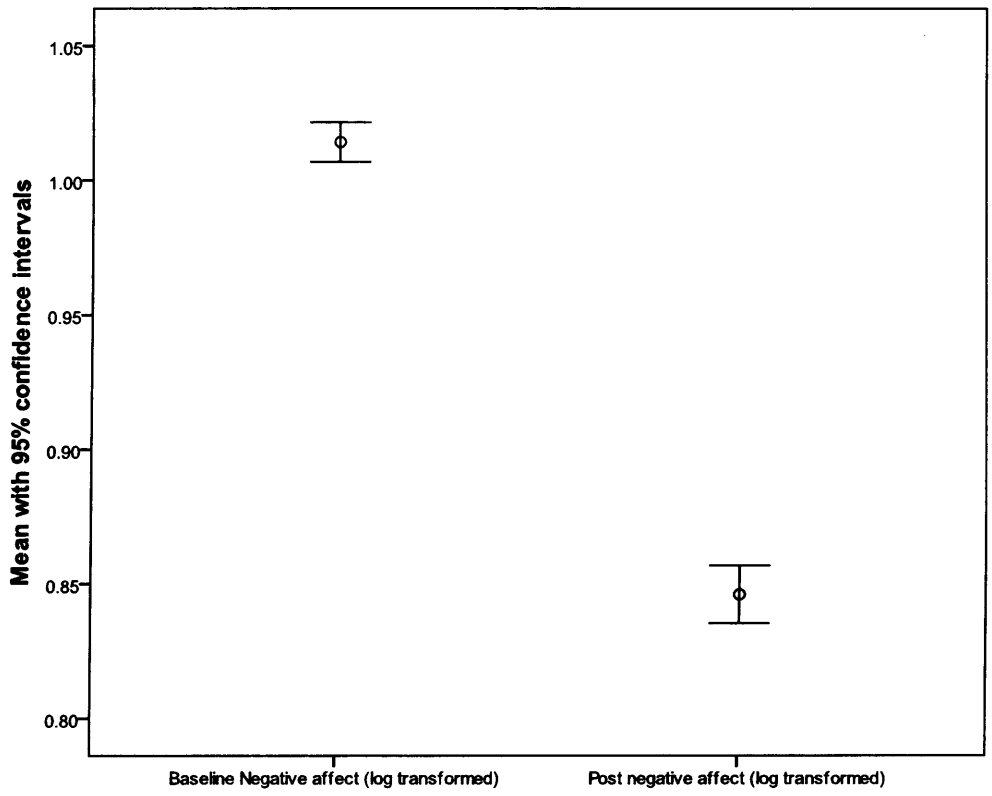


Figure 7.10 Error bar plots of mean and 95% confidence intervals of baseline and post-intervention negative affect (log transformed).

For the moderate/high risk category, the mean baseline *negative affect* score was 10.63 (SD= 2.93) compared to post-intervention mean of 9.17 (SD=3.98) log transformed. *Negative affect* reduced by 1.46 (95% CI=0.96-1.97) after viewing cardiovascular risk. Paired t-tests showed that this difference was significant (t=5.746, df=154, p=.000).

The decrease in negative emotions was greatest in those who were of low risk than in those of moderate/high risk. This is a logical and expected finding, suggesting that

people who find out that they are of low risk do not need to feel negative emotion, and can be reassured by their risk category.

7.8.3 Paired analysis of baseline and post-intervention worry about future risk of heart disease

The mean baseline *worry about future risk of heart disease* score was 2.80 (SD=1.04) and the mean post-intervention score was 2.15 (SD=0.98), demonstrated in Figure 7.11. The mean difference was 0.66 (95% CI= 0.60-0.71). Paired t-tests showed that this difference was significant (t=22.494, df=902, p=.000).

Subgroup analysis by risk category

A subgroup analysis split responses into low or moderate/ high risk. For the low risk category, the mean baseline *worry about future risk of heart disease* score was 2.73 (SD= 1.04) compared to 2.00 (SD=0.90) post-intervention. *Worry about future risk of heart disease* reduced by 0.73 (95% CI =0.67-0.79) after viewing cardiovascular risk. The paired t-tests showed that this difference was significant (t=22.997, df=747, p=.000).

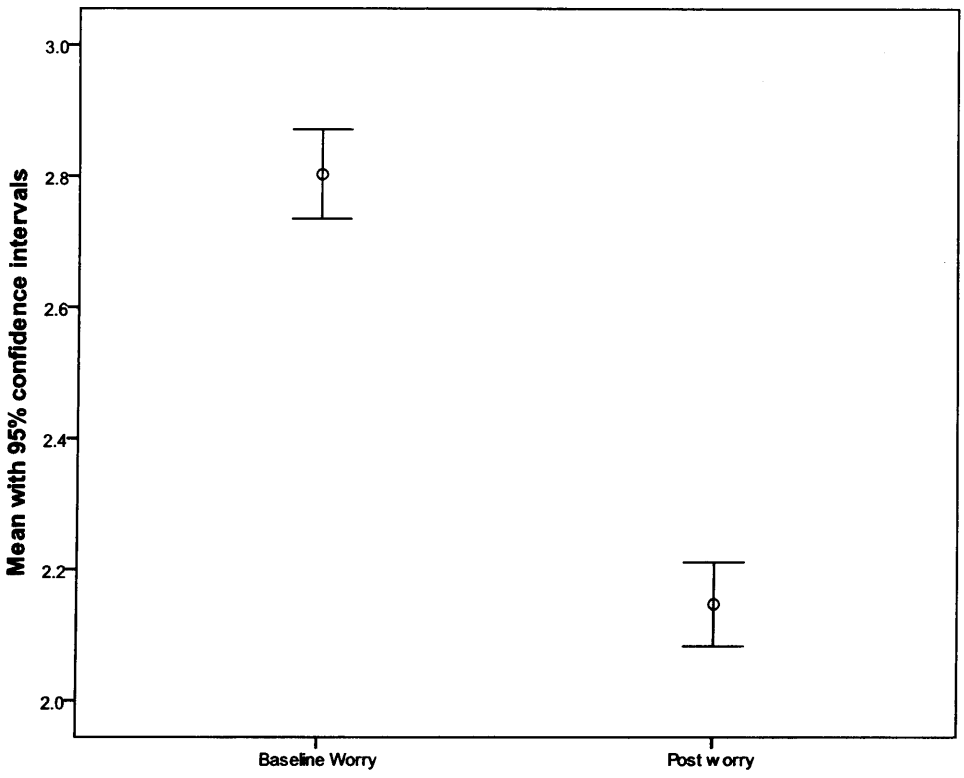


Figure 7.11 Error bar plots of mean and 95% confidence intervals of baseline and post-intervention worry about future risk of heart disease.

For the moderate/high risk category, the mean baseline *worry about future risk of heart disease* was 3.16 (SD=1.0) compared to 2.87(SD=1.04) post-intervention. *Worry about future risk of heart disease* reduced by 0.29 (95% CI=0.16-0.49). Paired t-tests showed that this difference was significant (t=4.443, df=154, p=.000).

The greatest reduction was seen in these of low cardiovascular risk. As with negative affect, this is in the expected direction and suggests that finding out that you are of low risk, reduces negative emotions including worry about future risk of heart disease.

7.8.4 Positive affect, negative affect and worry about future risk of heart disease split by condition

A further subgroup analysis split responses by three trial conditions (e.g. Bar graph, Pictogram and Metonym). This assessed whether the changes in baseline and post-intervention scores differed according to the different risk representation formats.

Positive affect was significantly reduced in the pictogram condition (t=4.386, df=221, p=.000). This format led to the greatest reduction across the conditions (mean difference= 0.74, 95% CI= 0.41-1.08). The bar graph format reduced *positive affect* the least (Mean difference= 0.29, 95% CI= -0.53-0.63).

Negative affect was significantly reduced across all the conditions e.g. bar graph (t=17.08, df=240, p=.000), pictogram (t=16.912, df=221, *p*=.000) and metonym (t=17.340, df=227, *p*=.000). However, only small reductions were seen. The pictogram led to the greatest reduction (M=0.17, 95% CI=0.14-0.18). The bar graph format lead to the least reduction in *negative affect* across the groups (M =0.16, 95% CI =0.14-0.18).

Across all formats, a significant decrease in *worry about future risk of heart disease* was observed, e.g. bar graph (t=11.125, df=240, *p*=.000); pictogram (t=12.531, df=221, *p*=.000); metonym (t=12.309, df=227, *p*=.000). The pictogram format led to the greatest reduction in w*orry about future risk of heart disease* (Mean difference =

0.67, 95% CI= 0.57-0.78) and the bar graph format led to the least reduction (Mean difference =.64, 95% CI=0.53-0.76).

Pictograms were responsible for the greatest reductions in *positive affect*, *negative affect* and *worry about future risk of heart disease*. Conversely, bar graphs altered *affect* and *worry about future risk of heart disease* the least. This suggests that pictograms make more of an impact when used to visually represent cardiovascular risk, compared to bar graphs which have the least influence over how a person feels about their risk.

7.8.5 Summary

This section described paired analyses conducted to assess changes to *affect* and *worry about future risk of heart disease* after respondents viewed their cardiovascular risk in this trial. *Positive affect, negative affect* and *worry about future risk of heart disease* all significantly decreased after viewing cardiovascular risk. When responses were split by risk category, the greatest reduction in *positive affect* was seen in those categorised as moderate/high risk. This is an expected finding as having elevated risk of CVD reduces feelings of reassurance and can cause concern.

Conversely, the greatest reduction in *negative affect* and *worry about future risk of heart disease* was seen for those at low risk. Again, this is an expected finding as

being of low risk can reduce previous negative emotions, worries and anxieties about CVD risk and can provide reassurance.

Responses were also split by the condition respondents were assigned to. *Negative affect* and *worry about future risk of heart disease* were significantly reduced across all conditions, whereas *positive affect* was significantly reduced by the pictogram format. The pictogram format consistently led to the great reductions in *affect* and *worry about future risk of heart disease* and the bar graph format consistently led to the least reductions in *affect* and *worry about future risk of heart disease*. This suggests that pictograms make more of an impact when used to present cardiovascular risk, compared to bar graphs which have the least influence over how a person feels about their risk.

7.9 Examination of understanding of risk information items

This section describes the examination of items used to assess *understanding of risk information*. *Absolute probability perception* (e.g. recalling risk category), *subjective understanding* (e.g. stating what someone in the same risk category should do about their cardiovascular risk) and *confidence in understanding* (e.g. how confident respondents were that they had understood their risk correctly) were used to measure *understanding of risk information*. The *level of understanding* respondents had was determined by assessing the accuracy of the responses to the *absolute probability perception* and *subjective understanding* items. Analysis of *level of*

understanding is described in this section, along with an assessment of the relationship between *level of understanding* and *confidence in understanding*, to determine whether those who report being highly confident that they have understood the risk information actually do understand their risk correctly.

7.9.1 Assessing level of understanding

121 respondents (13.4%) demonstrated *complete understanding*, as they answered both *absolute probability perception* and *subjective understanding* items correctly. 41 (4.5%) had *no understanding* and answered both items incorrectly. Of the 741 (82%) who had *partial understanding*, 17 (1.9%) correctly answered the *subjective understanding* item, but incorrectly answered the *absolute probability perception* item. 724 (80.2%) correctly answered the *absolute probability perception* item, but gave an inappropriate *subjective understanding* response (Figure 7.12). This suggests that the majority of respondents could accurately recall their risk category, but most did not understand the degree of action that needed to be taken because of their risk. Leading to the conclusion that either subjective understanding is not a suitable measure of understanding, or the respondents in this trial were overly prepared to take (or were already taking) actions to reduce their risk even though this was not necessary.

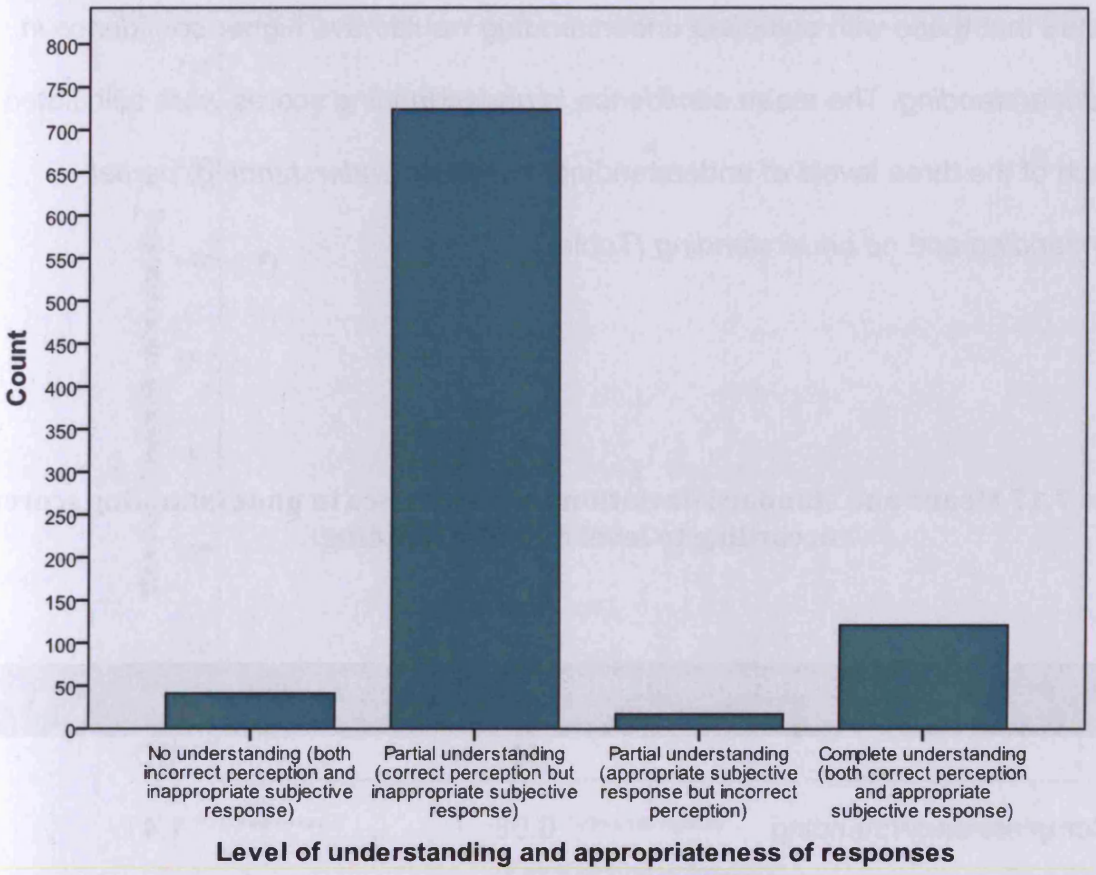


Figure 7.12 Frequencies for level of understanding and appropriateness of responses measuring understanding.

7.9.2 Relationship between level of understanding and confidence in understanding

A correlational analysis (Appendix 75) was conducted between *confidence in understanding* and *level of understanding* (see section 7.4 for a detailed description of these variables), to assess the hypothesis that people with a greater *level of understanding* would have higher *confidence in understanding*. Therefore, it was

expected that those with *complete understanding* would have higher *confidence in their understanding*. The mean *confidence in understanding* scores were calculated for each of the three levels of understanding: *complete understanding, partial understanding* and *no understanding (*Table 7.17*)*.

Table 7.17 Means and standard deviations of confidence in understanding scores according to level of understanding.

Confidence in understanding scores		
	M	**SD**
Complete understanding	6.08	1.41
Partial understanding	6.13	1.16
No understanding	5.02	1.70

It can be seen in Figure 7.13, that those with *complete understanding* did have higher *confidence in understanding* (M=6.08, SD=1.41) compared to those with *no understanding* (M=5.02, SD=1.70), consistent with the proposed hypothesis. However, respondents with *partial understanding* (i.e. correctly answering one out of the two *understanding* items) displayed the highest *confidence in their understanding of the risk information* overall (M=6.13, SD=1.16).

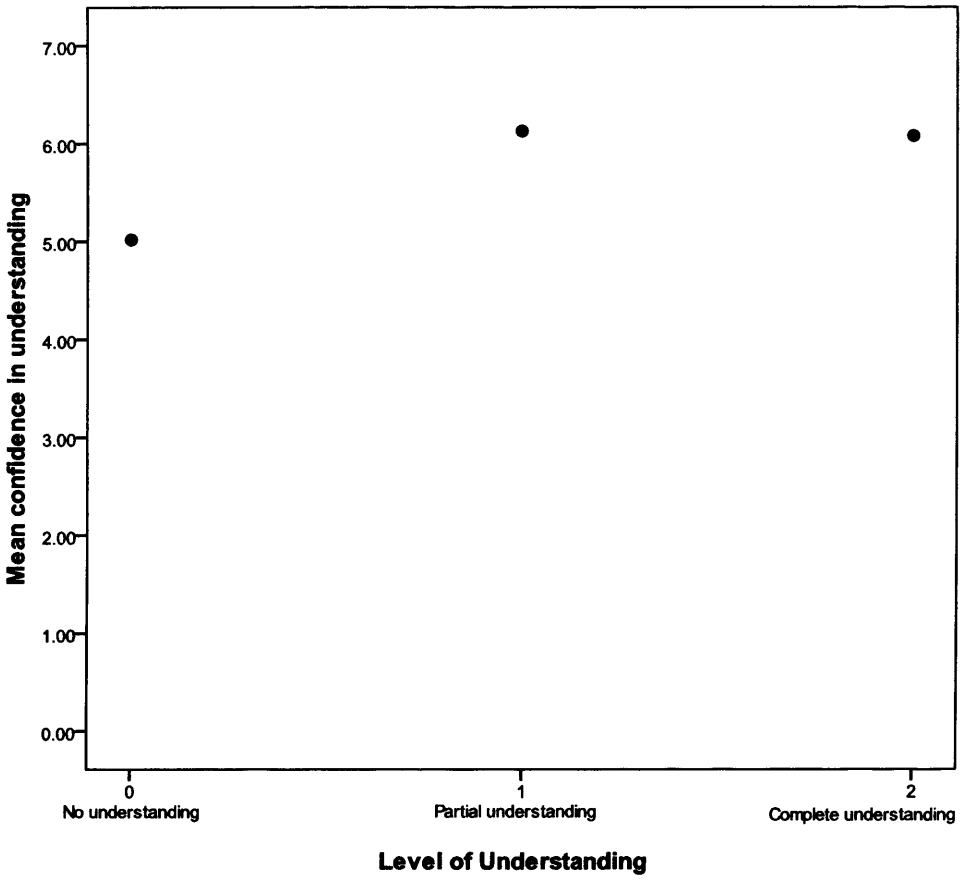


Figure 7.13 Mean confidence in understanding scores for each level of understanding.

A significant negative correlation between *level of understanding* and *confidence in understanding* was found (r= -.107, N=903, *p*=.001 two-tailed), suggesting that level of understanding decreases with high confidence in understanding. However, the relationship is weak as only 1% of the variance is explained (Appendix 75).

7.9.3 Subgroup analysis of the relationship between level of understanding and confidence in understanding split by risk category

Responses were split by risk category (dichotomised into low or moderate/high) to see if results varied according to the level risk of the respondents (Appendix 76). For the low risk category, there was a significant negative correlation between *level of understanding* and *confidence in understanding* (r= -.173, N=748, *p*=.000 two-tailed; r_s= -.172, N=748, *p*=.000 two-tailed). However, this correlation was not seen for the moderate/high risk category (r=-.013, N=155, *p*=.875 two-tailed).

7.9.4 Summary

This section reported the correlational analyses conducted to examine the relationship between *level of understanding* and *confidence in understanding*. It was hypothesised that those with a high level of understanding would have high confidence that they had understood the risk information. A plot of the mean *confidence in understanding* scores for each *level of understanding* (i.e. *no understanding, partial understanding* and *complete understanding*) revealed a trend consistent with the hypothesis, where higher confidence in understanding was seen in those who possessed *complete understanding* as opposed to those with *no understanding*. However, a significant negative relationship was found suggesting that understanding decreases with increasing confidence. This may an artefact resulting from the large proportion of respondents (82%) who displayed *partial*

understanding and also possessed the highest *confidence in understanding* scores of the groups.

Furthermore, the negative correlation found between *level of understanding* and *confidence in understanding* could be explained by *subjective understanding* (e.g. stating what someone in the same risk category should do about their cardiovascular risk) not being a suitable measure when assessing whether risk information has been understood. This is because those with *partial understanding* (who mainly answered the subjective understanding item incorrectly) may have actually understood the risk information correctly and be highly confident that they have done so, but are just overly prepared to take (or already engaged in) actions to reduce their risk even when it is not necessary.

7.10 Correlational validity between level of understanding and intention to change behaviour

This section will describe the analysis conducted to assess the correlational validity between *intention to change behaviour* and *level of understanding of risk information*. The concept of correlational validity (Ubel 2008) hypothesises that those with understanding of their risk should have a greater intention to change their behaviour in order to reduce their cardiovascular risk. A correlational analysis was conducted to determine whether understanding results in more appropriate *intentions to change behaviour*.

7.10.1 Correlational analysis between level of understanding and intention to change behaviour

Correlations between *level of understanding* and *intentions to exercise more, lose weight and stop smoking* were conducted (Appendix 77). It was hypothesised that higher *level of understanding* would result in a greater *intention to change behaviour*.

Intention to exercise more summary statistics for each level of understanding (e.g. *complete understanding*, *partial understanding* and *no understanding*) are presented in Figure 7.14. The greatest mean *intention to exercise more* score was seen for those with *partial understanding* (M=5.04, SD=1.19). Those with *complete understanding* had the lowest mean *intention to exercise more* scores (M=4.82, SD=1.35). The mean *intention to exercise more* score for those with *no understanding* was 4.9 (SD=1.25). This did not follow the hypothesised direction.

The correlational analysis found no significant relationship between *level of understanding* and *intention to exercise more* (r=-.041, N=903, p=.108).

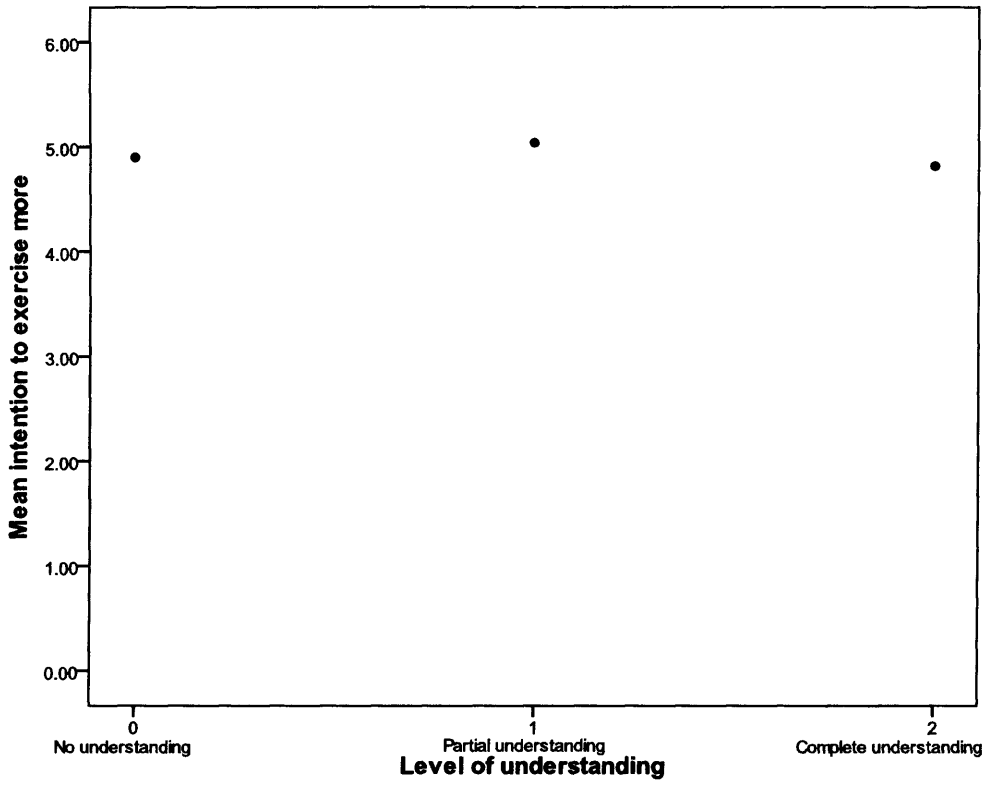


Figure 7.14 Mean *intention to exercise more* scores for each level of understanding.

Figure 7.15 demonstrates the *intention to lose weight* summary statistics for each of the three levels of understanding. The highest mean *intention to lose weight* score was seen in those with *partial understanding* (M=4.72, SD=1.56). Those with *complete understanding* had the lowest *intention to lose weight* (M=4.24, SD=1.81), counter to the hypothesis. The mean score for those with *no understanding* was 4.63 (SD=1.55).

The correlational analysis found a significant correlation between *level of understanding* and *intention to lose weight* (r=-.081, N=903, *p*=.008). This was a

negative correlation, where those possessing a high *level of understanding* had lower *intentions to lose weight*. However, the relationship was weak as 8% of the variance in scores was explained.

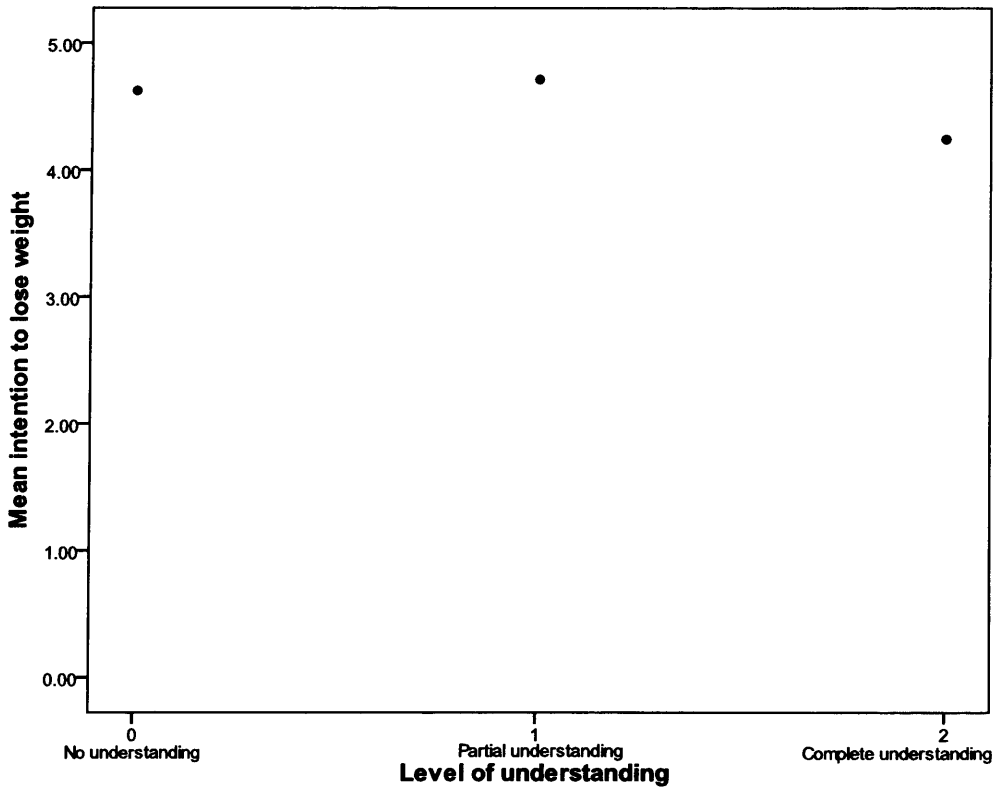


Figure 7.15 Mean intention to lose weight scores for each level of understanding.

Those with *no understanding* had the greatest *intention to stop smoking* (M= 4.24, SD=1.93). Those with *partial understanding* had the lowest *intention to stop smoking* (M= 4.04, SD=1.66). However, as seen in Figure 7.16, the differences are small. The mean score for those with *complete understanding* was 4.07 (SD=1.06). The

correlational analyses revealed no significant relationship between *level of understanding* and *intention to stop smoking* (r=-.019, N=81, *p*=.432).

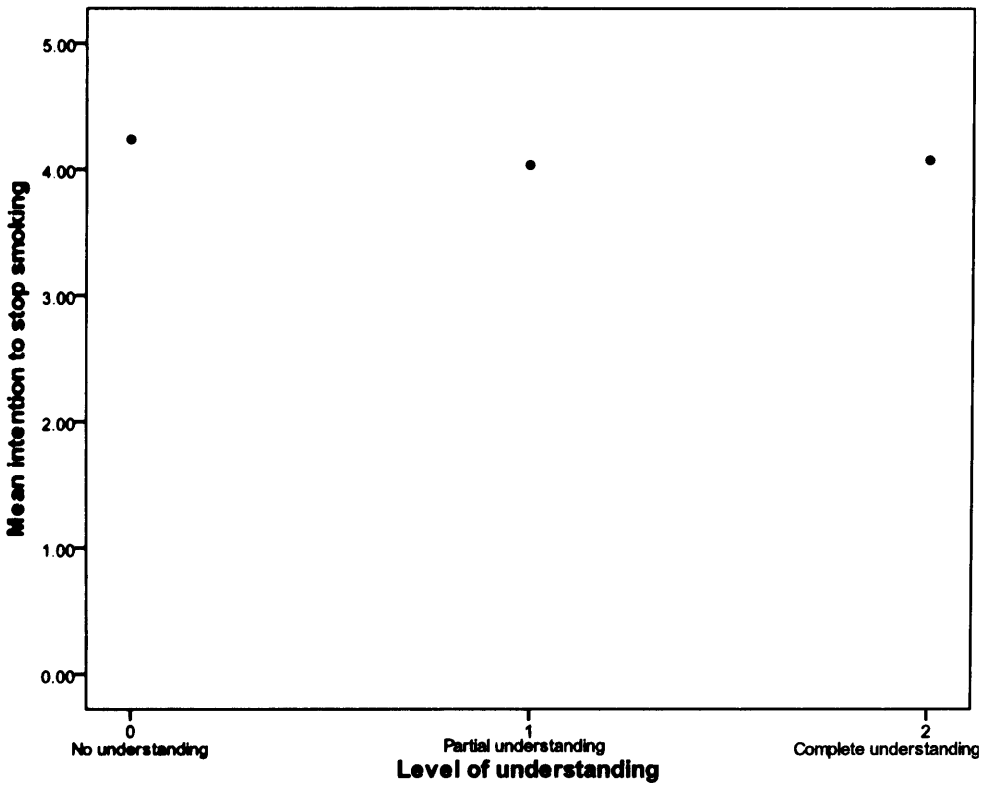


Figure 7.16 Mean intention to stop smoking scores for each level of understanding.

7.10.2 Subgroup analysis split by risk category

Analyses were split by the risk category of the respondents (Appendix 78). For those in the low risk category, a significant negative correlation between *level of understanding* and *intention to lose weight* was found, where *intention to lose weight* decreased with an increased *level of understanding* (r= -.104, N=748, *p*=.002). However, the relationship was weak as only 1% of the variance was explained. Conversely, no significant relationship was found between *level of understanding* and *intention to exercise more* (r= -.026, N=748, *p*=.240) or *intention to stop smoking* (r= -.111, N=49, *p*=.225).

For those in the moderate/ high risk category, *level of understanding* did not significantly correlate with *intention to exercise more* (r= -.090, N=155, *p*=.133), *intention to lose weight* (r= -.043, N=155, *p*=.300) or *intention to stop smoking* (r=.018, N=49, *p*=.461).

7.10.3 Summary

This section has described the correlational analyses of *intention to change behaviour* and *level of understanding*. This was conducted to examine the hypothesis that a higher *level of understanding* would result in a greater *intention to change behaviour*. A significant negative correlation was found between *intention to lose weight* and *understanding*, although not in the direction expected. Intentions to

lose weight decreased with increased level of understanding. This may be explained by the disproportionate number of respondents who were at low risk and correctly understood their risk category. They were reassured that they did not need to take any action (such as losing weight) to reduce their cardiovascular risk, and therefore had low intentions to change behaviour. No significant relationships were found between *level of understanding* and *intention to exercise more* or *stop smoking*. The subgroup analyses found no significant relationships between *level of understanding* and *intention to change behaviour* for those categorised as moderate/high risk. The relationship in the low risk category echoes what was found in the main analysis, where *intentions to lose weight* decreased with a high *level of understanding*. This strengthens the above explanation put forward to account for the unexpected direction of the relationship.

7.11 Relationship between worry about future risk of heart disease and intention to change behaviour

This section described the analysis conducted to assess the relationship between *worry about future risk of heart disease* and *intention to change behaviour*. An inverted-U/ curvilinear relationship was hypothesised, where lower *intentions to change behaviour* would result with very low and high levels of *worry about future risk of heart disease*. The analysis examined the existence of an inverted-U/ curvilinear relationship.

Firstly, the mean *intention to exercise more, lose weight* and *stop smoking* scores for each point on the *worry about future risk of heart disease* 5-point Likert scale were calculated to identify any visible trends in the data (Table 7.18).

Table 7.18 Means and standard deviations of intention to change behaviour scores for each point on the worry about future risk of heart disease scale.

Worry about future risk of heart disease scale	Intention to exercise more		Intention to lose weight		Intention to stop smoking	
	M	SD	M	SD	M	SD
1 (not at all worried)	5.12	1.34	4.63	1.76	4.08	1.75
2	4.10	1.12	4.54	1.61	3.97	1.71
3	4.90	1.20	4.75	1.43	4.35	1.63
4	4.94	1.28	4.89	1.38	3.72	1.43
5 (very worried)	4.96	1.13	5.10	1.48	3.67	0.88

Then, one-way ANOVAs were conducted to examine the relationship between each of the *intention to change behaviour* scores (exercise more, lose weight and stop smoking) and *worry about future risk of heart* disease (Appendix 79). A 2nd degree polynomial (quadratic) model was fitted to the data (i.e. curve with one bend), to assess whether there is evidence of a curvilinear relationship between *intention to change behaviour and worry about future risk of heart disease*. The polynomial contrasts were examined to see how well the data fitted the model, i.e. to what extent a curvilinear relationship existed.

7.11.1 Intention to exercise more

Figure 7.17 depicts the mean *intention to exercise more* scores for each point on the Likert Scale measuring *worry about future risk of heart disease*. The mean *intention to exercise more* scores at the extremes of the scale were greater than the mean score on the mid-point on the scale (M=5.12, SD=1.34 and M=4.96, SD=1.13 compared to M=4.90, SD=1.20). This indicates *intention to exercise more* is greater when respondents are not at all worried about the future risk of heart disease or very worried. This is the reverse of what would be expected in the hypothesised curvilinear relationship between the two variables.

A one-way ANOVA (sum of squares with 4 degrees of freedom) with a second degree polynomial model was conducted. There were no statistically significant differences between *intention to exercise more* and *worry about future risk of heart disease* ($F(4,898) = 1.004$, $p = .404$). However, this is not sensitive at detecting any meaningful first order trends (i.e. linear) or second order trends (including U shaped and inverted-U shaped). Therefore, these trends were examined using a quadratic term (sensitive to a curvilinear / U-shape or inverted-U shape between two variables). Again, no statistically significant trends were found in the data ($F(1,898) = .861$, $p = .354$). Although there was some evidence of a linear trend between the variables, where lower *intentions to exercise more* were associated with higher levels of *worry about future risk of heart disease*, this did not quite reach significance ($F(1,898) = 3.034$, $p = .082$).

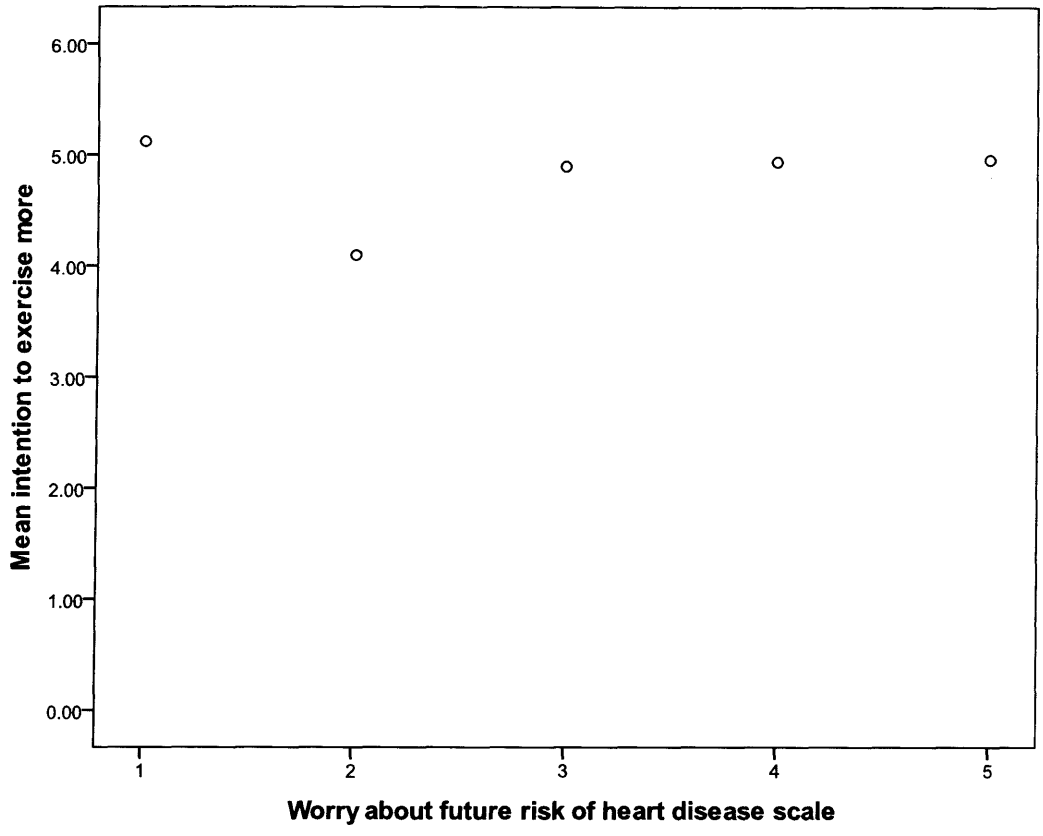


Figure 7.17 Mean intention to exercise more scores for each point on the worry about future risk of heart disease scale.

7.11.2 Intention to lose weight

The mean *intention to lose weight* scores increase with increased *worry about future risk of heart disease* (Figure 7.18). For example, the mean score was 4.63 (SD= 1.76) for respondents who reported that they were *not at all worried* about the future

risk of heart disease and 5.10 (SD=1.48) for those who were *very worried*. However, there was one exception to this, the second point of the Likert scale (M=4.54, SD=1.61).

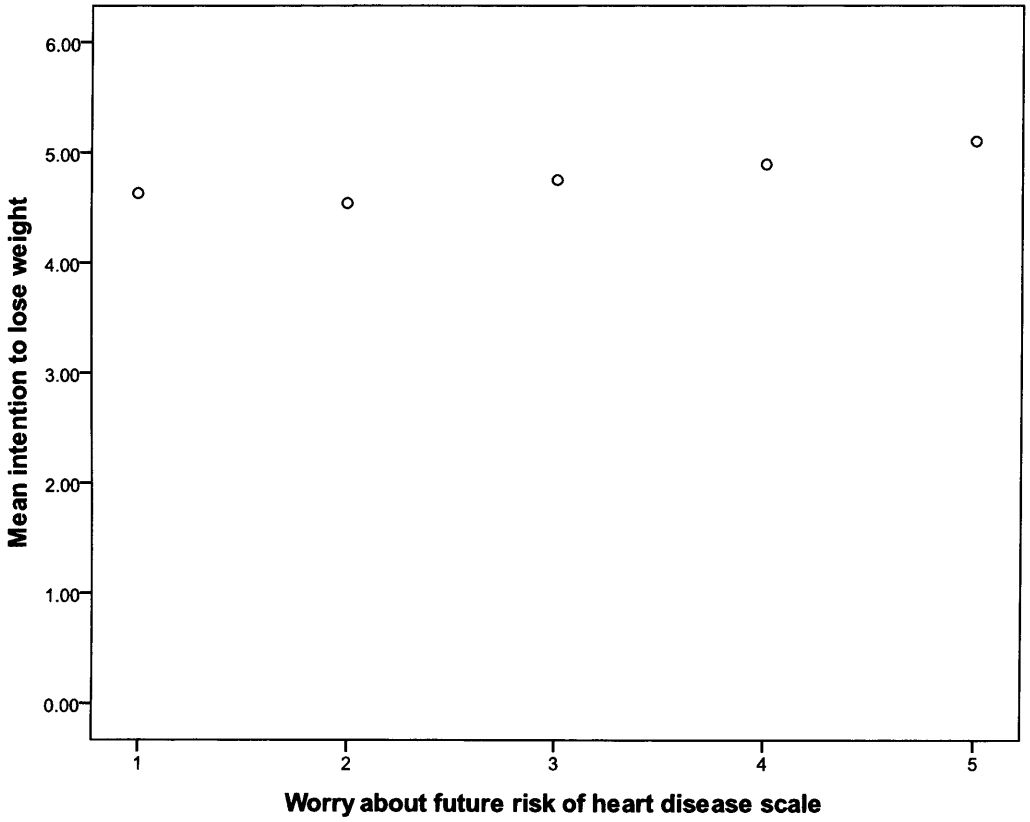


Figure 7.18 Mean intention to lose weight scores for each point on the worry about future risk of heart disease scale.

The one-way ANOVA did not find any significant difference between *intention to lose weight* and *worry about future risk of heart disease* scores ($F(3,898) = 1.359$, $p = .246$). There was no evidence of a quadratic/ curvilinear trend between the variables ($F(1,898) = 1.697$, $p = .193$), nor a linear trend ($F(1,898) = 2.922$, $p = .088$).

7.11.3 Intention to stop smoking

The mean intention to stop smoking scores for each of the points on the *worry about future risk of heart disease* scale are displayed on Figure 7.19. No pattern in the data is observed. This is confirmed by a one-way ANOVA that found no significant differences between *intention to stop smoking* and *worry about future risk of heart disease* ($F(3,76) = .396$, $p = .811$).

The linear term did not reveal any linear trends in the data ($F(1,76) = .084$, $p = .773$), and the quadratic term did not reveal any curvilinear trends in the data ($F(1,76) = .440$, $p = .509$). However, it must be acknowledged that the intention to stop smoking sample is reduced and comprises less than 10% of the respondents who completed the study as a whole.

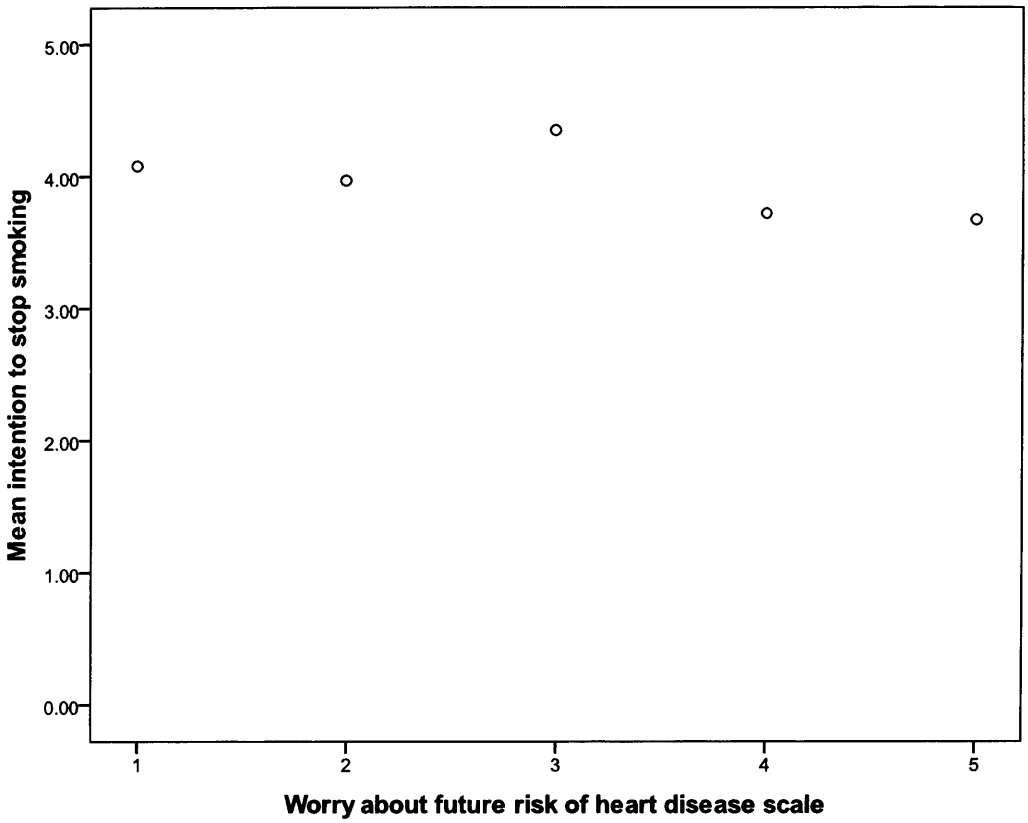


Figure 7.19 Mean intention to stop smoking scores for each point on the worry about future risk of heart disease scale.

7.11.4 Subgroup analysis split by risk category

Table 7.19 demonstrates the means and standard deviations for *intention to exercise more, lose weight* and *stop smoking* for each of the points on the *worry about future risk of heart disease* scale, when responses were split by risk category.

Table 7.19 Means and standard deviations of *intention to change behaviour* for each point of the *worry about future risk of heart disease* scale dichotomised by low or moderate/high risk category.

Worry	Low risk category						Moderate/high risk category					
	Intention to exercise more		*Intention to lose weight*		*Intention to stop smoking*		*Intention to exercise more*		*Intention to lose weight*		*Intention to stop smoking*	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
1 (not at all worried)	5.09	1.34	4.67	1.71	4.00	1.88	5.46	1.23	4.17	2.42	4.50	1.18
2	5.03	1.11	4.56	1.62	4.13	1.92	4.77	1.23	4.34	1.46	3.67	1.26
3	4.88	1.23	4.80	1.42	3.74	1.66	4.94	1.15	4.63	1.47	4.95	1.47
4	4.75	1.27	4.63	1.51	3.61	1.29	5.18	1.28	5.23	1.13	3.83	1.67
5 (very worried)	4.90	0.98	3.86	1.09	4.17	0.24	5.00	1.29	6.07	0.89	2.67	0.00

For the low risk category, there was a trend in *intention to exercise more* scores, where *intention to exercise more* decreased as *worry about future risk of heart disease* increased. Conversely, there did not seem to be any distinct pattern in *intention to lose weigtht* or *intention to stop smoking* scores.

For the moderate/high risk category, no visible trend was seen for *intention to exercise more* scores. But *intention to lose weight* scores increased with increasing *worry about future risk of heart disease* (M=4.17, SD=2.42 for those who were not at all worried about the future risk of heart disease and M=6.07, SD=.89 for those who

reported being very worried). Where *intention to stop smoking* was concerned, there was one respondent who reported being very worried about their future risk of heart disease, although they had the lowest intention to stop smoking (M=2.67).

One way ANOVAs were conducted for the low risk and moderate/high risk categories separately (Appendix 80). For the low risk category, there was no significant difference between *intention to exercise more* ($F(4,743) = 1.182$, $p = .317$), *intention to lose weight* ($F(4,743) = .955$, $p = .431$) or *intention to stop smoking* ($F(4,44) = .157$, $p = .959$) for each of the points on the *worry about future risk of heart disease* scale. There was no evidence to support the hypothesis of a curvilinear relationship between the *intention to exercise more* ($F(1,743) = .001$, $p = .918$), *intention to lose weight* ($F(1,743) = .173$, $p = .678$) or *intention to stop smoking* ($F(1,44) = .017$, $p = .896$) and *worry about future risk of heart disease.* Furthermore, no evidence of a linear relationship was seen for *intention to lose weight* ($F(1,743) = .000$, $p = .922$), or *intention to stop smoking* ($F(1,44) = .189$, $p = .666$) and *worry about future heart disease*. However, a significant linear trend was found for *intention to exercise more* ($F(1,743) = 4.295$, $p = .039$), where *intention to exercise more* decreased with increased *worry about future risk of heart disease*.

For the moderate/high risk category, there were no significant differences between the *intention to exercise more* ($F(4,150) = 1.104$, $p = .357$) or *intention to stop smoking* scores ($F(4,27) = 1.679$, $p = .184$) for each point of the *worry about future heart disease scale*. However, there was a significant difference in *intention to lose weight* scores across each level of *worry about future risk of heart disease* ($F(4,150) = 3.851$,

p=.005). This was a statistically significant linear trend (F(1,150)= 13.654, p=.000), where *intention to lose weight* increased as *worry about future risk of heart disease* increased. There was no evidence of a linear relationship between *intention to exercise more* (*F*(1,150) =.001, *p*=.973) or *intention to stop smoking* (*F*(1,27)=.015, *p*=.904) and *worry about future heart disease scale.* Inconsistent with the hypothesis, no significant curvilinear relationship was found for *intention to exercise more* (*F*(1,150) =1.598, *p*=.208), *intention to lose weight* (*F*(1,150) =1.713, *p*=.193), or *intention to stop smoking* (*F*(1,27)=2.101, *p*=.159) and *worry about future risk of heart disease.*

7.11.5 Summary

This section described the analysis conducted to examine a relationship between *intention to change behaviour* and *worry about future risk of heart disease*. It was hypothesised that there would be a curvilinear relationship where lower intentions to change behaviour would be found in those who were either not at all worried or very worried about the future risk of heart disease. One-way ANOVAS were conducted and a polynomial (quadratic) model was fitted to the data. For *intention to exercise more and intention to lose weight* a linear pattern was observed, where intentions increased with worry about future risk of heart disease. However, these trends were not statistically significant. No coherent pattern was identified for *intention to stop smoking.* There was no significant evidence of the hypothesised curvilinear direction. This is likely to be due to the variation in

intention to change behaviour scores among respondents at any given level of *worry about future risk of heart disease* that obscures any suggestion of a meaningful trend in the data. When responses were dichotomised by risk category, significant linear relationship were found between *worry about future risk of heart disease* and *intention to exercise more* for the low risk category; and *intention to lose weight* for the moderate/high risk category. *Intention to lose weight* increased with greater *worry about future risk of heart disease*, which is a logical finding, where it would be expected that those who are concerned about their future risk of heart disease would want to try and take action (such as losing weight) in order to reduce their risk. However, *intention to exercise more* decreased with greater *worry about future risk of heart disease,* which is not in the expected direction and is difficult to explain.

7.12 Summary of all results

To summarise, this trial found no statistically significant main effects of cardiovascular risk presentation format on *intention to change behaviour* (e.g. exercise more, lose weight or stop smoking), *level of understanding*, *confidence in understanding*, *positive and negative affect* or *worry about future risk of heart disease.*

Multiple regression analysis assessed which variables predicted *intention to change behaviour.* Significant models for *intention to exercise* and *intention to lose weight*

were found, where 11.7% and 3.8% of the variance in intention scores was explained respectively.

Intention to exercise more was significantly predicted by *positive affect, negative affect, level of understanding* and risk category of respondents. This suggests that with increasing risk of CVD, increasing positive emotions and decreasing negative emotions will lead to greater intentions to exercise more. However, decreasing level of understanding was also found to improve intentions, which is not in the direction that would be expected.

Intention to lose weight was significantly predicted by *positive affect* and *level of understanding.* This suggests that increasing positive emotions and decreasing level of understanding will improve intentions to lose weight; whereas, a person's level of cardiovascular risk and negative emotions (including worry about future risk of heart disease) play no part in decisions about losing weight.

Positive affect was the only variable to significantly predict all three behavioural intentions (*exercise more, lose weight* and *stop smoking),* it was consistently the largest contributor to the variance in intention scores. This suggests that developers of interventions aimed at increasing health protective behaviours should focus on increasing positive emotions to improve the effectiveness of the intervention.

Changes in *affect* and *worry about future risk of heart disease* after viewing cardiovascular risk were examined. There was a significant decrease in *positive*

affect, negative affect and *worry about future risk of heart disease* after viewing cardiovascular risk. These decreases were upheld when responses were split by risk category. *Positive affect* was reduced most in the moderate/ high risk category. This is an expected finding as realising that you have an elevated risk of CVD reduces feelings of reassurance and can cause concern. *Negative affect* and *worry about future risk of heart disease* was reduced most in the low risk category. Again, this is an expected finding as being of low risk can reduce previous negative emotions, worries and anxieties about risk of CVD risk, and can provide reassurance. The pictogram format consistently led to the greatest reductions in affect and worry about future risk of heart disease, and the bar graph format consistently led to the least reductions in affect and worry about future risk of heart disease. This suggests that pictograms make more of an impact when used to present cardiovascular risk, compared to bar graphs which have the least influence over how a person feels about their risk.

Further analyses revealed a significant negative correlation between *level of understanding* and *intention to lose weight*, where intention to lose weight decreases as understanding increases. This is inconsistent with the correlational validity hypothesis (Ubel 2008), suggesting intentions are greater with increased understanding. An explanation for this may be the disproportionate number of respondents who were at low risk and correctly understood their risk category, but were reassured that they did not need to take any action (such as losing weight) to reduce their CVD risk. No significant correlations were found between *level of understanding* and *intention to exercise more* or *intention to lose weight*.

Additionally, a significant negative correlation was found between *level of understanding* and *confidence in understanding*, where confidence decreases as *level of understanding* increases. It is likely that this finding is attributable to the inappropriate subjective understanding responses (which indicates what people think someone of the same risk category should do to reduce their risk, e.g. nothing, a little or a lot). This suggests that either the subjective understanding item is not a suitable measure of whether respondents have understood the risk information presented to them, or that the respondents in this trial were just overly prepared to take action to reduce their risk of CVD even though this was not necessary.

Lastly, it was hypothesised that low and high levels of *worry about future risk of heart disease* would lead to reduced *intention to change behaviour*. However, there was no evidence of a curvilinear relationship between *intention to change behaviour* and *worry about future risk of heart disease*. When responses were dichotomised by risk category, significant linear relationships were found between *worry about future risk of heart disease* and *intention to exercise more* for the low risk category; and *intention to lose weight* for the moderate/high risk category. *Intention to lose weight* increased with greater *worry about future risk of heart disease*, which is a logical finding, but *intention to exercise more* decreased with greater *worry about future risk of heart disease.* A plausible explanation cannot be suggested for the direction of this finding.

Chapter 8. Secondary results of a web-based randomised controlled trial of cardiovascular risk representation formats.

8.1 Introduction

This chapter describes the results of the secondary objectives of the web-based randomised controlled trial on cardiovascular risk representation formats. This chapter is divided into sections; the research objectives and/or hypotheses are presented at the start, the results are reported and summarised at the end of each section.

As with the data analysis of the primary objectives, the main outputs are presented in the appendices. Syntax and full SPSS outputs are accessible using the following link to an on-line Google document:
https://docs.google.com/viewer?a=v&pid=explorer&chrome=true&srcid=0B0ZzQPPd5mfKZTQ0MjliMDgtMjE3MS00MGVlLWIyMmItMTQzZjMwZGIyMzlk&hl=en_GB.

The secondary objectives are outlined below:

- Examination of the existence of the Hawthorne effect by comparing the responses of the two control groups.
- Analysis of within-group changes between pre and post-intervention responses in the group who completed both questionnaires.

- Examining the appropriateness of intention to change behaviour when requesting copy of risk output, including assessment of direct and indirect intentions to change behaviour.
- Assessment of the Theory of Planned Behaviour's efficacy to predict intention to change behaviour to reduce future heart risk.
- An evaluation of the use of the internet-provided risk formatter (process evaluation), including analysis of web-logs.

8.2 Existence of a Hawthorne effect

This section describes the examination of a possible Hawthrone effect (Adair 1984) of an outcome questionnaire about cardiovascular risk. This was done using two control groups: the first control group was given a pre-intervention questionnaire asking respondents about their cardiovascular risk perceptions and intentions to reduce future cardiovascular risk. The second control group was not given the pre-intervention questionnaire but received the same graphical risk representation format as the first control group (e.g. bar graph). It was hypothesised that respondents who received the pre-intervention questionnaire would have higher intentions to change behaviour to reduce risk, than those who did not receive the pre-intervention questionnaire.

8.2.1 Comparison of the two control groups

Figure 8.1 demonstrates the Error bar plots of 95% confidence intervals for mean *intention to exercise more*, *lose weight* and *stop smoking* scores for control group 1 (who completed the pre-intervention questionnaire) and control group 2 (who were not offered the pre-intervention questionnaire).

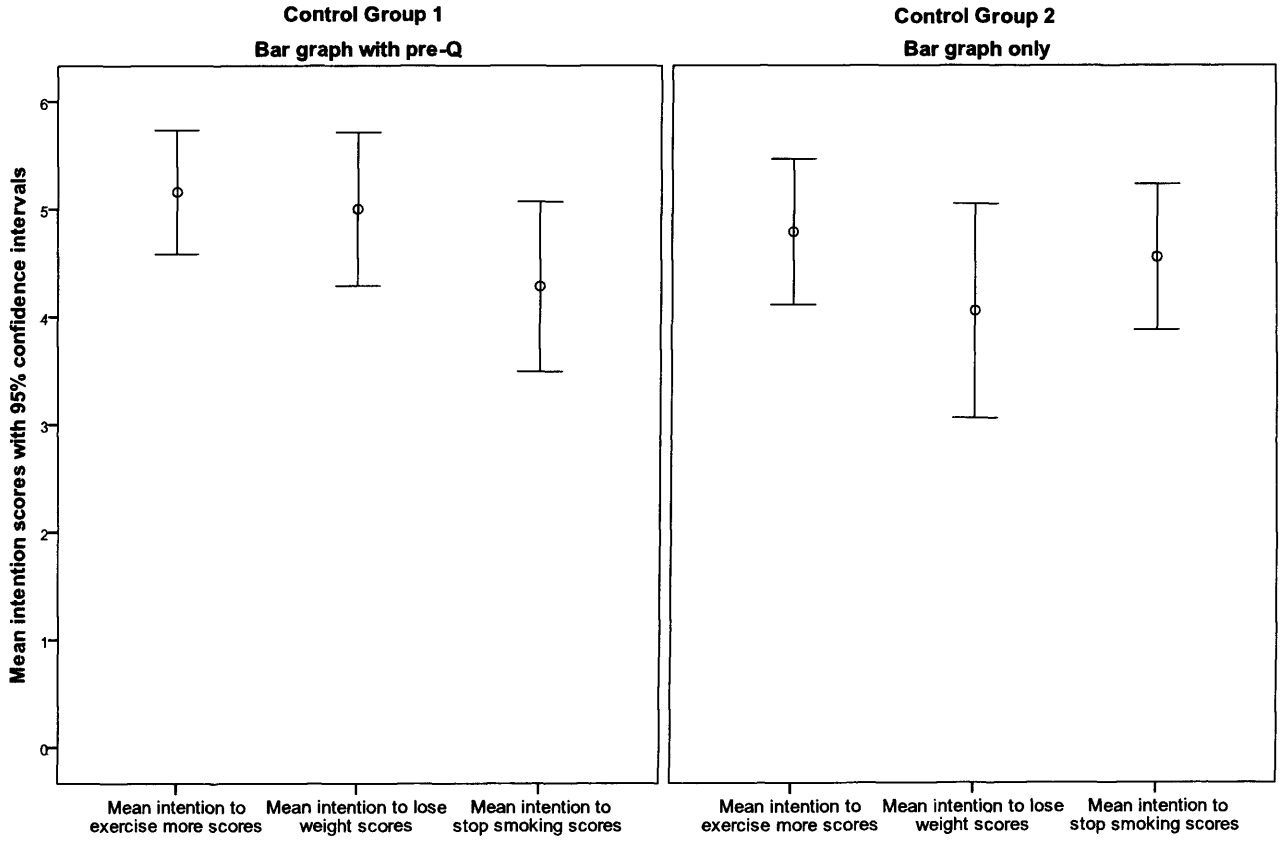


Figure 8.1 Error bar plots of 95% confidence intervals for mean post-intention to exercise more, lose weight and stopping smoking scores for control group 1 and control group 2.

Those who received the pre-intervention questionnaire (control group 1) had slightly higher *intentions to exercise more* (M=5.06, SD=1.2) and *lose weight* (M=4.75, SD=1.56) than those who did not receive the pre-intervention questionnaire (control group 2) (M=5.02, SD= 1.21 and M=4.65, SD= 1.61, respectively). This was in the hypothesised direction. However, *intention to stop smoking* was highest in the group who did not receive the pre-intervention questionnaire (M=4.55, SD=1.45) compared to those who did (M=4.28, SD =1.64), which was contrary to the hypothesis.

The planned comparisons reported in Chapter 7 (Section 7.6.2) revealed no significant differences between the *Bar graph* and *Bar graph with pre-intervention questionnaire* conditions (Appendix 64). Respondents who received the bar graph format did not differ from those who completed a pre-intervention questionnaire. The scores of the two groups did not significantly differ in terms of: *intention to exercise more* (t=-.301, df=899, *p*=.764); *intention to lose weight* (t=.651, df=899, *p*=.515); *intention to stop smoking* (t=-.527, df=77, *p*=.600); *level of understanding* (t=-.782 df=899, *p*=.434); *confidence in understanding* (t=-.112, df=899, *p*=.911); *positive affect* (t=-1.015, df=899, *p*=.311); *negative affect* (t=-.732, df=899, *p*=.464) and *worry about future risk of heart disease* (t=.354, df=899, *p*=.723). This suggests that questionnaire did not have an intervention effect.

Therefore, it is concluded that there was no Hawthorne effect of thinking about cardiovascular risk on intentions to change behaviour in order to reduce risk. Demonstrating that answering questions about personalised risk of future cardiovascular disease before viewing actual risk does not lead to increased intentions to changing your behaviour to reduce risk (such as and exercising more,

losing weight and stopping smoking), neither does it affect level of understanding of risk information, or alter positive and negative emotions, including worry about future risk of heart disease.

8.2.2 Subgroup analysis by risk category

Responses were split by either low or moderate and high risk categories (Appendix 65). Again, there were no significant differences between those who received the pre-intervention questionnaire and those who did not for low risk or moderate/high risk respondents (all *p* values >0.5).

8.2.3 Summary

This section has described the comparison of the two control groups to look for the existence of a Hawthorne effect of an outcome questionnaire about cardiovascular risk. There were no significant differences between the control group who received the pre-intervention questionnaire and the control group who did not. When responses were split by risk category (low or moderate/high) still no Hawthorne effect was evident. This demonstrates that answering questions about your risk of future cardiovascular disease before viewing your actual risk does not lead to increased intentions to changing your behaviour (such as exercising more, losing weight and stopping smoking), neither does it affect your level of understanding of your risk information, or alter your positive and negative emotions, including worry about your future risk of heart disease.

8.3 Analysis of pre and post-intervention intention to change behaviour to reduce cardiovascular risk

This section will describe the analysis of the responses from control group 1 who received a pre-intervention questionnaire before viewing their cardiovascular risk and also completed the post-intervention questionnaire. This is to see whether intentions to reduce cardiovascular risk by behaviour change (e.g. exercising more, losing weight and stopping smoking) are increased or decreased after viewing personally calculated cardiovascular risk.

8.3.1 Within-group changes in intention to exercise more, lose weight and stop smoking

Serial within-group changes of *intention to change behaviour* between the pre and post-intervention questionnaires of the first control group were assessed. The pre-intervention *intention to reduce risk of heart disease* score was compared to post-intervention scores for *intention to exercise more, lose weight* and *stop smoking*. Assessment of these changes gives an indication of the behaviours likely to be chosen by respondents who originally intended to reduce their risk of heart disease; and determines whether viewing cardiovascular risk result actually increases or decreases the original intention to reduce cardiovascular risk.

Figure 8.2 demonstrates the mean intention scores with 95% confidence intervals for pre-intervention *intention to reduce risk of heart disease* and post-intervention mean

intention to exercise more, lose weight and *stopping smoking* for control group 1 scores.

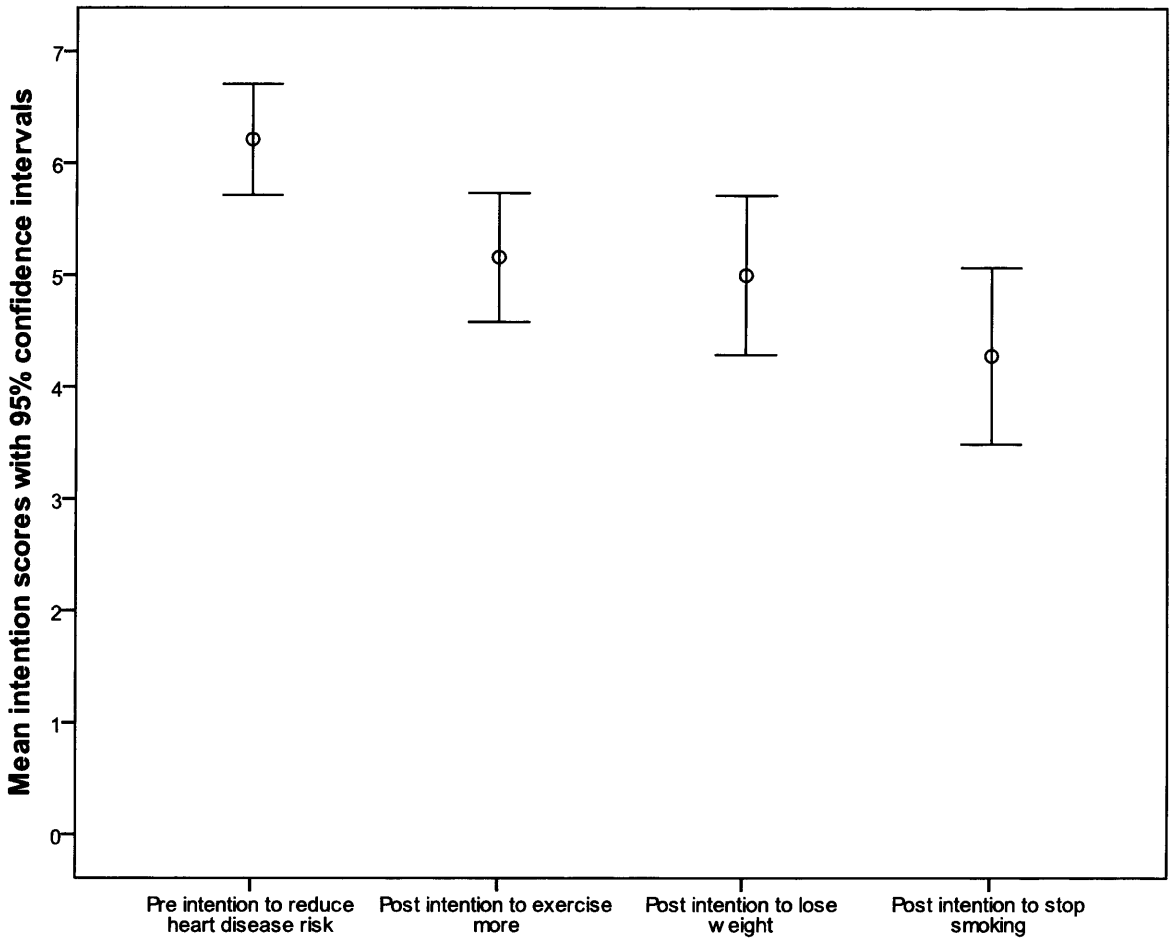


Figure 8.2 Error bar plots of mean intention scores with 95% confidence intervals for pre-intention to reduce risk of heart disease and post-intention to exercise more, lose weight and smoking cessation for control group 1.

Pre-intervention *intention to reduce cardiovascular risk* was higher (M=6.26, SD=1.27) than the post-intervention *intention to exercise more* (M=5.06, SD=1.20), *lose weight* (M=4.75, SD= 1.56) and *stop smoking* (M=4.28, SD=1.638).

There was a statistically significant effect of viewing the cardiovascular risk, although it was not in the expected direction (Appendix 81). There was a significant decrease in intention to reduce cardiovascular risk by *exercising more* after viewing cardiovascular risk ($t(211)=9.915$, $p=.000$). However the eta squared statistic (.318) indicated a small effect size (calculated from equation given by Pallant 2006) (Pallant 2006, p.212). Furthermore, there was a statistically significant decrease in intention to reduce cardiovascular risk by *losing weight* after viewing cardiovascular risk ($t(211)=11.641$, $p=.000$). Again, the eta statistic (.391) indicated a small effect size. Lastly, the same was seen for *intention to stop smoking*, where intention to reduce cardiovascular risk by stopping smoking scores significantly decreased after viewing cardiovascular risk results ($t(18)=4.496$, $p=.000$). The eta squared statistic (.529) indicated a small to moderate effect size.

It was expected that intentions to change behaviours would increase after viewing cardiovascular risk, and respondents would have greater intentions to exercise more, lose weight and stop smoking that their initial pre-intervention intention to reduce their risk of heart disease. The results are contrary to this, and may be because intention to reduce heart disease risk is more theoretical than the specific lifestyle changes: exercising more, losing weight and stopping smoking, which are more practical options, and hence they may be viewed differently. Alternatively, respondents may have expected their cardiovascular risk to be higher, and therefore may have been reassured by their risk result, which led to reduced intentions to change behaviour in order to reduce risk.

8.3.2 Within-group changes in intention to exercise more, lose weight and stop smoking subgroup analysis split by risk category

As risk magnitude may have had an influence on the intention scores, paired t-tests were recalculated with the respondent's risk category as a subgroup (Appendix 82). Figure 8.3 demonstrates the mean intention scores for pre-intervention *intention to reduce heart disease risk* and mean post-intervention *intention to exercise more, lose weight* and *stop smoking* for control group 1, dichotomised by the risk category of respondents.

Again, pre-intervention *intention to reduce cardiovascular risk* (M=6.27, SD=1.24) was greater than post-intervention *intention to exercise more* (M=5.04, SD=1.22), *lose weight* (M=4.70, SD=1.63) and *stop smoking* (M=4.53, SD=1.74) for respondents categorised as low risk.

The same was seen for those at moderate/high risk, where the pre-intervention *intention to reduce cardiovascular risk* (M=6.18, SD=1.45) was greater than the post-intervention *intentions to exercise more* (M=5.17, SD=1.11), *lose weight* (M=5.02 , SD= 1.04) and *stop smoking* (M=3.86, SD=1.48).

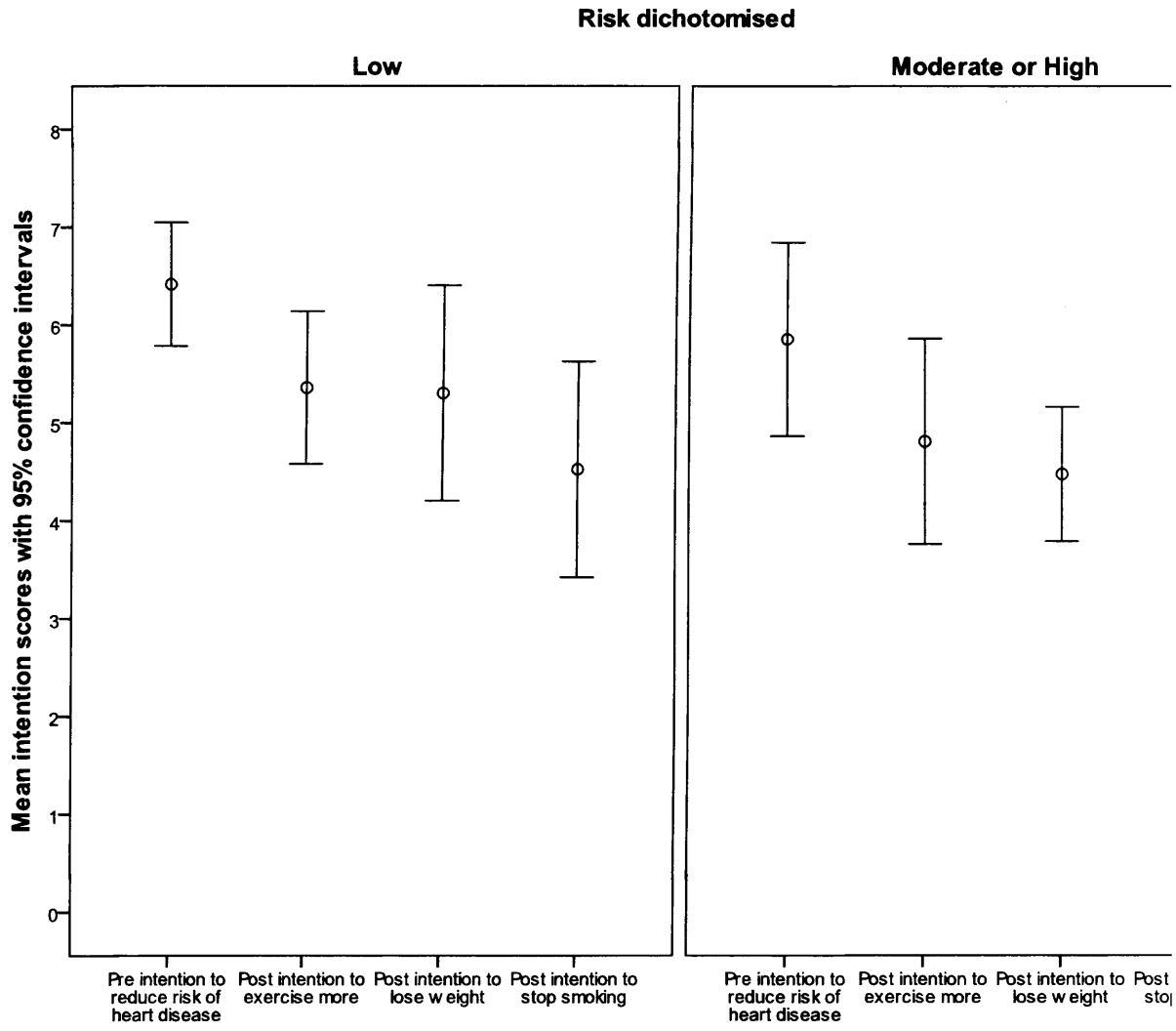


Figure 8.3 Error bar plots of mean intention score with 95% confidence intervals for pre-intention to reduce risk of heart disease and post-intention to exercise more, lose weight and stopping smoking scores for control group 1 dichotomised by risk category.

Low risk category

For respondents at low risk, there was a significant decrease in intention to reduce cardiovascular risk by *exercising more* (t(178)=9.235, *p*=.000), *losing weight*

(t(178)=11.01, *p*=.000) and *stopping smoking* (t(11)=3.548, *p*=.005) after viewing cardiovascular risk.

Moderate/high risk category

A significant decrease in intention to reduce cardiovascular risk by *exercising more* (t(32)=3.584, *p*=.001), *losing weight* (t(32)=3.843, *p*=.001) and *stopping smoking* (t(6)=2.564, *p*=.043) after viewing cardiovascular risk was also found for respondents in the moderate/high risk category. However, the *intention to stop smoking* results should be interpreted with caution due to small cell sizes (n=7).

8.3.3 Summary

This section has described the analysis of serial within-group changes of respondents allocated to control group 1 who completed the pre and post-intervention questionnaires. This was to determine whether intention to reduce cardiovascular risk by changing behaviour (exercising more, losing weight and stopping smoking) increased or decreased after viewing actual cardiovascular risk. Significant differences in intention scores were found, although this was not in the direction that was expected. There was a significant decrease in *intention to reduce cardiovascular risk* by *exercising more, losing weight* and *stopping smoking* after viewing risk. This may have been due to the large proportion of respondents who were categorised as low risk, who realised that they did not need to reduce their cardiovascular risk. Perhaps they were expecting to have a higher risk result, and

therefore felt reassured by their lower risk category. Although, this does not explain the significant decrease was still evident in the respondents who were categorised as moderate/high risk in the sub-group analysis.

Alternatively, there may be a limitation when comparing the results directly, as asking respondents about their intentions to reduce their risk of heart disease is more theoretical than asking about their intentions to perform specific lifestyle changes, such as exercising more, losing weight and stopping smoking. Therefore, the two may be viewed differently, leading to the differences that were found before and after respondents viewed their cardiovascular risk.

8.4 Intention to reduce cardiovascular risk when requesting a copy of risk output

This section describes the examination of intention to change behaviour between those who request a copy of their risk output and those who do not. At the end of the study respondents were given the option to leave their contact details if they wanted a copy of their risk results to be sent to them. It was suggested that they could take these results to their GP. The analysis of the groups who requested a copy of their results and those who did not determined whether those who wanted a copy of their risk output had greater intentions to reduce their cardiovascular risk, by exercising more, losing weight and stopping smoking, than those who did not.

As already described in Chapter 7, 143 respondents requested a copy of their risk output result. The bar graph condition (Control group 2) had the highest proportion

of respondents requesting a copy of their risk output (n=40) and the metonym format (Intervention group 2) had the lowest proportion of respondents requesting a copy of their risk output (n=31) (Table 7.3). No significant differences were found across conditions between those who requested a copy of their risk output results and those that did not (Chi square = 2.163, df = 3, *p*=.539) (Appendix 47).

Independent samples t-tests were conducted to compare the *intention to exercise more, lose weight* and *stop smoking* scores for those who requested a copy of their risk output results and those that did not (Appendix 83). These are described below.

8.4.1 Intention to exercise more

Box plots (Figure 8.4) demonstrate the mean *intention to exercise more* scores for respondents who requested a copy of their risk output and those that did not. The mean was higher for those who requested their risk output results (M=5.13, SD 1.12) than for those who did not request their results (M=4.98, SD 1.23).

Independent t-tests revealed no significant differences in the *intention to exercise more* scores between the two groups ($t(901)= -1.348$, $p=.178$ (equal variances assumed as the Levene's test was not significant, $p=.218$)), indicating that those who requested a copy of their risk output did not possess greater intentions to reduce their cardiovascular risk by exercising more than those who did not request a copy of their risk output .

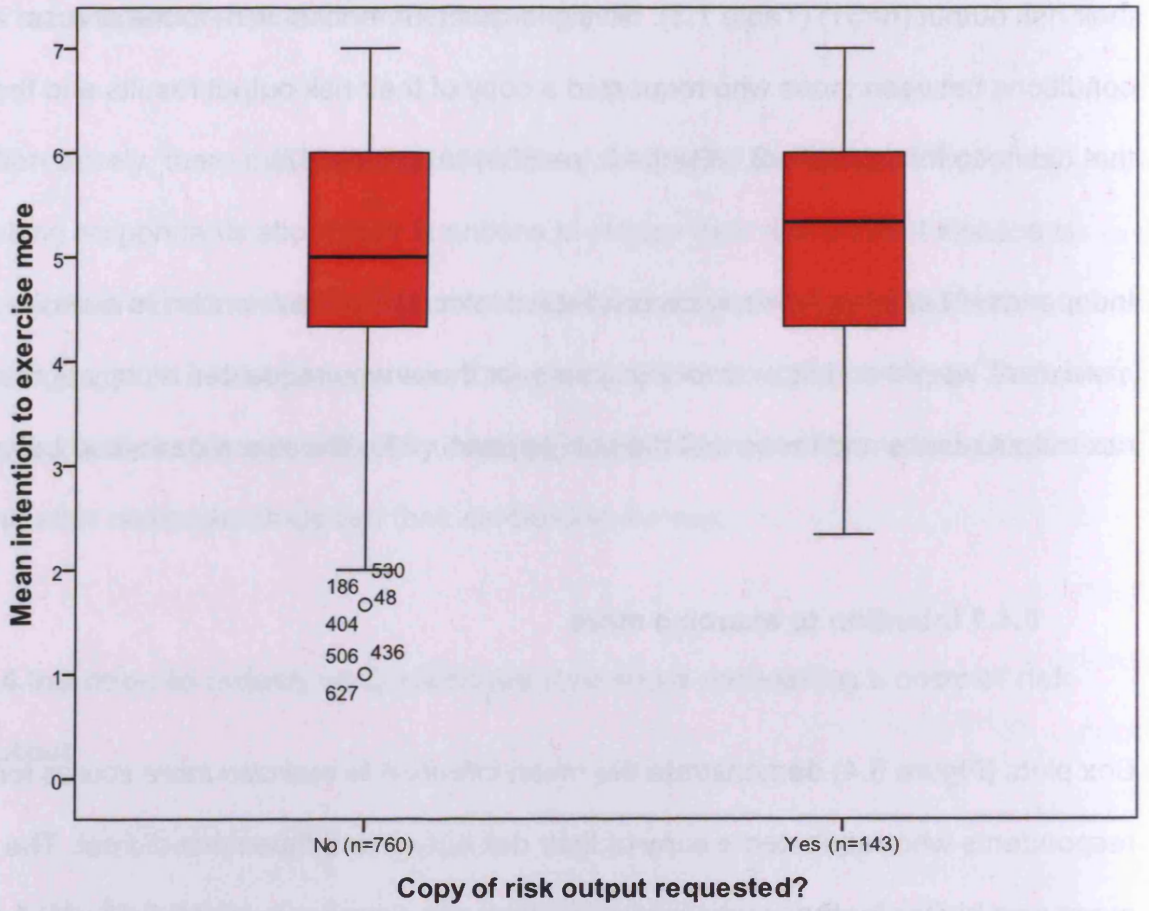


Figure 8.4 Comparison of mean intention to exercise more scores for respondents who requested a copy of their risk output and those who did not.

Subgroup analysis by risk category

A subgroup analysis of risk category was conducted, where respondents were dichotomised into those at low risk or moderate/high risk (Appendix 84). In the low risk category, those who requested a copy of their risk output results had a greater *intention to exercise* more than those who did not request a copy (M=5.17, SD= 1.13 compared to M=4.98, SD=1.23). However, the difference was not significant; $t(746)= -1.513$, $p=.131$ (equal variances assumed as the Levene's test was not significant, $p=.431$).

In the moderate/high risk category, again, *intention to exercise more* was higher for those who requested their results than for those who did not (M=5.02, SD= 1.115 compared M=5.00, SD=1.253), but again this difference did not reach significance ($t(153)= -.108$, $p=.914$ equal variances assumed).

8.4.2 Intention to lose weight

Figure 8.5 shows the mean *intention to lose weight* scores for respondents who requested a copy of their risk output and those that did not. *Intention to lose weight* was higher in those who requested a copy of their risk output (M=4.88, SD=1.41) compared to who did not request a copy of their risk output (M=4.60, SD=1.63). The difference was significant ($t(220.331)= -2.080$, $p=.039$ (equal variances not assumed as Levene's test was significant, $p=.037$)), indicating that those who requested a

copy of their risk output had greater intentions to lose weight than those who did not request a copy of their risk output.

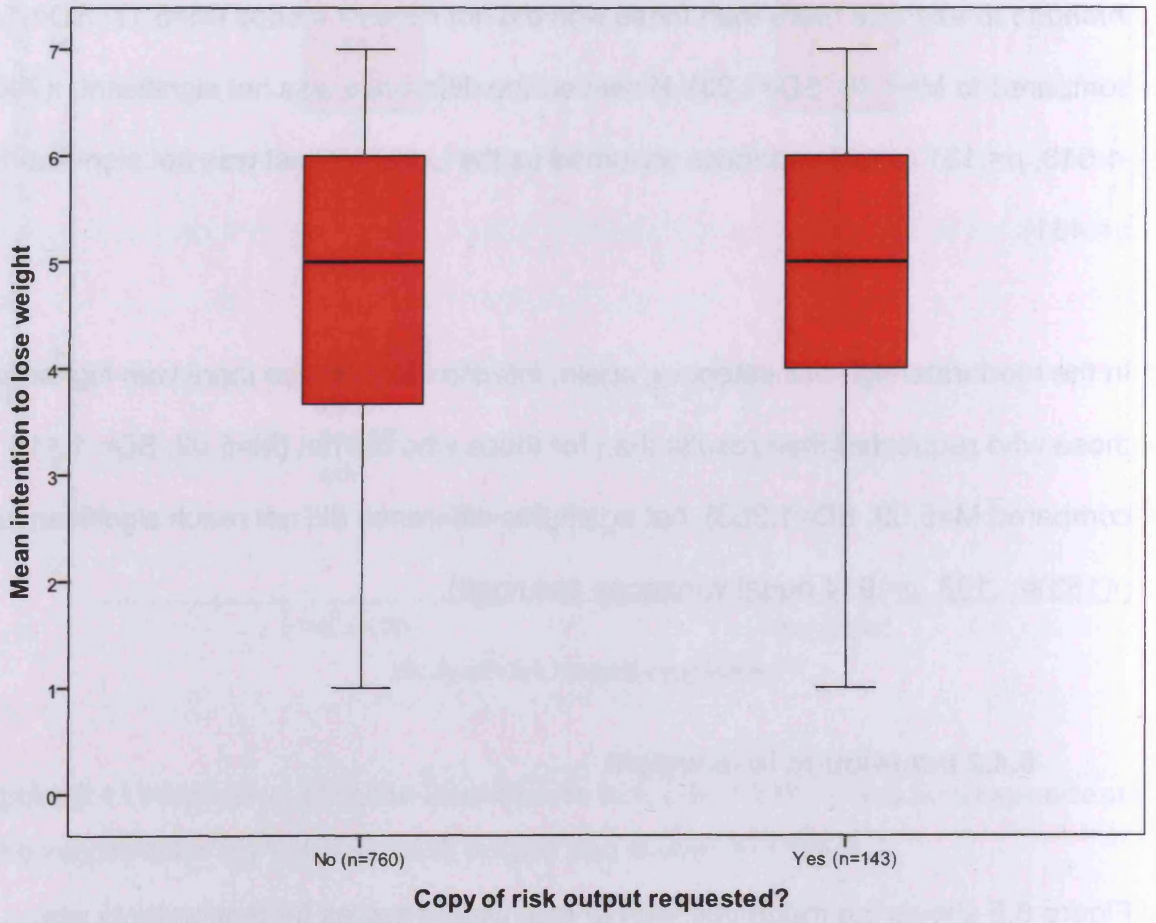


Figure 8.5 Comparison of mean intention to lose weight scores for respondents who requested a copy of their risk output and those who did not.

Subgroup analysis by risk category

A subgroup analysis of risk category dichotomising respondents into low or moderate/high risk was conducted (Appendix 84). For the low risk category, those who requested a copy of their risk output results had a higher *intention to lose weight* than those who did not request a copy (M=4.80, SD=1.46 compared to M= 4.61, SD=1.63). However, this difference was not significant (t(746)=-1.086, *p*=.278 equal variances assumed).

In the moderate/high risk category, those who requested a copy of their risk output also had a higher *intention to lose weight* than those who did not (M=5.08, SD=1.27 compared to M=4.58, SD=1.64), but again, this difference was not significant (*t*(153)= -1.765, *p*=.080 equal variances assumed).

8.4.3 Intention to stop smoking

As demonstrated in Figure 8.6, those who did not request a copy of their risk output had a higher *intention to stop smoking* than those who did request a copy (M=4.17, SD= 1.61 compared to M=3.60, SD= 1.56). This was the not in the expected direction. However, Independent t-tests found that this difference was not significant (*t*(79)=1.263, *p*=.210 (equal variances assumed as the Levene's test was not significant, *p*=.458)). This suggests that those requesting a copy of their risk output did not possess more appropriate *intentions to reduce their cardiovascular risk by stopping smoking* than those who did not request a copy of their risk output.

However, results should be interepeted with caution as only 16 of the current smokers requested a copy of their risk output.

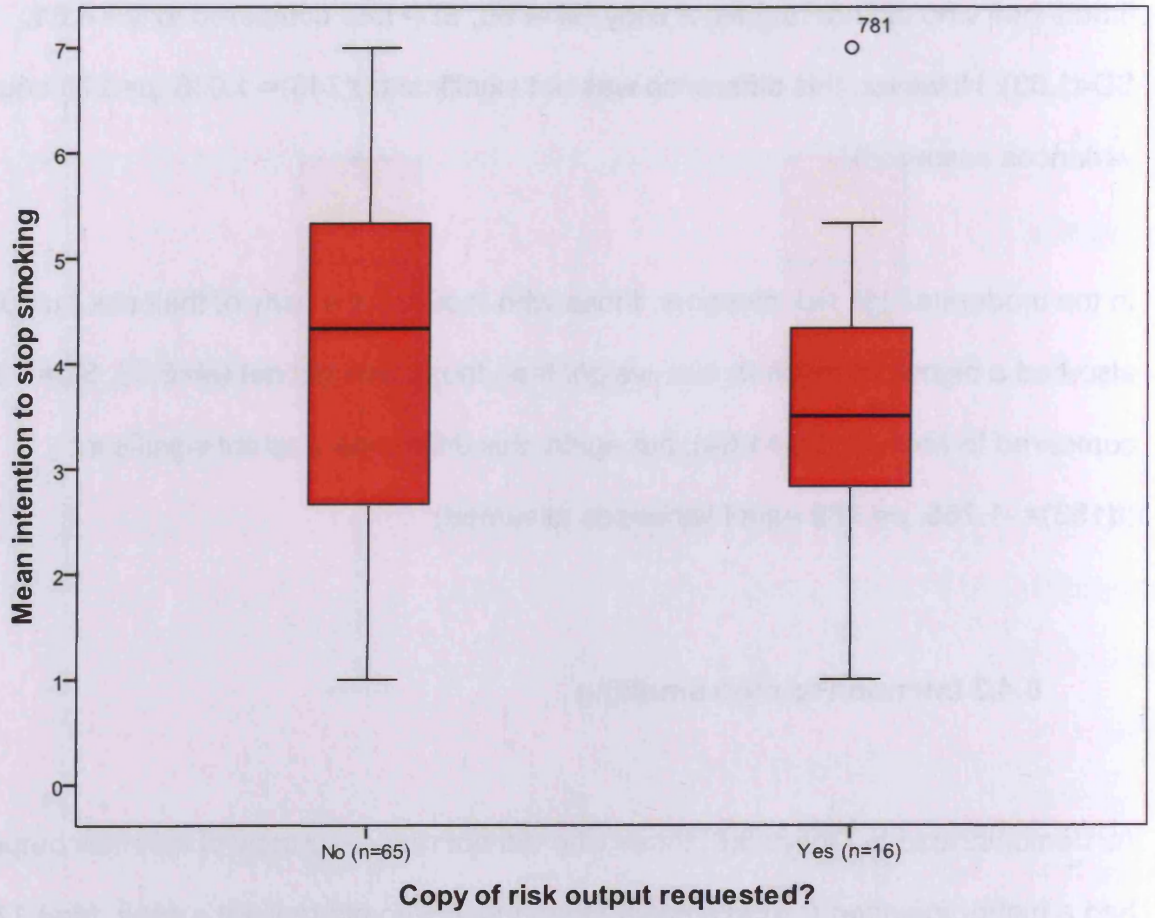


Figure 8.6 Comparison of mean intention to stop smoking scores for respondents who request a copy of their risk output and those who did not.

Subgroup analysis by risk category

When risk was dichotomised (Appendix 84), those in the low risk category who did not request a copy of their risk output had higher *intentions to stop smoking* (M=3.99, SD= 1.742) than those that did (M= 3.76, SD=1.585). This demonstrates that those who requested a copy of their risk output were less likely to want to stop smoking than those who requested a copy of their risk results. However, the trend was not significant ($t(47)=.399$, $p=.692$ equal variances assumed).

Again, higher *intentions to stop smoking* were found for those who did not request a copy of their risk output (M=4.42, SD=1.407) compared to those who did (M=3.27, SD=1.606) in the moderate/high risk category. However, this difference was not significant $t(30)=1.650$, $p=.109$ equal variances assumed as Levene's test was not significant, $p=.984$). It should be acknowledged that limited number of smokers who participated in this study led to small cell sizes (11 low risk and 5 moderate/high risk respondents requested a copy of their risk output). Therefore, the results should be interpreted with caution.

8.4.4 Summary

This section describes the comparison of intentions to reduce cardiovascular risk by *exercising more, losing weight* and *stopping smoking* in respondents who requested a copy of their risk output and those who did not. It was hypothesised that higher

intentions to reduce cardiovascular risk would result in those who wanted a copy of their risk output to retain for future use. However, the only significant difference between groups was seen for *intention to lose weight*, where those who requested a copy of their risk output had higher *intentions to lose weight* that those who did not. This indicates that people with greater intentions to reduce cardiovascular risk by losing weight are more likely to want a copy of their risk output, maybe so that they can take it to their GP to start a discussion regarding reducing their cardiovascular risk.

8.5 Comparing direct and indirect measures of intention to change behaviour

This section describes the assessment of direct and indirect intentions to change behaviour, to see whether those who request a copy of their risk output actually indicate that they intend reduce cardiovascular risk by *exercising more, losing weight* or *stopping smoking*. It was hypothesised that there would be a positive relationship between respondents requesting a copy of risk output results and intentions to reduce cardiovascular risk by exercising more, losing weight and stop smoking. Pearson product-moment correlation coefficients were used to examine the relationship between direct and indirect measures of intention (Appendix 85).

8.5.1 Intentions to exercise more, lose weight and stop smoking

Overall, weak relationships were found between direct and indirect measures of intention to reduce cardiovascular risk by *exercising more, losing weight* and *stopping smoking*. There was no significant correlation between *intention to exercise more* (r=.45, n=903, *p*=.178), *intention to lose weight* (r=.63, n=903, *p*=.060) or *intention to stop smoking* (r= -.141, n=81, *p*=.210) and requesting a copy of risk output results.

8.5.2 Subgroup analysis by risk category

Responses were split by risk category dichotomised into low or moderate/high and analysed separately (Appendix 86). Again, no relationships were found between the direct and indirect measures of intention. For those in the low risk category, there was no significant correlation between *intention to exercise more* (r=.055 n=748, *p*=.131), *intention to lose weight* (r=.040, n=748, *p*=.278) or *intention to stop smoking* (r=-.058 n=49, *p*=.692) and requesting copy of risk output results.

Neither was a relationship evident for those in the moderate/high risk category. No significant relationship was found between *intention to exercise more* (r=.009 n=155, *p*=.914), *intention to lose weight* (r=.141, n=155, *p*=.080) or *intention to stop smoking* (r=-.289 n=32, *p*=.109) and requesting copy of risk output results.

8.5.3 Summary

Overall, there were no significant relationships between the direct and indirect measures of intention to reduce cardiovascular risk by *exercising more, losing weight* and *stopping smoking*. This shows that those who requested a copy of their risk output results do not have greater intentions to reduce their cardiovascular risk by exercising more, losing weight and stopping smoking. This could imply that those who request a copy of their risk output results are not doing so for the purposes of wanting to reduce their cardiovascular risk and taking it to their GP to discuss cardiovascular risk reduction.

8.6 The efficacy of the Theory of Planned Behaviour in predicting intention to change behaviour

This section describes the assessment of the subcomponents of the Theory of Planned Behaviour (attitudes, subjective norms and perceived behavioural control). Multiple regression models were conducted to see how well the subcomponents predict intention to change behaviour in order to reduce cardiovascular risk, by explaining the variance in intention to *exercise more, lose weight* and *stop smoking* scores.

8.6.1 Assumption testing

Multivariate assumptions were examined before conducting the regression analysis. Firstly, the assumptions of multicolinearity and singularity were assessed by correlation matrices (Appendix 87). For the dependent variables of *intention to exercise more* and *intention to lose weight*, there were two instances where correlations were above 0.7. However, as these were correlations between the independent variables with the dependent variables, no action needed to be taken. A violation would have occurred if an independent variable correlated with other independent variables, and in these instances it is recommended that these are removed (Tabachnick and Fidell 2001). Additionally, the coefficients table was consulted and the tolerance values were above the minimum value of .10, whereas the VIF (variance inflation factor) values were all less than 10, indicating no violation. Assumptions of linearity, homoscedasticity of residuals and existence of multivariate outliers were assessed previously and were found not be violated (see Chapter 7).

8.6.2 Intention to exercise more

Multiple regression analysis examined *intention to exercise more* (Appendix 88). Using the enter method, a significant model emerged: $F(4,898)= 267.731$, $p=.000$. The model explained 54.2% of the variance in *intention to exercise more* scores (Adjusted $R^2 = .542$).

Figure 8.7 provides information for the predictor variables entered into the model and shows the standardised beta coefficients for the independent variable of in*tention to exercise more*. Two components made the largest statistically significant contribution in explaining the variance in *intention to exercise more*. *Perceived behavioural control* accounted for 59.7% and *attitudes* accounted for 24%. Demonstrating that *intention to exercise more* is increased with greater perceived control and more positive attitudes towards exercising more. This suggests that exercising is dependent on personal motivation, such as own perceived control about being able to exercise and attitude towards exercising. It is not influenced by the views of others (i.e. subjective norms) or your personal cardiovascular risk.

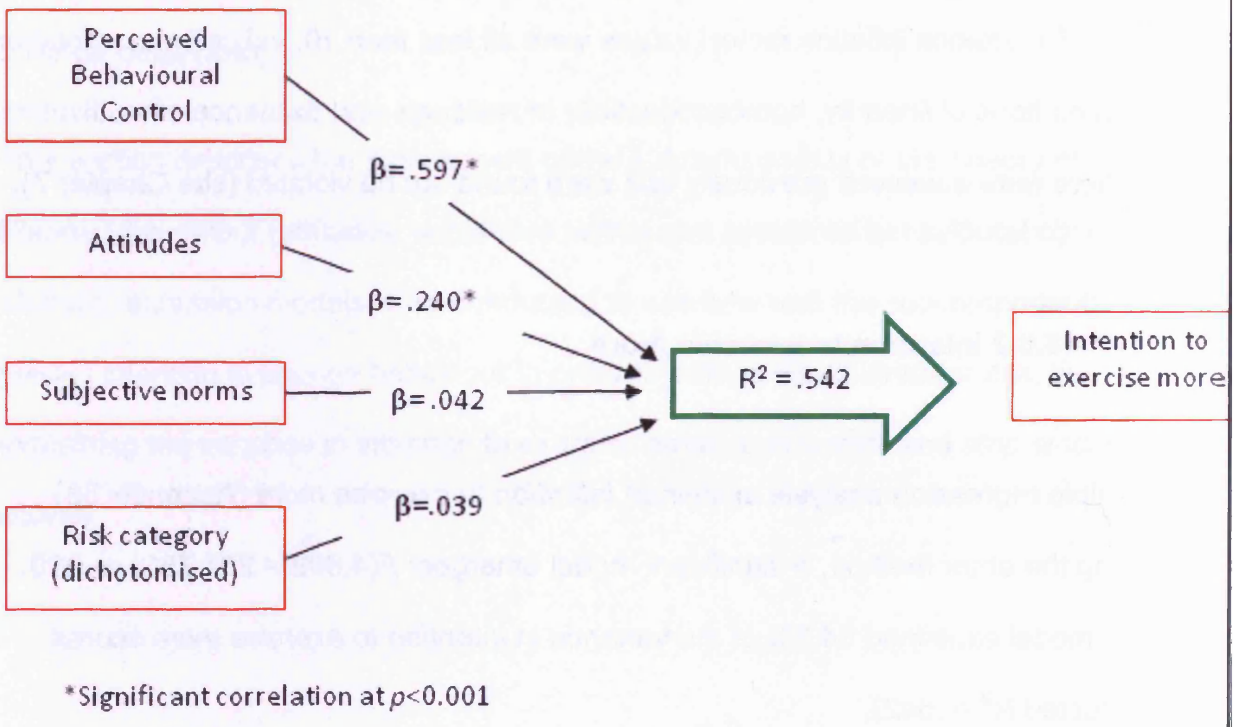


Figure 8.7 Standardised beta coefficients for Intention to exercise more in a Multiple Regression Model assessing the subcomponents of the TPB

8.6.3 Intention to lose weight

Multiple regression analysis examined *intention to lose weight* (Appendix 89). Using the enter method, a significant model emerged: $F(4,898)= 429.469$, $p=.000$. The model explained 65.5% of the variance in intention to exercise more scores (Adjusted $R^2 = .655$).

Figure 8.8 provides information for the predictor variables entered into the model and shows the standardised beta coefficients for *intention to lose weight*. The three subcomponents of the TPB made a statistically significant contribution in explaining the variance in *intention to lose weight*. *Attitudes* accounted for 70.3%, *perceived behavioural control* accounted for 28.6% and *subjective norms* predicted 6.1%. This indicates that intention to lose weight can be increased with more positive attitudes towards losing weight, greater perceived control and greater influence of subjective norms (i.e. the views of significant others). Losing weight is more dependent on personal motivation, such as your attitude towards losing weight and your own perceived control about being able to lose weight; however, the views of others do have small influence on intentions to lose weight. Conversely, actual cardiovascular risk does not play a role in decisions to lose weight.

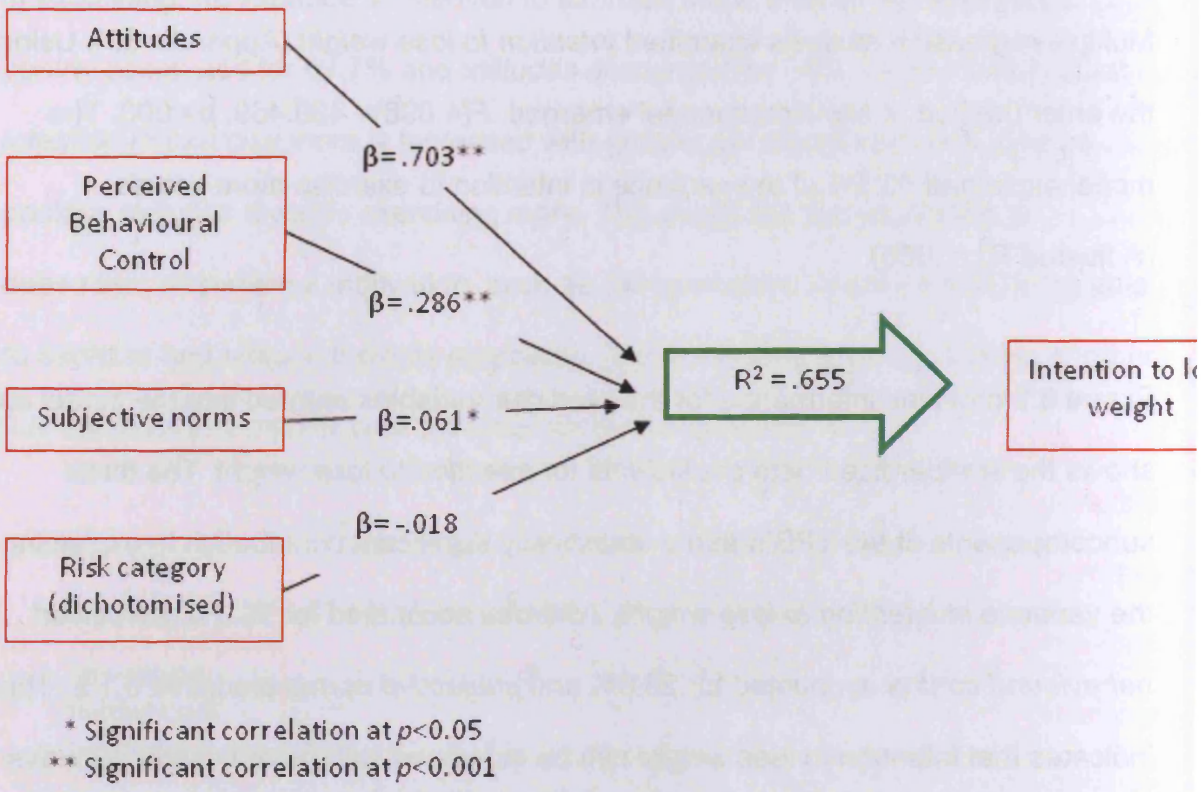


Figure 8.8 Standardised beta coefficients for Intention to lose weight in a Multiple Regression Model assessing the subcomponents of the TPB.

8.6.4 Intention to stop smoking

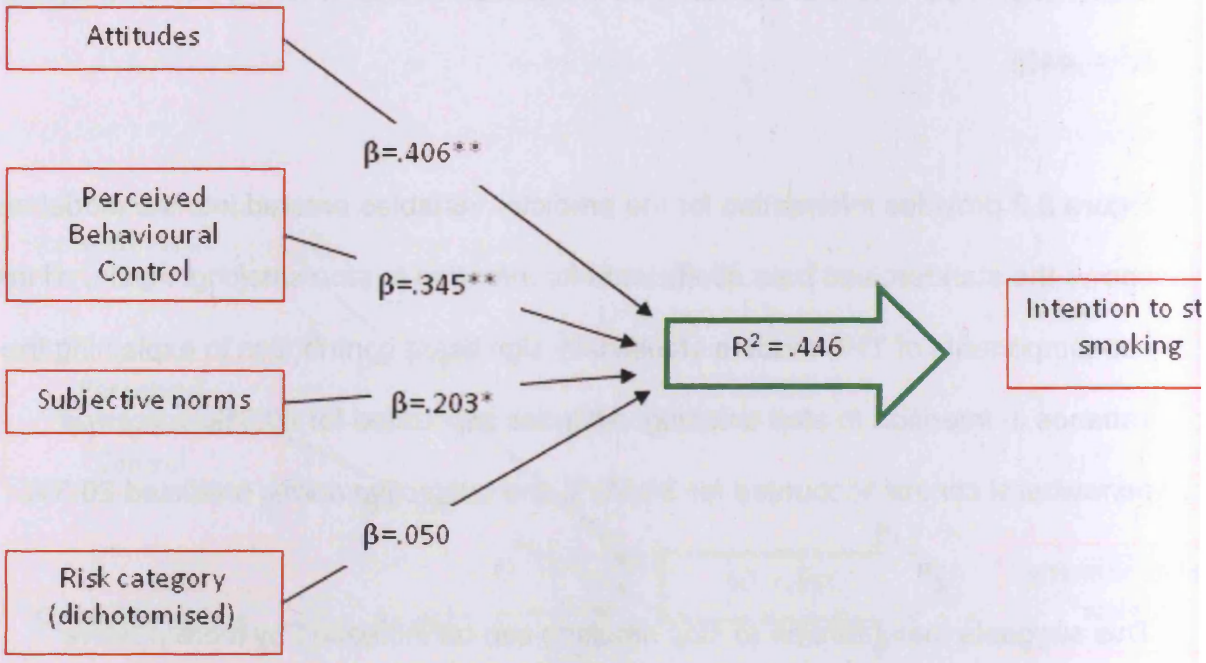
Multiple regression analysis examined *intention to stop smoking* (Appendix 90).

Using the enter method, a significant model emerged: $F(4,76)= 17.119$, $p=.000$. The

model explained 44.6% of the variance in *intention to stop smoking* scores (Adjusted R^2 = .446).

Figure 8.9 provides information for the predictor variables entered into the model and shows the standardised beta coefficients for *intention to stop smoking.* Again, all the subcomponents of TPB made a statistically significant contribution in explaining the variance in *intention to stop smoking. Attitudes* accounted for 40.6%, *perceived behavioural control* accounted for 34.5%% and *subjective norms* predicted 20.3%.

This suggests that *intention to stop smoking* can be increased by more positive attitudes towards stopping smoking, greater perceived behavioural control and with greater subjective norms. Stopping smoking is dependent on personal motivation such as attitudes towards smoking and perceived control over being able to stop smoking, as well as the influence of other people. As seen with intentions to exercise more and lose weight, personal risk of having a future coronary heart disease event does not influence intentions to stop smoking. However, caution should be taken when interpreting these results, due to the smaller cell sizes and the low internal consistency of some of the components.



* Significant correlation at $p<0.05$
** Significant correlation at $p<0.001$

Figure 8.9 Standardised beta coefficients for Intention to stop smoking in a Multiple Regression Model assessing the subcomponents of the TPB.

8.6.5 Summary

This section described the assessment of the efficacy of the Theory of Planned Behaviour at predicting intentions to perform the three cardiovascular risk reducing behaviours of: *exercising more, losing weight* and *stopping smoking*. Multiple regression models were conducted and the subcomponents of the Theory of Planned Behaviour were entered as independent variables. Significant models emerged, indicating that the subcomponents of the TPB do significantly predict

intention exercise more, lose weight and stop smoking. *Attitudes* and *perceived behavioural control* consistently predicted the intentions for all behaviours (*exercising more, losing weight* and *stopping smoking*). *Subjective norms* significantly predicted *intention to lose weight* and *stop smoking*. This suggests that higher scores on these components lead to greater intentions.

The findings suggest that personal motivation, such as your perceived control about performing the behaviour and your attitude towards the behaviour, is more influential than the views of others (i.e. subjective norms). Conversely, the risk category of respondents did not significantly predict intentions, suggesting that behaviour change is not dependent on personal risk of having a future coronary heart disease event. The weak contribution made by cardiovascular risk when deciding whether to change behaviour may be due to a lack of interest in one's cardiovascular risk or that the risk is not properly understood. However, as described previously, caution must be taken when interpreting these findings, as some of the components of the TPB failed to reach internal consistency.

8.7 Process Evaluation

This section describes a number of analyses conducted to evaluate the process of participating in the web-based RCT. This is to gain further information about the visitors who accessed the website and/or participated in the study, such as the time respondents spent on the website. Website analytics software was installed (e.g. *Goolge Analytics* and *AW Stats*). This generates statistics about the total number of

visits to the website, the country of origin of visitors and information regarding external websites that were visited comprising the *myHeartRisk* website hyperlink. Examples of the reports that were generated by the website analytics software are given in Appendices 91 and 92.

Google Analytics was installed at the start of the recruitment period (11th February 2010); however, due to a software conflict it had to be removed on 23rd February 2010 and replaced with *AW stats*. Therefore, the process evaluation analyses using the web analytic software combines the results from both *Google Analytics* and *AW stats*. It must be acknowledged that the statistics reported by these web analytic services are based on all traffic to the website, including those who visited the homepage only, partial completers, full completers, and non-human activity (such as spiders, bots, metacrawlers etc.). It may not accurately reflect the numbers of actual human traffic. Additionally, these two web analytic software systems use different visitor collection metrics and are not directly comparable. Therefore, the results generated from collating the information from these two different web analytic systems (*Google Analytics* and *AW Stats*) should be interpreted with caution.

8.7.1 Time spent on website

This section describes the procedure used to calculate the mean time respondents spent on the *myHeartRisk* website. The SQL database was queried to retrieve the time that each page of the website was accessed by all visitors. This information was exported into a spreadsheet, where fully completed responses were separated from

incomplete ones. The times spent on the website pages by the respondents who successfully completed the study were imported into a SPSS database. The time visited on the 'homepage' was subtracted from the time visited on the 'thank you page' (the last page before respondents have the option to input their contact details to request a copy of their risk output), this gave the total number of minutes/ seconds that the respondents spent on the website in total. There were two incidences where it was indicated that the total time spent was zero minutes/seconds, as this was obviously a glitch in the web-log database, it was felt necessary to exclude these when conducting the descriptive analyses for the total time spent on the website. Therefore, a filter was devised to exclude all cases where the time spent on the website was stated as zero.

The mean total time spent on the website by respondents who fully completed the study was 16.42 minutes (SD= 64.50). The shortest time spent was 2.03 mins and the longest time spent was 1271.41 mins (21.19 hours). 20 respondents took over 1 hour to complete the study. Two of these were on the website for over 20 hours. However, it was concluded that this was just artefact where the user had not closed the website browser after use.

8.7.2 Analysis of drop-outs

The risk category of the respondents who partially completed the study but dropped out before completing the post-intervention questionnaire was analysed. This was to examine whether there were actually more respondents categorised as moderate

and high risk who were motivated enough to visit the website and have their risk assessed (but dropped out before the end), than the proportion moderate and high risk people who completed the study.

Of the 144 respondents who partially completed the study, 112 completed the risk assessment but dropped out before completing the post-intervention questionnaire. The risk categories of these partial completers were analysed. As seen in those who fully completed the study, there was a disproportionately large number of low risk respondents (n= 78, 69.64%), 22 were categorised as moderate risk (19.64%) and 11 (9.82%) were high risk. This demonstrates that more low risk respondents were motivated to take part in the study and have their risk assessed than those at moderate and high risk. Therefore, it cannot be concluded that a reason for the dropout after the risk assessment was distress from finding out that they were at a higher risk category.

8.7.3 Number of visits obtained across the recruitment period

As shown in Figure 8.10, there were 3684 visits (hits) to the website throughout the recruitment period according to the SQL database. Nearly half of these visits (n=1675, 45.5%) were made during the first month of recruitment (February 2010). The number of hits decreases with continuing duration of the recruitment period. The website achieved 345 hits (9.4%) in the last whole month of recruitment (May 2010), and 3% (n= 111) was achieved in the last week of recruitment (1-7th June 2010). This is consistent with the employment of the recruitment strategies, as more effort

was made at advertising the study at the start of the recruitment period than towards the end. This demonstrates that increased exposure of the study increases traffic to the website, and therefore increases the likelihood of obtaining respondents who complete the study.

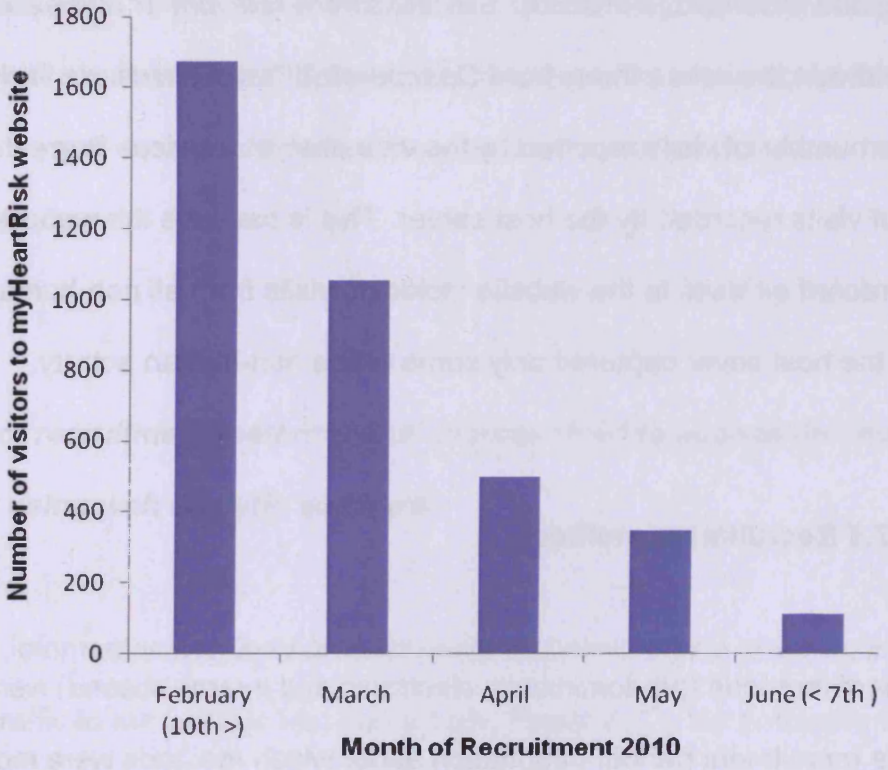


Figure 8.10 Number of hits obtained across the recruitment period according to the SQL database.

8.7.4 Country of origin of respondents

As web-based studies are accessible globally, information about the country of origin of the website visitors is of interest. The web analytic services use information from

the visitor's Internet Protocol (IP) addresses to determine this information. According to the web analytic services, visitors to *myHeartRisk* website were recorded from 46 different countries. The three countries with the highest number of visitors were: UK (n=10512), Australia (n=187) and USA (n=169). However, the web analytic services categorised some users into categories without an identifiable country. These were: *Commercial*, classified by suffix *.com* (n=12823); *Network*, classified by suffix *.net* (n=1288); and *Unknown* (n=10260). The visits from *Network* IP addresses are likely to be worldwide; however, those from *Commercial* IP addresses are likely to be from USA. The number of visits reported by the web analytic services is greater than the number of visits recorded by the host server. This is because the web analytic services record all visits to the website including visits from all non-human sources, whereas the host sever captured only some of the non-human activity.

8.7.5 Recruitment methods

A number of methods (predominientlly electronic and internet-based) were employed during the recruitment period. Information about which methods were most successful was obtained from the self-reporting of respondents and also statistics from the web analystic software. Each will be described in turn.

Self-reported recruitment methods

At the end of the study, respondents were asked to indicate where they heard about the study and the *myHeartRisk* website. Figure 8.11 demonstrates where

respondents reported that they had been recruited to take part in the study. The most successful recruitment method appears to be email invitation as 31.6% (n=285) of respondents indicated that they heard about the study by this method. Social networking sites (including *Facebook, Twitter* and *over 50s forums*) were the second most successful recruitment method, as 22.3% of respondents (n=201) were recruited by this method. Newspaper articles recruited the fewest respondents (n=47, 5.2%) and 112 (12.4%) of respondents did not disclose information about where they heard about the study/ website. However, it must be noted that this information is self-reported, therefore it cannot be concluded that these frequencies are entirely accurate.

Analysis of recruitment methods and sources used to access the myHeartRisk hyperlink using web analytic software

The visitor information obtained from the web analytics service gives an indication of where all traffic to the website has come from. Figure 8.12 demonstrates the number of visits produced by each method of recruitment. For example, social networking sites seemed to produce the most traffic (n=919). When these were analysed further, *Twitter* was found to produce 634 visits. Forums (including *Sagazone* and *Over50s*) produced 165 visits, social bookmarking sites (e.g. *delicious, reddit, stumble upon*) produced 90 visits and *Facebook* produced 30 visits.

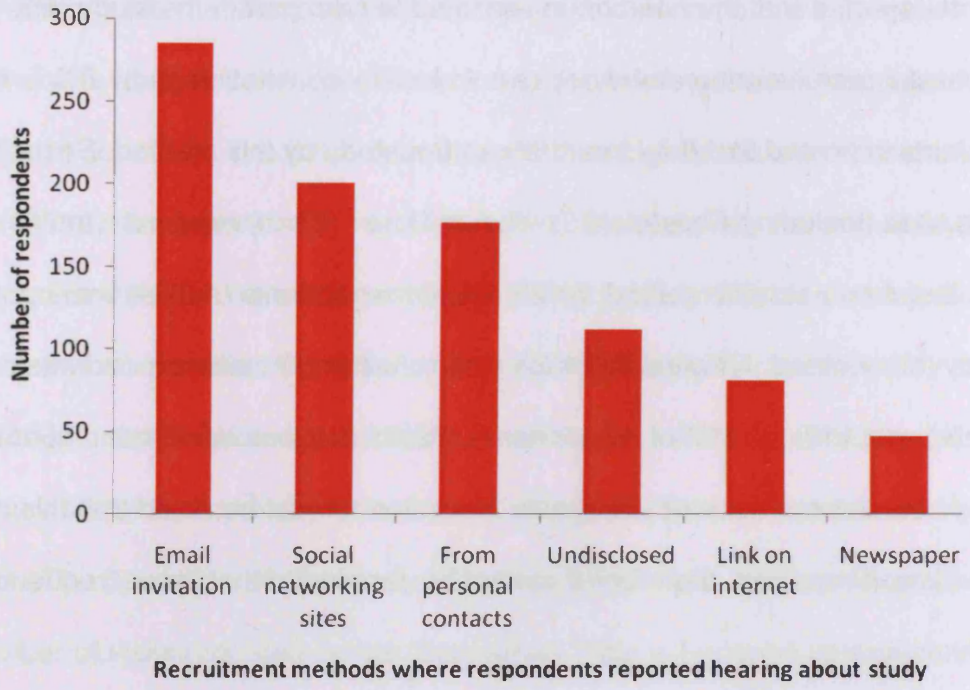


Figure 8.11 Frequencies of the recruitment methods.

University electronic noticeboards and staff intranet was the second most popluar method used to access the *myHeartRisk* website (n=672). Of these, Cardiff University produced 468 visits, University of Glamorgan produced 117 visits and University of Wales, Newport produced 70 visits.

335 vistors to the website came from Search engines. *Google* (including suffixes: .com, .co.uk, .au, and .be) produced 214 visits, *Yahoo* produced 55 and *Microsoft live/Bing* produced 58 visits. A hyperlink on the Cardiff Council intranet / staff email produced 49 visits. Additionally, there were 41 miscillaneous websites with hyperlinks that people used to visit the *myHeartRisk* website. The most popular of

these was http://www.decisionlaboratory.com, which produced 27 visits. However, there were 460 direct visits to the *myHeartRisk* website where no hyperlink was used.

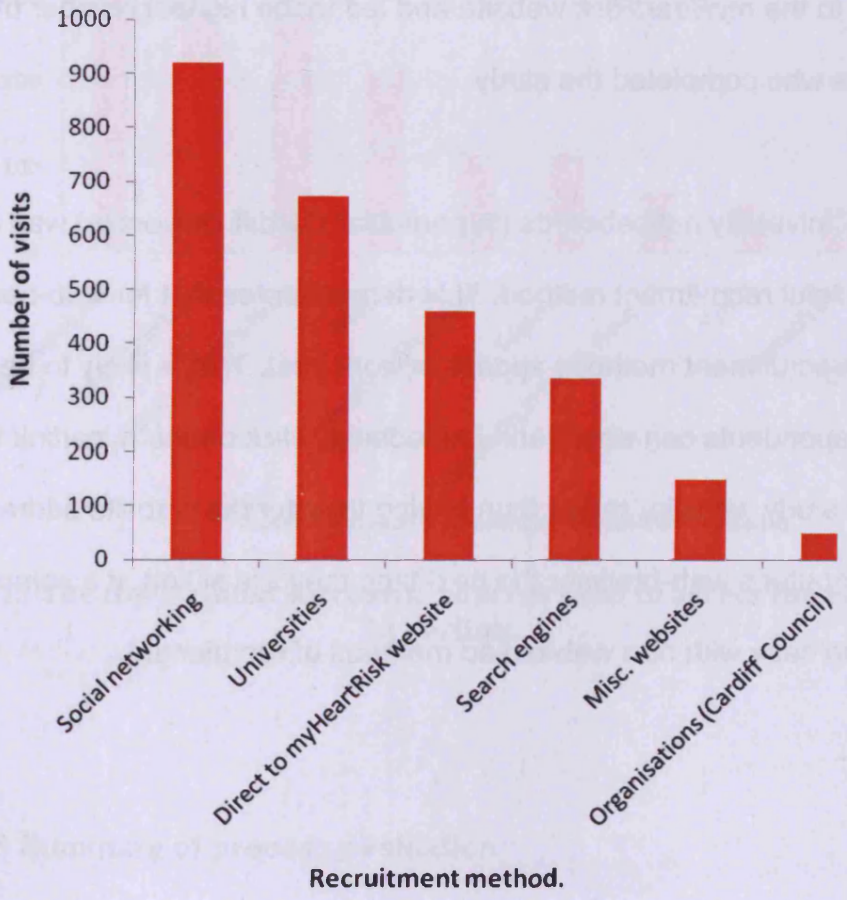


Figure 8.12 Number of visits produced by each type of recruitment method.

The top 10 most successful sources used to access the *myHeartRisk* hyperlink are represented in Figure 8.13. The Cardiff University electronic noticeboard produced the most traffic (n=468), followed by direct visits to the *myHeartRisk* website (n=460) and *Twitter* (social networking site) produced 351 hits to the *myHeatRisk* website.

When information about recruitment methods from respondents self-reporting and the amount of traffic according to the web analytic software was combined, it can be seen that social networking sites (in particular *twitter.com*) appear to be the most successful method of recruitment (apart from email invitations), as it generated the most traffic to the *myHeartRisk* website and led to the highest number of respondents who completed the study.

Posting on University noticeboards (in particular Cardiff University) was the second most successful recruitment method. This demonstrates that for web-based studies, web-based recruitment methods appear to work best. This is likely to be because potential respondents can easily and immediately click on the hyperlink that takes them to the study website, rather than having to enter the website address manually into the computer's web-browser the next time they are sitting at a computer, as would be the case with non web-based methods of recruitment.

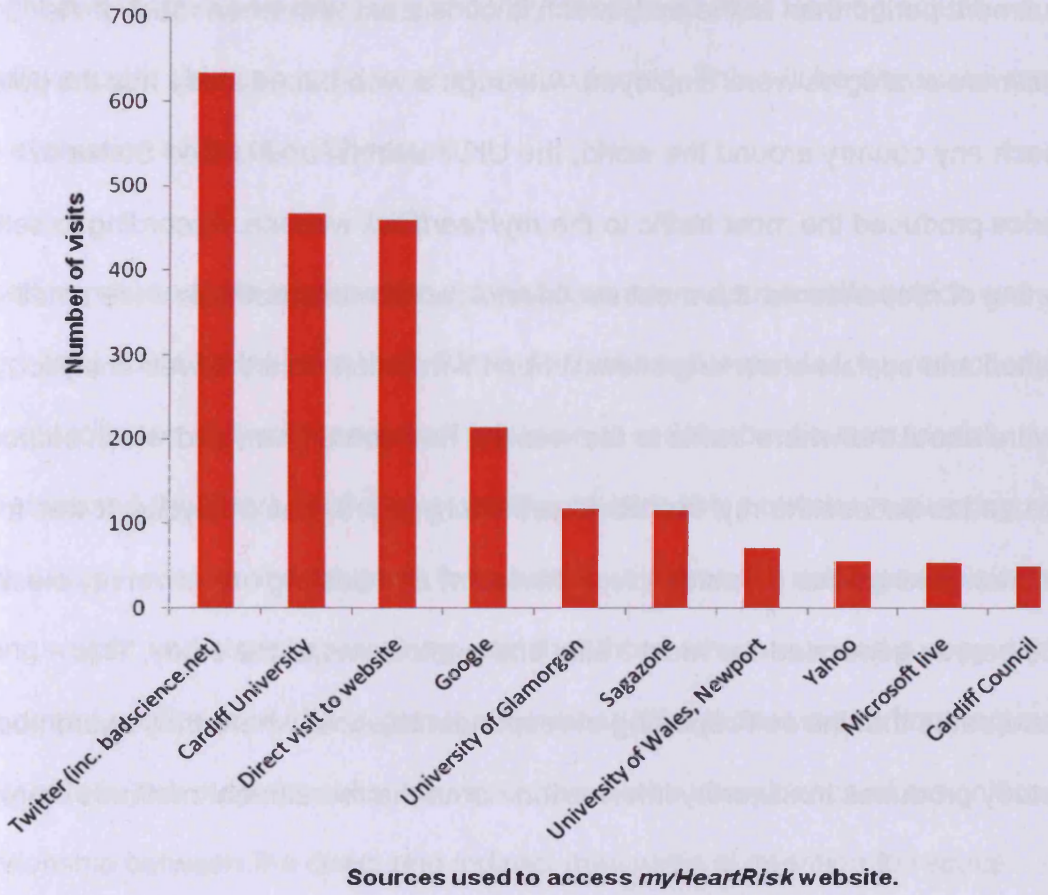


Figure 8.13 The top 10 most successful sources used to access the myHeartRisk hyperlink.

8.7.6 Summary of process evaluation

This section described the process evaluation conducted to gain further information about the visitors to the website and/or participants of the study. This included the time respondents spent on the website, number of visits throughout the recruitment period, the country of origin of visitors and which recruitment methods were most successful. Respondents completed the study in a reasonable amount of time (Mean= 16.42 minutes). There were more visits to the website at the start of the

recruitment period than at the end, which is consistent with when most of the recruitment strategies were employed. Although a web-based study has the potential to reach any country around the world, the UK, Australia and United States of America produced the most traffic to the *myHeartRisk* website. According to self-reporting of respondents, the most successful recruitment methods were email invitation and social networking sites. When information from the web analytic software about the where traffic to the website had come from, and which sources were used to access the myHeartRisk website hyperlink was analysed, it was found social networking sites (in particular *twitter.com*) and posting on University electronic notice boards generated the most traffic and participants to the study. This demonstrates that the self-reporting of respondents about where they heard about the study produces trustworthy information about the recruitment methods employed.

8.8 Summary of all results

The results from the secondary objectives of the study were described in this chapter. The findings are summarised below:

Comparison of the two control groups provided no evidence of a Hawthorne effect, demonstrating that thinking about your future risk of cardiovascular disease before viewing your actual risk does not lead to an increased intention to change behaviour to reduce cardiovascular risk. Analysis of responses from the first control group, who completed the pre and post-intervention questionnaires, showed that intention to reduce cardiovascular risk by changing behaviour (e.g. exercising more, losing

weight and stopping smoking) significantly decreased after viewing actual cardiovascular risk, converse to what was expected. This will be discussed more in the evaluation of the trial (Chapter 9).

Whether respondents requested a copy of their risk output results (which was suggested could be taken to their GP to discuss cardiovascular risk reduction) was thought to be an indirect measure of intention to reduce cardiovascular risk. It was hypothesised that there would be a positive relationship between requesting a copy of risk output results and intention to reduce cardiovascular risk by exercising more, losing weight and stopping smoking; and that those who requested a copy of their risk output results would have greater intentions than those who did not request a copy of their risk output results. However, there was no evidence of a significant relationship between the direct and indirect measures of intention to reduce cardiovascular risk, showing that those who requested a copy of their risk output results were not significantly more likely to have greater intentions to reduce their cardiovascular risk by *exercising more, losing weight* and *stopping smoking*.

Conversely, those who requested a copy of their risk output results possessed greater intentions to lose weight than those who did not request a copy of their risk output. However, it cannot be determined whether the reason respondents requested a copy of their risk output was actually for them to take it to their GP, even though it was suggested that they could do this. Perhaps a copy of their risk output results was requested for reasons other than assisting with discussions about cardiovascular risk reduction with a GP. This indicates that requesting a copy of your

risk output results is not an adequate indirect measure of intention to change behaviour.

The efficacy of the Theory of Planned Behaviour (TPB) at predicting the intention to reduce cardiovascular risk was examined using multiple regression models. The subcomponents of the TPB significantly predicted intention to *exercise more, lose weight* and *stop smoking*. *Attitudes* and *perceived behavioural control* were the main components that predicted intentions for all behaviours (exercising more, losing weight and stopping smoking). *Subjective norms* significantly predicted *intention to lose weight* and *stop smoking*. This suggests that higher scores on these components lead to greater intentions. Therefore, an intervention aimed at increasing intentions to change these behaviours, should focus on installing positive attitudes and increasing perceived behavioural control over the behaviour. However, some of the subcomponents failed to reach internal consistency and therefore, these findings should be interpreted with caution.

Lastly, a process evaluation was conducted in order to gain further information about the visitors to the website and/or participants of the study. The mean time spent on the website was just under 17 minutes. There were more visitors to the website at the start of the recruitment period when most of the recruitment strategies were employed. Most traffic to the *myHeartRisk* website came from the UK, Australia and USA.

Self-reporting from respondents about where they heard about the study, and the statistics generated by web analytic software, indicated that the most successful

recruitment methods were electronic (internet-based) strategies. The top three methods that generated the most traffic and participants to the study appeared to be email invitations, social networking sites (in particular *twitter.com*) and posting on University electronic notice boards.

Chapter 9. Evaluation of the web-based randomised controlled trial of cardiovascular risk representation formats.

9.1 Introduction

This chapter will provide an evaluation and critique of the RCT conducted on the effects of cardiovascular risk representation formats on intention to change behaviour, understanding of risk information, positive and negative affect and worry about future risk of heart disease. This chapter will summarise the main findings of the trial, compare them to previous literature and consider the strengths and weaknesses of the trial.

9.2 Summary of main findings

This section summarises the main findings of the trial. Possible reasons behind the unexpected results that did not support the hypotheses are given.

9.2.1 Effects of cardiovascular risk representation formats

This trial found no significant main effects of graphical cardiovascular risk representation format on *intentions to change behaviour, understanding of risk*

information, affect or *worry about future risk of heart disease*. This finding suggests that the type of format used to present risk to individuals has little effect in motivating individuals to making risk-reducing changes to their behaviour, does not influence emotions (including worry about future risk of heart disease); and that no one format is more helpful in facilitating understanding of risk information than another. This leads to the conclusion that intentions to change behaviour in order to reduce cardiovascular risk, are not influenced by the risk representation format used in the risk communication, but are dependent on other factors. Therefore, developers of risk communication interventions need to use clear representation formats in their tools, but may not need to be concerned with the subtle differences in formats. It may be more beneficial for them to focus more on the motivational issues regarding risk reducing behaviour change. However, it is possible that the lack of effect found in this study is due to a type II error resulting from the biased, unrepresentative sample. This will be discussed in more detail in Chapter 10.

9.2.2 Predicting intention to change behaviour

Multiple regression models found that a moderate amount of variance in *intention to exercise more* and *intention to lose weight* scores was explained by the independent variables measured in this trial (11.7% and 3.8% respectively). *Intention to stop smoking* was not significantly predicted by the independent variables. This is likely to be due to the lack of current smokers in the study (n=81, 9%) resulting in an inadequately powered model.

Intention to exercise more was significantly predicted by *affect* (positive and negative), risk category of respondents (as described above) and *understanding of risk information*. Whereas, *intention to lose weight* was significantly predicted by *positive affect* and *understanding*. This is an important finding to the developers of interventions aimed at increasing health-protective behaviours, as it suggests that increasing *positive emotions* will facilitate greater intentions to adopt behaviours, such as increasing level of physical activity and losing weight.

Understanding of risk information also made a significant contribution; however the beta coefficients were negative, indicating that in an intervention aiming to increase intention to exercise more or lose weight, understanding of risk information should be reduced. This should not be taken as evidence that motivating behaviour change results from limiting an individual's understanding of the risk information, which could be argued to be unethical. A more plausible explanation is that this is an artefact resulting from the high proportion of respondents who possessed complete or partial understanding of the risk information presented to them, and the high proportion of respondents who were categorised as low cardiovascular risk but still possessed high intentions to change behaviour.

9.2.3 Changes in affect

This trial found that viewing cardiovascular risk alters emotions by significantly reducing *positive and negative affect* and *worry about future risk of heart disease*. The extent that these were reduced depended on the person's risk category. For

example, those of moderate or high cardiovascular risk had greatest reductions in *positive affect,* whilst those at low cardiovascular risk had greatest reductions in *negative affect* and *worry about future risk of heart disease*. This demonstrates that risk magnitude plays an important role in how people feel about their risk, which in turn may influence subsequent behaviours. However, this is only partially supported by the multiple regression models that found that the risk magnitude only significantly predicted *intention to exercise more*, and not *intentions to lose weight* or *stop smoking*.

The lack of influence of risk magnitude on intentions to lose weight and stop smoking may be due to the over-representative sample of people at low risk who did not actually need to lose weight or stop smoking, and therefore had low intentions to perform these behaviours. This would decrease the ability to detect meaningful trends in the data. Alternatively, it could be that people perceive increasing the amount of exercise that they do as more effective in reducing cardiovascular risk than losing weight or stopping smoking. Therefore, exercising more would be the favoured risk reduction option, resulting in greater intentions to perform this behaviour when informed of personal cardiovascular risk.

9.2.4 Correlational validity hypothesis between understanding and intention to change behaviour

This trial found no support for the correlational validity hypothesis (Ubel 2008) that suggests intentions to change behaviour are greater with increased understanding of

risk information. No significant correlations were found between the *level of understanding* and *intention to exercise more* or *intention to lose weight.* The reverse was found for *intention to lose weight,* where intention significantly decreased with increased understanding (in those of low cardiovascular risk). A reason for this is finding is likely to be due to the over-representative sample of respondents categorised as low cardiovascular risk and a small number of respondents categorised as moderate or high risk (n=155, 17.2%). Furthermore, the majority of respondents possessed partial to full understanding of the risk information presented to them. The uneven cell sizes result in an under-powered analysis and reduces the statistical ability to identify any significant differences between intentions to change behaviour (i.e. exercising more, losing weight and stopping smoking) and understanding of risk information. Therefore, the correlational validity hypothesis cannot be confirmed or rebutted by the results of this trial. Further research is needed before any conclusions are made regarding the true relationship between understanding of risk information and intention to change behaviour.

9.2.5 Curvilinear relationship between intention to change behaviour and worry about future risk of heart disease

Previous literature supports the existence of a curvilinear (inverted-U) relationship between worry and intention to change behaviour hypothesised that the extremes of *worry about future risk of heart disease* (i.e. low and high) lead to the reduced *intention to change behaviour* (Consedine et al. 2004; Witte 1998). The results from this trial did not support this hypothesis as there was no evidence of a curvilinear

relationship between *intention to change behaviour* and *worry about future risk of heart disease*. Significant positive relationships were found when responses were dichotomised by risk category. However, these relationships were linear. For example, *intention to lose weight* for those categorised as moderate risk, increased with greater *worry about future risk of heart disease*. This relationship is logical, as those of moderate or high risk may in fact be worried about their risk of having a future coronary heart disease, and feel that losing weight would help reduce their cardiovascular risk. However, for those categorised as low risk, increased *worry about future risk of heart disease* led to decreased *intention to exercise more*.

A possible explanation for this finding is that respondents were worried about their future risk of heart disease, but felt that increasing exercise levels was not an effective method to reduce cardiovascular risk. However, it is more likely that this finding is an artefact from having a over-representative sample of low risk respondents who did not need to reduce their cardiovascular risk. This makes it difficult to detect true differences in the data. Furthermore, the results were skewed by the 'worried well' who possessed high intentions to change behaviour even though they were informed of their low cardiovascular risk. Perhaps these respondents were reassured by their low risk result, but were still anxious about their future risk of heart disease, and therefore still intended to maintain a healthy lifestyle so not to elevate their cardiovascular risk in the future by modifiable risk factors.

9.2.6 Hawthorne effect

Comparison of the two control groups, in which one group received a pre-intervention questionnaire on perceptions of and intentions to reduce cardiovascular risk provided no evidence of a Hawthorne effect. This demonstrates that thinking about your future risk of cardiovascular disease before viewing your actual risk does not lead to an increased intention to change behaviour. Converse to what was expected, the analysis of responses from the first control group who completed the pre and post-intervention questionnaires, showed that intention to reduce cardiovascular risk by changing behaviour (exercising more, losing weight and stopping smoking) significantly *decreased* after viewing actual cardiovascular risk.

Again, this finding is likely to be due to the over-representation of respondents categorised as low cardiovascular risk, and the 'worried well' who were concerned about their risk. Perhaps they initially thought their risk was higher than that predicted by the risk calculator (i.e. were incorrectly pessimistic about their risk), and therefore reported a high intention to reduce their risk of heart disease at pre-intervention. This intention may have decreased after they were informed of their low risk result.

9.2.7 Theory of Planned Behaviour

The efficacy of the Theory of Planned Behaviour at predicting the intention to reduce cardiovascular risk through *exercising more, losing weight* and *stopping smoking* was

examined using multiple regression models. The subcomponents of the TPB significantly predicted *intention to exercise more, lose weight* and *stop smoking*. *Attitudes* and *perceived behavioural control* were the main components that predicted intentions for all behaviours (exercising more, losing weight and stopping smoking), *subjective norms* significantly predicted *intention to lose weight* and *stop smoking*.

This finding suggests that greater intentions to change behaviour in order to reduce cardiovascular risk can be achieved by promoting more positive attitudes towards the behaviours, increasing perceived behavioural control (i.e. sense of control over heart disease and the self-efficacy that the desired behaviour can be achieved), and for losing weight and stopping smoking only, increasing the perceived influence of significant others.

However, these findings should be interpreted with caution, as although the items measuring the components appeared to have face validity, some items failed to reach internal consistency (i.e. they did not correlate with each other to a satisfactory level as expected in psychological scales).

9.2.8 Direct and indirect measures of intention to change behaviour

An indirect measure of intention to reduce cardiovascular risk was whether respondents requested a copy of their risk output results that could be taken to their GP to discuss cardiovascular risk reduction. It was hypothesised that there would be a positive relationship between requesting a copy of risk output results and intentions to

exercise more, lose weight and stop smoking; those who requested a copy of their risk output results would have greater intentions than those who did not request a copy of their risk output results. However, there was no evidence of a significant relationship between the direct and indirect measures of intention to change behaviour, showing that those who requested a copy of their risk output results were not more likely to have greater intentions to *exercising more, losing weight* and *stopping smoking* than those who did not.

This study shows that requesting a copy of cardiovascular risk output results is not an adequate measure of intention to reduce cardiovascular risk. It cannot be certain that respondents who requested a copy of their risk output actually intended to take it to their GP to facilitate discussions about cardiovascular risk reduction. Perhaps a copy of their risk output results was requested for other reasons, such as a reminder of their risk printed for reassurance, a token for taking part in the study, or curiosity as to what the output would look like or whether information about risk reduction would be provided. As intention to change behaviour is only a proxy measure of actual behaviour change, this finding shows that in circumstances where actual behaviour change cannot be measured, a more appropriate measure is needed than indirect measures that are merely suggestive of behaviour change.

9.2.9 Measures of understanding of risk information

This trial attempted to address the limitations of previous research that has measured understanding by asking respondents to report the risk that was presented to them.

This measures recall ability and not whether respondents have actually understood the risk information. Additionally, proxy measures of respondent's self reported confidence in their understanding are often used in other studies. Again, this does not address whether individuals are accurate in their interpretation of the risk information.

This trial attempted to address these issues by using a measure of *subjective understanding*. This asked respondents what someone in the same risk category as them should do about their cardiovascular risk. The pre-defined options were: *do a lot to reduce risk*; *do a little to reduce risk* or *do nothing to reduce risk*. This measure allowed the assessment of whether respondents understood the *implications* of their risk category. For example, a correct response for someone categorised as high risk would be the acknowledgment that someone in that risk category should be doing a lot in order to reduce their cardiovascular risk. This was measured along with *probability perception* (i.e. recall of the assigned risk category) and confidence in understanding (i.e. how confident respondents are that they have understood the risk information presented to them). Comparing the responses for the *probability perception* and *subjective understanding* items allowed a judgement to be made on the level of understanding of the respondents. Those who answered both items correctly were regarded as having complete understanding of their risk, those who answered one of the two items correctly had partial understanding, and those who answered both items incorrectly were said to have no understanding.

Level of understanding and confidence in understanding

Level of understanding was compared to *confidence in understanding* to see whether respondents who reported being confident that they understood the risk information presented to them had actually interpreted the information correctly. This allowed for conclusions to be made about the adequateness of *confidence in understanding* as a proxy for measuring whether respondents understood the risk information.

The findings of this trial found a significant negative correlation between *level of understanding* and *confidence in understanding*, where confidence decreased as *level of understanding* increased. This suggests that those who report being confident that they have understood their risk were more likely to have interpreted their risk incorrectly. This provides evidence against the use of *confidence in understanding* as a proxy measure. As the analysis combined the responses across the four trial conditions, a reason for these findings could be that respondents in the second intervention group were unfamiliar with the metonym format, as this trial was the first to use this representation format to communicate cardiovascular risk. Perhaps respondents felt unsure about the images used to represent the different risk categories for future coronary heart disease risk, and were therefore unconfident in their interpretation of their risk category.

An additional explanation for the findings could be the over-representation of respondents who possessed a partial or high level of understanding which may have resulted from the biased sample of highly educated respondents (educated to degree level or equivalent), who were likely to have above average numeracy skills.

Inappropriate subjective understanding

The majority of respondents had only a partial level of understanding, as most incorrectly answered the *subjective understanding* item. Low risk individuals felt that someone of their risk category should be 'doing a lot' to reduce their cardiovascular risk, thus leading to the conclusion that they possessed an inappropriate subjective understanding of their cardiovascular risk. A more fitting response for someone categorised as low risk would be that they did not need to do anything further in order to reduce their cardiovascular risk.

One explanation for the lack of subjective understanding was that the responses came from the 'worried well'. The 'worried well' are anxious and over-pessimistic in their risk perceptions about developing cardiovascular disease in the future, and feel that it is best to live a healthy lifestyle and do everything they can to prevent the occurrence of future disease.

However, another possible explanation could be that respondents who took part in this trial did not trust the risk prediction given to them. The Personal Heart Score (Mainous et al. 2007) predicts cardiovascular risk based on self-reported information, in absence of physiological measurements. This may have provided a conservative result leading to an under-estimation of risk. Respondents may not have trusted the result that was presented to them. This will be discussed further with regards to the internal validity of the intervention of this trial.

9.2.10 Summary

This section has described the main findings of the RCT of cardiovascular risk representation formats. The most plausible explanation given for the lack of effect or findings contrary to the hypotheses was the over-representative sample of respondents at low cardiovascular risk, and the possible 'worried well' who reported inappropriate intentions to change behaviour to reduce cardiovascular risk. This skewed the majority of the findings because intention to change behaviour was the primary outcome measure and was used in most of the analyses.

9.3 Comparison with previous literature

This section will present previous research that supports or contradicts the findings from this trial. Differences in risk representation formats, positive emotions and health, the impact of risk magnitude on intention to change behaviour, risk perceptions, and the psychological effect of screening and risk prediction will be considered.

9.3.1 Evidence of different effects of risk representation formats

This trial did not find any significant differences in the graphical risk representation formats, in terms of intention to change behaviour, understanding of risk information, positive and negative affect and worry about future risk of heart disease. This finding

suggests that the representation format used when communicating risk is of little importance. No one format is better than another at influencing a patient's motivation to reduce cardiovascular risk, enhancing understanding of the risk information or altering emotions. This is consistent with a previous web-based RCT that examined the effects and preferences for different risk formats in people with diabetes (Edwards et al. 2006b). The trial comprised four intervention groups: (1) detailed numerical information (absolute/relative risk; numbers needed to treat); (2) anchoring information (i.e. matching it to everyday or familiar risks/descriptions); (3) graphical presentation (bar graphs, thermometer scales; population/ crowd diagrams; and (4) all three combined. No significant effects of the interventions were found on decisional conflict (e.g. patients' confidence or uncertainty about whether they feel their treatment choice is the best for them personally) or satisfaction with the information. However, natural frequencies were the most preferred numerical format, and bar graphs were the most preferred graphical format, these were viewed as more helpful than pictograms or thermometer formats (Edwards et al. 2006b).

More recently, a trial of cancer and arthritis patients in Singapore examined the effects of risk representation formats on agreement to participate in a hypothetical clinical trial of a pain relief medication. Patients received information about the risk of side effects in one of three formats (frequency, percentage and verbal descriptor). No differences were found in the willingness to participate in the hypothetical trial, or on the likelihood of changing one's decision. However, the frequency format was strongly preferred by most patients (Cheung et al. 2010).

Furthermore, differences in risk perceptions, emotional reactions and screening intentions resulting from different formats for presenting risk of colorectal cancer was been assessed by Lipkus et al (1999). Participants were presented with absolute lifetime risk of getting colorectal cancer either with or without comparative risk, compared to other cancers and related risk factors (e.g. age and polyps). No differences were found between the formats in how worried, anxious and fearful participants felt about getting colorectal cancer or their intentions to be screened for colorectal cancer (Lipkus et al. 1999).

Evidence that risk presented in different formats has little impact on the treatment of patients by health professionals comes from a trial by Fahey et al (2001), who evaluated the effect of framing of cardiovascular risk as two formats in clinical practice guidelines for controlling blood pressure. No significant differences were seen when risk was presented in the clinical guidelines as absolute risk or as numbers needed to treat in blood pressure control, cardiovascular risk reduction or intensity of prescribing of blood pressure lowering drugs at 12 month follow-up (Fahey et al. 2001).

Some research evidence contradicts the lack of effect of different cardiovascular risk representation formats found in this trial. For example, Timmermans et al (2008) presented participants with hypothetical health scenarios (including hereditary hypercholesterolemia, hereditary breast cancer and prenatal testing for Down syndrome) where risk information was presented in different formats (percentages, natural frequencies and pictogram/ population diagrams). A correlation was found between affective evaluation and perceived chance of the risk occurring. There were

significant differences between the formats ($p<.05$). Population diagrams had the highest affective impact, i.e. risks were regarded as the most frightening, worrisome and serious compared to risks presented as percentages and frequencies. There is debate whether this is a desirable effect. It is suggested that a problem of using a more 'affective' format may be that evaluation of the probability is influenced and distorted by the value of the outcome of the risk (i.e. value induced bias) leading to inaccurate risk perceptions. Furthermore, the risk representation formats influenced treatment decisions, as significantly more respondents receiving the pictogram formats favoured preventive surgery over screening, than respondents who received risks as frequencies or percentages ($p=.05$), perhaps this was due to the heightened affective evaluation and greater perceived chance of risks occurring when this format was presented. Conversely, no significant differences were found between the formats for cognitive evaluation e.g. how complex, difficult to understand and how hard it was to imagine the formats (Timmermans et al. 2008).

An on-line randomised trial by Soureti et al (2010) compared percentage format with cardiovascular age equivalent or Heart-Age analogy format. The 204 participants who received the Heart-Age format, had more realistic risk perceptions that were more in-line with their actual risk, but were significantly more worried ($p=.005$) and were more likely to view the risk result as a 'wake-up' call ($p=.004$), than the 209 respondents who received the percentage format (particularly in younger individuals at higher CVD risk). The Heart-Age format also lead to significantly greater percentage of respondents (84.3%) reporting that they intended to eat more healthily and increase their level of physical activity (82.4%), compared to 79.9% and 76.6%

of respondents who received the percentage format expressing 10-year risk of cardiovascular disease (Soureti et al. 2010).

Another web-based randomised trial compared four graphical displays of the benefits of antibiotics for people with sore throat who were deciding whether to seek treatment (Carling et al. 2009a). Participants were asked to imagine they had a sore throat and were deciding whether or not to seek medical treatment. Information about the benefits of antibiotic treatment were presented in four formats although only two of these displayed equivalent information (e.g. a pictogram of happy/sad face icons and a bar graph showing the proportion of people with symptoms on day three with and without treatment). There were significant differences in the participants' ability to understand the information presented by the formats and participants showed preferences for one format over another. For example, a bar graph (showing the duration of symptoms) was reported to be the easiest to understand (37%) and was the most preferred format (38%), whereas the pictogram of faces was the least easiest to understand and was preferred the least out of all the formats. There were also significant differences in the decisions to seek medical treatment across the graphical formats, but not for the two formats that presented equivocal information. These two formats had the highest proportion of respondents reporting they would seek medical treatment (34.6% and 34.4% respectively) with no significant difference between them (Carling et al. 2009a).

Furthermore, Carling et al (2009) report the findings a web-based randomised trial comparing summary statistics for communicating the effects of statins on the risk of coronary heart disease (Carling et al. 2009b). Information was presented in six formats (relative risk reduction, absolute risk reduction, number needed to treat, event rates, tablets needed to take and natural frequencies). The relative risk reduction format (known to be most persuasive) motivated behaviour change through treatment choices, as it resulted in a 21% higher probability of choosing to take statins, compared to the other formats. Furthermore, natural frequencies were reported to be best understood, as 86% of participants reported they understood them well or very well (Carling et al. 2009b). However, as understanding was measured by self-report, it cannot be determined whether any of the formats led to a more accurate understanding of the risk information and not just perceived understanding.

Lastly, an analogue study comprising hypothetical risk profiles examined the impact of graphical risk representation formats on motivation to quit smoking. It was hypothesised intentions to quit smoking would differ in participants who viewed pictograms comprising grouped icon displays compared to dispersed icon displays. 180 smokers were randomly allocated to vignettes about the genetic risk of Crohn's disease, varying in terms of the graphical display (e.g. icon arrays of grouped or dispersed icons). Grouped icon displays were more motivating than the dispersed icons, as participants receiving risk information in the form of grouped icons reported a greater intention to quit smoking than those who received the dispersed icon array (Wright et al. 2008).

The inconsistent research into the effects of risk representation formats is likely to be partly due to previous research that has focused on different formats, using different outcome measures to assess their effects. However, the contradictory results do also suggest that there are individual differences in how people respond to risk representation formats (perhaps based on a variety of factors that have not been controlled for in the previous trials), and it may never be determined with format is the most effective in terms of motivating behaviour change, facilitating understanding and altering inappropriate emotions, as there is simply no 'magic bullet' for communicating risk to everybody.

This view is supported by findings from a focus groups of health consumers and GPs (Hill et al. 2010). Sixteen risk representation formats were presented including statements, icon arrays / population diagrams, graphical formats (such as bar graph, thermometer, line graph) alone or in combination. Participants were asked about their understanding of risk and how they thought risk tools might be discussed in a doctor-patient encounter. For each format, consumers were asked whether the format was clear and how it made them feel (e.g. scared, concerned, reassured, do not care); GPs were asked whether they thought their patients would understand and how they thought they would react. Formats were considered to be the most preferred if they were most easily understood and the most effective in convincing consumers that 16% was a high risk for CVD over 5 years. There was evidence that no one format is suitable for all patients, as some formats were rated as clear and effective by some, but rated as unclear and confusing by others. For example, many participants viewed the icon arrays/ population diagrams and line graphs as unclear,

confusing or potentially misleading, but graphical formats in general were perceived as helpful for representing risk. The most preferred formats were vertical bar graph, thermometer scale (presenting risk as percentages and using colour to indicate risk levels (as a traffic light system). Two formats that were preferred provided comparative risk information to help indicate degree of risk, this included risk statement presenting risk as a percentage and comparison with an average older person. Concern was raised over the use of green to indicate low risk (i.e. the traffic light system), with fears that this could be interpreted as safety rather than neutrality (Hill et al. 2010). An additional focus group regarding diabetes risk information reported similar findings, such as preferences for simple visual formats, with logical use of colour and comparative cues (Price et al. 2009).

To conclude, this trial did not find any differences in the effects of graphical risk representation formats on intentions to change behaviour, understanding of risk information and emotions. It still remains unclear whether this trial failed to identify true differing effects resulting from the risk representation formats, or whether the portrayal of risk has little influence on patients' behaviours, cognitions and emotions. It could also be true that there is no 'magic bullet' suitable for communicating risk to everyone, which if this is the case, creates considerable challenges for GPs when conveying risk information to patients. More research is needed before any conclusions can be drawn as to the importance of representation formats in risk communication.

9.3.2 Positive emotions and health

Positive affect was the largest contributor to the variance in intention to change behaviour scores. It was the only variable that was significantly associated with all three behavioural intentions (*exercise more, lose weight* and *stop smoking)*. Positive emotions accounted for 32.9% of the variance in *intention to exercise more* scores, 18.8% of the variance in *intention to lose weight* scores, and 28% of the variance in *intention to stop smoking* scores. This suggests that positive emotions have an influence on decisions to change behaviour.

This finding supports previous research on 'positivity' that suggests that positive emotions, such as appreciation, hope, gratitude and joy, contribute to psychological and physical well-being via more effective coping (Tugade et al. 2004). Positive emotions open the mind by broadening a person's outlook, allowing for the discovery and building of new skills, new knowledge and new ways of being (Fredrickson 2009). Positivity has long-term effects, as positive emotions help to build-up resources. These include physical resources, such as a better night's sleep, as well as psychological resources, such as increased optimism and resilience (Fredrickson 2009).

More specifically, the broaden-and-build theory of positive emotions (Fredrickson 2001) postulates that positive emotions 'broaden' people's ideas about possible actions in contrast to negative emotions that narrow ideas. This leads to increased awareness to a wider range of thoughts, actions and acceptable behavioural options, making the person more creative and receptive to information, meaning a person in

a positive frame of mind will be more accepting and willing to make behavioural changes in order to reduce health risks.

When relating the findings of this trial to this theory, it can be suggested that positivity and positive emotions lead to 'a richer appreciation of life' (Tugade et al. 2004, p.1166). This results in a desire for longevity and wanting to be at your best by looking after your health. Positivity and positive emotions means people will be more likely to look after themselves, be open to new knowledge and suggestions about how to stay healthy, and be more likely to adopt health protective behaviours. Additionally, Fredrickson suggests that positivity can help build psychological strength which can facilitate changing 'bad' habits into good ones (Fredrickson 2009). The evidence that positive emotions lead to better coping strategies by increasing psychological resilience, means that positive emotions may reduce the need for people to rely on behavioural practices that are considered harmful to their health, as a way of coping with life-events and stressful situations, such as smoking, eating unhealthy food, excessive alcohol consumption etc. Therefore, developers of health interventions should focus on increasing a person's positive emotions to effectively increase health protective behaviours.

9.3.3 Risk perceptions

This trial found evidence of inappropriate risk perceptions, as the item measuring *subjective understanding* (i.e. what someone in the same risk category should do to reduce their risk) indicated that individuals at low risk intended to 'do a lot' to reduce

their risk of future heart disease. These could be labelled as the 'worried well', who are informed about their low risk but are still anxious to monitor their risk and may feel the urge to ask for diagnostic or therapeutic interventions (van Steenkiste et al. 2004b).

Risk perceptions can be inaccurate in two ways: firstly, as demonstrated above, low-risk patients overestimate their risk or are overly anxious about their risk of CVD (termed as incorrect pessimism or pessimistic bias); and secondly, high-risk patients underestimate the probability of CVD or are not anxious about being of elevated risk (termed incorrect optimism or optimistic bias). It is surmised that the inappropriate intentions to change behaviour displayed by the low-risk respondents in this trial are suggestive of an overestimation of cardiovascular risk and pessimistic bias.

Studies comparing actual and perceived risk of CVD, have found that inappropriate risk perceptions are common among patients in primary care settings. For example incorrect pessimism was seen in 1 in 5 low risk patients visiting the GP for a consultation about their cardiovascular risk (van der Weijden et al. 2007). Additionally, incorrect perceptions and overestimations of risk have been seen in between 42 to 48% of participants in other studies (Alwan et al. 2009; Frijling et al. 2004).

Evidence for underestimation of risk (i.e. optimistic bias) has also been found. For example, the study described above by van der Weijden et al (2007) found that nearly 4 in 5 high risk patients were incorrectly optimistic about their risk (van der Weijden et al. 2007). In another study, patients were asked to compare their risk of

CHD or MI with an average person of the same and sex. More than one-third of high-risk patients reported their risk of MI as lower than the average person (equating to nearly half of women and more than one half of men reporting optimistic bias) (Aalto et al. 2007). Furthermore, when assessing patients' perceptions of their risk of heart attack and stroke, 45% displayed optimistic bias. This was higher than the percentage of people overestimating their risk of cancer or risk of a motor vehicle crash (16% and 11% respectively) (Kreuter and Strecher 1995).

Biases in risk perception have also been seen in doctors as well as patients (Lloyd 2001). A review into the risk perceptions of patients facing treatment risks sought to identify the accuracy of the risk perceptions, the factors that affect these risk perceptions and explanations for the reasons why risk perceptions are not always accurate. The findings suggested that both patients and doctors exhibit some form of biases in risk perception and decision making, where many patients have poor comprehension and recall of risk information (Lloyd 2001).

Interventions aimed at correcting patients' risk perceptions have had varying success. For example, in a study Paterson et al 2002, where nearly all participants overestimated their risk, a *Heartcheck* workbook displaying 10-year risk of having a coronary event (e.g. angina pectoris, MI or coronary death) in percentages, and relative risk presented in a table format, along with information about major contributing risk factors, successfully corrected risk misconceptions. This was seen even in participants under 40 years of age and those of low numeracy skills (Paterson et al. 2002). Moreover, Kreuter and Strecher (1995) found a risk feedback intervention, comprising graphic and numerical presentation of 10-year mortality risk

of MI and a table of treatment options and goals for achieving and maintaining desirable risk level, significantly improved accuracy of risk perceptions in those who were optimistically biased. This was maintained at 6 month follow-up (Kreuter and Strecher 1995).

However, some interventions have been found not to successfully alter inaccurate risk perceptions. For example, a web-based risk calculator for predicting diabetes risk for those who were over 45 years of age, failed to correct inaccurate risk perceptions after using the website. Reasons for this finding were proposed, including participants not paying attention to the information provided, having numeracy difficulties or limited understanding of the risk estimates, and the information viewed as being non-credible and not persuasive (Harle et al. 2008).

Correction of risk perceptions may only be successful in the short-term. For example, a study by Christian et al (2005) found that most women in their sample, who were of low risk, overestimated their risk; whereas most women at moderate/high risk underestimated their risk. A brief educational intervention aimed at improving knowledge of personal risk improved accuracy of risk perceptions immediately after the intervention, but after one month follow-up, only half the participants maintained their accurate perceptions (Christian et al. 2005). This could be taken as evidence to support the findings from patient interviews by van Steenkiste et al (2004) that found risk perceptions are rarely based on facts, and are more often based on familiarity with the disease, and how it relates to experiences with family, close friends or colleagues who have suffered from CVD (van Steenkiste et al. 2004b).

Risk perceptions have been found to have an effect on emotions. For example, higher perceived risk has been associated with a less positive and more negative mood (measured by *PANAS*). Providing patients, who were originally incorrectly pessimistic about their risk of CHD and stroke as a consequence of diabetes, with an accurate risk estimate of their CHD/stroke risk improved their mood, by decreasing negative emotions and increasing positive emotions. Mood improved with increasing correction of the difference between actual and perceive risk, i.e. biggest improvements in mood were seen for those who had the greatest inaccuracies of their perceived risk compared to their actual risk (Asimakopoulou et al. 2008b).

Furthermore, in the study by van der Weijden et al (2007), anxiety correlated moderately well with absolute probability perception, suggesting that correcting inappropriate risk perceptions might be a successful vehicle to reduce inappropriate anxiety (van der Weijden et al. 2007).

Risk perceptions also have the potential to influence health-related intentions and behaviours (Ali 2002). A study into the Health Belief Model revealed that perceived susceptibility to CHD explained 76% of the variance in CHD preventive behaviours such as 'engaging in physical activity for at least 30 minutes 3-5 days a week' and 'when eating out, selecting low fat, low cholesterol foods' (Ali 2002).

In contrast, evidence against a relationship between risk perceptions and intention to change behaviour has also been found (Hivert et al. 2009). The perception of diabetes risk was measured in non-diabetic patients using a validated risk perception survey. Those who had a higher perceived risk did not display greater intentions to

adopt a healthier lifestyle than those who had lower perceived risk (p=0.69). However, true differences between the groups may not have been detected due to the biased sample willing to take part in the study. Participants in this sample were possibly more health conscious than non-participants, as there was a high reporting of behaviour changes that were made recently before participating in the study. Additionally, the sample comprised middle-aged, Caucasian and well educated participants, which further limits that generalisability of the results (Hivert et al. 2009).

To conclude, this trial has provided evidence that people have difficulty in accurately estimating their risk. This is consistent with other research that has found that patients commonly overestimate their risk. Research shows that risk perceptions influence emotions and subsequent intentions and behaviour. It is important for patients to have accurate risk estimates, as inaccurate risk estimation can have implications in primary care. For example, high risk patients who do not perceive themselves to be at risk and are prescribed medication for lowering cholesterol may be poorly motivated to adhere to the medication. Conversely, low risk individual's who overestimate their risk and worry about their health may request treatment and be over-treated or over-investigated (van der Weijden et al. 2008).

9.3.4 Psychological effects of screening and risk prediction

This trial found that viewing cardiovascular risk significantly decreased *negative affect* and *worry about future risk of heart disease*. The greatest reductions were

seen for those categorised as low risk. This supports the findings by Pijl et al (2009) that presenting a patient's actual risk of diabetes (in a graphical bar graph, accompanied by information about diabetes and prevention), increased positive affect and decreased negative affect and worry about the chances of getting diabetes at three month follow-up (although differences were not statistically significant) (Pijl et al. 2009). In a cardiovascular screening context, a randomised trial into a population-based intervention programme aiming to reduce risk of CVD found no evidence to suggest that participation on the programme led to an increase in anxiety or concern about health. However, this may have been due to the intervention being nurse-led and therefore, any adverse effects may have been dispelled (Marteau et al. 1996).

This trial also found a decrease in *positive affect* for all respondents, including those of low cardiovascular risk. This was unexpected as a low risk outcome could be associated with providing reassurance to the individual and therefore, positive emotions should increase, particularly in the 'worried well'. Previous studies have found a lack of reassurance from favourable (i.e. negative) test results, and proposes that this stems from a disparity between expectations of being at increased personal risk and the negative or low risk result, which may lead to distrust of the risk assessment tool and its result (Michie et al. 2003; Michie et al. 2002). This suggests that upholding the original (incorrect) risk perception by mistrusting the new risk information is favoured over updating or readjusting initial estimations of own risk.

The decrease in positive emotions seen in this trial is likely to be short-term consequence only. A review into the psychological effects of screening that included 54 risk assessment studies (21 involving cardiovascular risk), examined the psychological effects of predicting individuals' risk of illness. It was found that adverse psychological effects (such as depression, anxiety, poorer perceptions of health and psychological distress) were common as an immediate consequence of having a positive test result. Anxiety and depression were significantly higher in those with a positive result compared with those who tested negative in the short-term (up to four weeks after testing). However, these effects dissipated over time, and there was no evidence of any long-term adverse effects (Shaw et al. 1999).

It is argued that the variation in the responses to risk assessment arises from the differences in how risk is assessed, and in how participants respond to threatening information. It is suggested by Shaw et al (1999) that providing detailed information about the meaning of test results and methods of coping with the distress generated by positive test results are important components to include in risk assessment programmes, to minimise the occurrence of adverse psychological distress (Shaw et al. 1999). In contrast, it is important to ensure that people who are found not to be at increased risk do not develop a false sense of reassurance or feel invulnerable to any adverse effects resulting from their risky behaviour. Additionally, there is a need for these people to understand that they have a residual (albeit lower) risk of developing the condition and should be encouraged to engage in risk reducing behaviours relevant for the general population (Marteau and Lerman 2001).

To conclude, this trial found that viewing cardiovascular risk decreased negative emotions and worry about future risk of heart disease. This lends support to previous research that has found risk screening does not have adverse psychological effects in this kind of population. Positive emotion was also reduced, although this was likely to be only a short-term consequence. A beneficial use of cardiovascular risk prediction tools may be to provide reassurance to the 'worried well' who are over pessimistic about their future risk of developing CVD. However, the low risk respondents in this trial did not display reassurance from their risk result (suggested by an increase in positive emotion). A reason for this may be because of a mismatch between prior risk perceptions and the actual results, which led to a mistrust of the risk information presented to them.

9.3.5 Predicting intention to change behaviour

This trial assessed the efficacy of the Theory of Planned Behaviour (TPB) (Ajzen 1991) to predict intention to change behaviour to reduce risk of future heart disease. The subcomponents of the TPB (attitudes, perceived behavioural control and subjective norms) were entered into multiple regression models, to see how well they predicted intention to change behaviour by explaining the variance in intention to *exercise more, lose weight* and *stop smoking* scores. The TPB components made a significant contribution to explaining the variance in *intention to exercise more, intention to lose weight and intention to stop smoking.* For *intention to exercise* more, 54.2% of the variance in scores was significantly predicted by the TPB components. For *intention to lose weight*, 65.5% of the variance in scores was significantly

predicted, and for *intention to stop smoking* 44.6%. This is slightly higher than what has been found in previous literature reviews on studies that have utilised the TPB.

For example, a meta-analysis of the relationships among variables in the Theory of reasoned action and the TPB found between 40-50% of the variance in intention was explained by the TPB components (Sutton 1998). Furthermore, Armitage and Conner (2001) included 185 independent studies in a review and found 39% of the variance was explained (Armitage and Conner 2001). However, the percentages reported by these reviews are derived from studies into different types of health behaviour from screening through to addictive behaviours. Additionally, 'file-drawer' problem or publication bias may have arisen, where only studies showing significant findings have been submitted for publication (Armitage and Conner 2001). Therefore, it is difficult to make direct comparisons with the findings of this trial.

In the context of cardiovascular risk prevention, a recent randomised trial into a decision aid for reducing cardiovascular risk, measured intention to adhere to the decision made during a consultation with a GP regarding cardiovascular risk prevention. 44% of the variance in intention to adhere to the decision was explained by the TPB components (Krones et al. 2010), which is lower than the variance in *intention to exercise more* and *lose weight scores* explained in this trial. However, the lack of internal reliability of some of the components in this trial must be remembered.

This trial demonstrated that attitudes and perceived behavioural control significantly predicted intentions to change behaviour (24 -70% for attitudes and (29-60% for

perceived behavioural control). The subjective norms component was the weakest contributor accounting for between 6% and 20% of the variance in *intention to lose weight* and *intention to stop smoking,* and did not significantly predict *intention to exercise more*. This supports previous research, as subjective norms have been found to account for the least variance of the components (between 1-12%) (Armitage and Conner 2001; Krones et al. 2010). An explanation for this may be that people do not attend to the views of their significant others because they are known, constant, in the background and do not change.

Conversely, perceived behavioural control has most often been the variable making the strongest contribution with the highest explanatory value, as much as 34% (Conner and Sparks 2005; Godin and Kok 1996; Krones et al. 2010). It has added another 6% of the prediction of intention independently, over and above attitudes and subjective norms components, which suggests perceived behavioural control influences behaviours directly and indirectly, independently of the other TPB components in this context (Armitage and Conner 2001).

Intention as a measure of behaviour change

This trial was not able to assess whether the risk representation formats had any motivating effects on respondent's actual lifestyle. Instead, intention to change behaviour was measured. Intentions are associated with an increased likelihood of changing actual behaviour, and therefore are considered an adequate proxy measure for predicting behaviour. However, previous reviews reported that intention

only explains between 27-34% of the variance in behavioural change. The likely explanation for this is that people have good intentions but fail to act on them (Godin and Kok 1996; Orbell and Sheeran 1998; Sutton 1998).

It remains unclear whether high intentions will lead to actual changes in behaviour. Evidence against the use of intentions to predict behaviour comes from Silagy et al (1993). A postal questionnaire followed by a health check by nurses found that most smokers were aware of the risk posed to their health, and 91% expressed a desire to stop smoking. However, only 39% claimed to have seriously tried to stop smoking during the 12 month follow-up. Additionally, in the 188 participants with high fat diets who regarded a high-fat diet as harmful, 91% wanted to reduce the fat in their diet, but only 61% had attempted to do this. Lastly, in 289 obese participants who regarded their diet as harmful, 98% wanted to change their diets, but only 76% had actually changed their diet at follow-up (Silagy et al. 1993).

It was not possible to determine in this trial whether respondents who indicated high intentions to exercise more, lose weight or stop smoking actually executed these and made the changes to their behaviour. However, as indicated by previous research, intentions may only have a small influence over behaviours. Therefore, future trials of risk representation formats should measure actual behaviour change, to determine whether they have any impact. Additionally, future trials should combine risk communication with other behaviour change strategies to increase their effectiveness.

To conclude, this trial supports the TPB's ability to predict intention to change behaviour through the components of attitudes, subjective norms and perceived behavioural control. More variance was explained by the components on this trial than has been demonstrated previously. Consistent with other research, subjective norms made the least contribution; whereas perceived behavioural control and attitudes components made the greatest contribution in explaining the overall variance in intention to change behaviour. This suggests that behavioural change interventions should focus on increasing perceived behavioural control and positive attitudes. Assessing actual behaviour change as opposed to intentions should also be considered. However, more studies into lifestyle behaviour change, using the TPB with reliable scales are needed before any real conclusions can be made.

9.3.6 Risk magnitude and intention to change behaviour

This trial entered the risk category of respondents (i.e. low risk or moderate/high risk) into multiple regression models to see whether risk magnitude predicted respondents' intentions to change behaviour. Risk magnitude significantly predicted intention to exercise more, by explaining 6.9% of the variance in scores. The beta coefficient indicates a positive relationship between the two variables, suggesting that the higher the risk magnitude, the greater the intention to exercise more. The effect of risk magnitude on intentions is consistent with previous work involving vignette studies (Frosch et al. 2008; Sanderson and Michie 2007; Wright et al. 2006; Wright et al. 2008). For example, Wright et al 2008 used an analogue design and examined the impact of risk magnitude (as well as graphical risk format described

previously) on motivation to quit smoking. It was hypothesised that higher magnitudes of risk would generate greater intentions to stop smoking. 180 smokers were randomly allocated to receive vignettes about the genetic risk of Crohn's disease that differed in the risk magnitude that was presented (e.g. 3%, 6% or 50%). The greater the magnitude of risk, the stronger the participants' intentions to adopt risk-reducing behaviour. Pairwise comparisons showed that those who received the highest risk magnitude (e.g. 50%) had significantly higher intentions to quit smoking than those receiving the lowest magnitude (e.g. 3%) (Wright et al. 2008).

If higher risk estimates motivate behaviour change, it follows that lower risk estimates would decrease motivation to engage in health behaviours. However, this was not found in this trial or by previous research. A study by Grant et al (2009) surveyed a nationally representative sample of physicians and patients in the US, asking for views regarding genetic testing for diabetes risk prediction. Both patients and physicians reported high expectations that genetic testing would increase patient motivation to adopt the necessary behaviours to control or prevent type 2 diabetes. 71% of patients indicated that receiving a 'high risk' result would be very likely to improve motivation to adopt preventative lifestyle changes. 78% reported that genetic testing would make them much more motivated to adhere to medications, and only two patients reported that receiving a low risk result would make them 'much less motivated' (Grant et al. 2009). This is what would be expected by the 'worried well' population, who despite being told of their low risk, are still cautious, likely to perform risk reducing behaviour and monitor their risk (van Steenkiste et al. 2004b).

To conclude, risk magnitude significantly predicted intention to exercise more, where a higher risk estimate was associated with greater intention. This supports previous research conducted using analogue designs with hypothetical risk profiles. However, it is questionable whether low risk estimates decrease motivation to engage in risk reducing behaviours.

9.3.7 Summary

This section has compared the findings of notable interest in this trial with previous literature. This trial did not find any significant differences in the graphical risk representation formats, in terms of intention to change behaviour, understanding of risk information, positive and negative affect and worry about future risk of heart disease. However, it remains unclear whether the portrayal of risk does have little influence on patient's behaviours, cognitions and emotions, or whether this trial failed to identify true differing effects resulting from the risk representation formats. The contradictory evidence also points towards there being no 'magic bullet' that is suitable for communicating risk to everyone. Therefore, more research is needed before any conclusions can be drawn as to the importance of representation formats in risk communication.

This trial provided evidence that individuals' have difficulty in accurately understanding their risk. This supports the previous research, which has also demonstrated that risk perceptions influence emotions and subsequent intentions

and behaviour. This has implications in primary care, as accurate risk perceptions reduce time wasting, superfluous prescribing and frustration in both patients and physicians. Furthermore, this trial found viewing cardiovascular risk decreased negative emotion and worry about future risk of heart disease. This lends support to previous research that has found risk screening does not lead to adverse psychological effects. The lack of reassurance (i.e. no increase in positive emotion) may have occurred because of a mismatch between prior risk perceptions and the actual results, leading to a mistrust of the risk information presented.

This trial used the TPB as the theoretical model underpinning the primary outcome measure (intention to change behaviour), it assessed the ability of the TPB to predict intention to change behaviour through the components of attitudes, subjective norms and perceived behavioural control. The TPB significantly predicted intention to exercise more and intention to lose weight. More variance was explained by the components on this trial than demonstrated by previous studies. However, in-line with other research, subjective norms made the least contribution, whereas perceived behavioural control and attitudes components made the greatest contribution to explaining the overall variance in intention to change behaviour. Lastly, this trial partially supports previous evidence suggesting that risk magnitude plays a role in predicting individuals' intentions and behaviour, where a higher risk estimate was associated with greater intention to exercise more. This demonstrates that a number of factors contribute a person's decision to reduce cardiovascular risk and adopt lifestyle changes and risk reducing behaviours.

9.4 Strengths of the Randomised Controlled Trial

This section summaries the strengths of the randomised controlled trial, which has been conducted and reported according to the Consolidated Standards of Reporting Trials (CONSORT) statement guidelines (Schulz et al. 2010). A critique of the trial will be made looking at aspects deemed important for assessing internal validity (e.g. extent that systematic error or bias is minimised) and external validity (e.g. the generalisability of the results of a trial to a wider population), such as recruitment, randomisation, intervention, outcome measurement and analysis, in accordance with the MRC framework for developing and evaluating complex interventions (Medical Research Council 2000; Medical Research Council 2008).

9.4.1 Recruitment

A number of recruitment methods were implemented. These included both internet-based (such as invitation on staff intranet electronic notice boards of the local Council and Universities, posting on social networking websites and forums, and the 'snowballing' technique of emailing personal contacts); as well as non internet-based methods (such as a press release in local newspapers, a radio interview and advertisements via posters and cards). These diverse methods enabled a wide audience to be reached, which maximises potential participation in the study, increasing data collection. Internet-based methods appeared to be the most successful. It is thought this was because respondents are already at their computer and if interested in participating in the study, would just have to click on the hyperlink

to take them to the study website. However, balanced risk stratification was not achieved by doing this. The SQL database recorded 2463 visits to the website, of which, 908 completed the study (before data cleaning). Therefore it can be estimated that there was a 63% (n=1555) drop-out rate.

Research has identified features of web-based surveys that may influence drop-out rates. For example, open-ended questions, questions arranged in tables, 'fancy' slow to load graphics (thought to increase the download time for each webpage), unclear instructions on how to complete, and absence of navigational aids have been found to increase the likelihood of dropouts (Bosnjak and Tuten 2001). For this study, drop-out rates due to the design of the website were minimised, as the website was designed with the target population in mind, (i.e. 45-64 year olds). Ease of use was an important consideration, where all text was displayed in an adequate font size and instructions were clearly visible. There was simple navigation throughout the web pages by use of a 'click to continue' button, and sliding scales were used for recording age, height and weight of respondents. It was also piloted on a small sample of lay people who fitted the inclusion criteria, as well as academics with experience of undertaking research in a healthcare setting. Furthermore, an incentive was provided for respondents, as it was stated that a £1 donation would be given to the British Heart Foundation for every person who took part and completed the study. It has been shown that incentives can maximise data collection by increasing the numbers of people who are willing to participate, and improve the retention rates of those who finish the study (Göritz 2006). Therefore, the high drop-

out rates are likely to be due to reasons other than the design/usability of the website and lack of incentive.

9.4.2 Randomisation

The use of a computer generated randomiser has the advantage of concealing allocation of respondents to the trial conditions and thus minimising selection bias, which in turn enhances the internal validity of the trial. Table 7.2 in Chapter 7 (results of primary objectives) shows the characteristics of the sample for each of the conditions, the even distribution demonstrates the success of the randomisation.

9.4.3 Intervention

The intervention of this study comprised a web-based risk formatter tool that predicted an individual's 10-year risk of having a future coronary heart disease event (e.g. MI, angina pectoris or coronary death).

Real cardiovascular risk assessment

This is one of the first web-based four armed RCTs on the effects of different cardiovascular risk presentation formats that has used actual risk assessment, rather than analogue design with hypothetical patient risk profiles. The risk formatter tool

was specifically designed for this study and went through an extensive piloting procedure assessing usability and internal logic.

Web delivery

The web-based risk formatter tool for predicting future cardiovascular risk used the Personal Heart Score algorithm (Mainous et al. 2007). This departs from traditional methods for assessing cardiovascular risk, which involve risk assessment in a clinical setting and use physiological assessments, such as cholesterol and blood pressure measurements. The Personal Heart Score (Mainous et al. 2007) enables a rudimentary assessment of the future risk of having a coronary heart disease event by using non-laboratory self-reported information. This maximises the data collection as participants do not need to know their cholesterol or blood pressure measurements, which may involve visiting their GP for a clinical assessment. The Personal Heart Score (Mainous et al. 2007) provides an adequate starting point for individuals who have not thought about their risk of heart disease before and therefore, are not aware that they may be at risk. Normally, an individual would have their risk assessed in a clinical setting in a consultation with their GP. In contrast, respondents in this trial completed a risk assessment remotely in a setting of their choice, usually in their homes or work place. The researcher is absent, thus reducing researcher bias.

The Personal Heart Score (Mainous et al. 2007) categories risk into low, moderate and high. This is advantageous to some individuals who are thought to translate

numeric risks into categories when interpreting and using the information (Wertz et al. 1989).

9.4.4 Outcome measurement

The primary and secondary outcome measures in this trial were clearly defined *a priori* and assessed by self-completion on-line questionnaires. A self-completion approach can result in more truthful responses due to anonymity. This minimises social desirability bias (the tendency for respondents to reply in a manner that will be viewed favourably by others) (Oppenheim 2001).

The primary outcome measure was intention to change behaviour (e.g. exercising more, losing weight and stopping smoking) in order to reduce cardiovascular risk. This was chosen because intention is a good proxy measure, in instances where it is not possible to measure actual behaviour change. Additionally, it has been used as the main outcome in many previously published trials (Marteau et al. 2010; Price et al. 2008; Watts et al. 2003). Other outcomes measured in this trial comprised *understanding of risk information*, *affect*, *worry about future risk of heart disease* and the subcomponents of the Theory of Planned Behaviour (TPB) (*attitudes, subjective norms, perceived behavioural control*). Justification for the assessment of these outcome measures is presented in Chapter 5.

Two outcomes measured in this study used existing well-validated scales or adapted items from existing scales. For example, *positive and negative affect* was measured using the Positive and Negative Affect Schedule- Short Form (PANAS-SF) (Thompson 2007). This has been validated, demonstrating construct validity and has been used extensively in previous research (Watson et al. 1988). The one-item scale measuring *worry about future risk of heart disease* was developed by adapting previously validated scales relating to other health conditions such the Lerman Breast Cancer Worry Scale (Lerman et al. 1991).

Alternatively, some of the outcomes were measured using items developed specifically for the purpose of this study. This included understanding of risk information (i.e. *absolute probability perception, subjective understanding and confidence in understanding items*), intention to change behaviour (i.e. *exercise more, lose weight* and *stop smoking*) and the subcomponents of the TPB (*attitudes, subjective norms and perceived behaviour control*) (Ajzen 1991). All questionnaire items went through a piloting procedure before the trial commencement, and in the case of the TPB components, items were developed using guidance from published guidelines on constructing TPB questionnaires from the University of Newcastle (Francis et al. 2004). This manual integrates advice from previous literature on the TPB, has been widely used in previous research that has required TPB questionnaire development (Frosch et al. 2008; Giles et al. 2007; Tavousi et al. 2009). It has gone through a process of extensive reviewing and trialling.

9.4 5 Analysis

The plan of analysis was finalised during the development of the protocol for the trial (Appendix 20). This was done with advice from a statistical expert. The sample size calculation was based on a previously published trial (Wright et al. 2008) that used Likert scales for the same primary outcome measure as this trial (i.e. intention to change behaviour). The sample size calculation stipulated that a fully powered study, sufficient to attain a power 90% for the primary outcome measure of intention to change behaviour, would need approximately 200 subjects in each condition, equalling 800 subjects needed in total. This was exceeded, as the total sample size for the final analysis was 903.

Data analyses were conducted according to the analysis plan developed *a priori*. A slight amendment to the proposed risk category subgroup analyses was made due to the disproportionate cell sizes of the low risk category, compared to the moderate and high risk categories. Instead of analysing the three categories separately, respondents were dichotomised into either low or moderate/high risk. The conventional statistical tests were performed and *p* values and 95% confidence intervals were calculated where appropriate.

9.4.6 Summary

This section has highlighted the strengths of this randomised controlled trial, paying attention to the recruitment, randomisation, intervention, outcome measurement and analysis. To summarise, this study is one of the first to use a four-armed randomised controlled trial to assess the effects of different graphical cardiovascular risk representation formats using actual risk assessment (and not hypothetical risk profiles). The web-based design placed no time or location constraints on participants. It used self-reported, non-physiological measurements in the assessment of cardiovascular risk, which maximised data collection by enabling those who had not thought about their risk, and not previously visited a GP for a clinical assessment to participate. Where possible, validated scales were used to measure the outcomes of interest, and extensive piloting was undertaken in instances where a new scale had to be developed for the purposes of the study. Lastly, a plan of analysis was developed and sample size calculation was performed before the commencement of the trial, in accordance with the CONSORT guidelines for randomised controlled trials (Schulz et al. 2010).

9.5 Weaknesses of the Randomised Controlled Trial

In the same way as the strengths of the randomised controlled trial, the weaknesses will also be considered in accordance with the CONSORT statement guidelines

(Schulz et al. 2010). Again, particular attention has been paid to the factors influencing the external and internal and validity of the trial, in accordance with the MRC framework (Medical Research Council 2000; Medical Research Council 2008).

9.5.1 External validity

There are a number of factors that limit the external validity of the findings of this RCT. This concerns the extent that the results can be generalised to a wider population.

9.5.2 Recruitment

Weaknesses of the trial that affect external validity mostly arise from the way respondents were recruited. For example, the methods of recruitment that were used, the incentive to participate and the opt-in nature of the study will be discussed in turn, with reference to the potential biases that result.

Recruitment methods

The recruitment of a trial is an important aspect to consider when assessing external validity. Firstly, the trial was web-based and therefore limited participation to those who had access to a computer with the internet, and possessed adequate computer

literacy skills. In a recent survey on internet access by the Office of National Statistics (Office of National Statistics 2010), it was estimated that 60% of all adults in the UK (30.1 million) have access to the internet, with 9.2 million adults reporting that they have never used the internet.

Recruitment for this trial used a number of methods, mainly web-based. Some methods were more successful than others, leading to greater recruitment rates (i.e. internet-based methods), whereas others were less successful, leading to lower recruiting rates (i.e. posters and card advertisements). This affects the external validity of the trial's results. The top three methods that generated the most traffic and participants to the study were email invitations, social networking sites (in particular *Twitter.com, Facebook, Over 50 forums*) and posting on University electronic notice boards. Four Universities agreed to post a link on their staff electronic notice boards, which led to an over-representation of respondents who were highly educated to degree level or equivalent. This meant the sample were likely to possess high numeracy and literacy skills, leading to an increased likelihood that they understood the risk information presented to them regardless of its representation format. This may have reduced the ability to detect true differing effects of the risk representation formats on understanding of risk information.

Incentive to participate

The incentive of a £1 donation made to the British Heart Foundation for every respondent who participated and completed the study, may have resulted in an

altruistic motivation to take part in the study to support the charity, rather than a desire to have their future risk of cardiovascular disease assessed.

Opt-in nature of study

The opt-in nature of the study leads to volunteer bias, as internet users volunteered to have their future risk of cardiovascular disease assessed, as opposed to respondents recruited through alternative methods (such as general practice). The respondents who took part in this study may have possessed different characteristics to those of the general population. For example, they may have an interest in their health and cardiovascular risk, making them curious or worried about their health, and therefore, more motivated to reduce their cardiovascular risk, than other populations such as smokers who are less concerned about their health.

Furthermore, the opt-in nature of the recruitment results in a self-selecting sample. This makes collection of data on the external validity of respondents difficult. The web-based delivery means it was not possible to determine a meaningful response rate and gather information on the number or characteristics of those who did not want to participate. Only an estimation of the number of those who did not consent to the study was collected from those who indicated on the 'Consent' webpage that they did not wish to participate in the trial (n=31). However, this figure is likely to be underestimated, as it is possible that those who did not want to participate (a) did not visit the homepage in the first place, or (b) visited the website but left without ticking the appropriate box on the consent page that indicated they did not wish to take part in the study. Therefore, it is possible that there were significant differences between

those who wished to participate and those who did not on variables that were unmeasured. The external validity of the findings is limited in this respect.

9.5.3 Biased Sample

The trial comprised a sample that was biased for a number of reasons including the age, level of education level and cardiovascular risk category. This limits the generalisability of the results.

Age and level of education

The sample achieved by this trial predominantly comprised those who were at the lower end of the age range criteria (i.e. 45 year olds) and educated to degree level or equivalent. This reflects the demographics of internet users reported by the Office of National Statistics. For example, 97% of adults educated to degree level use the internet, compared to only 45% of those without formal qualifications; and the younger the adult, the more likely they are to use the internet. As 99% of 16 to 25 year olds access the internet compared to 40% of over 65 year olds (Office of National Statistics 2010).

Internet Users

The web-based nature of the study resulted in a sample that was large (n=903), but not representative of those without internet access. Additionally, the study

participation was limited to those with adequate computer literacy skills. However, the goal of the study was not to achieve representative sampling, but rather to compare the impact of different cardiovascular graphical risk representation formats.

Low cardiovascular risk

The sample predominantly comprised respondents who were categorised as being of low cardiovascular risk. The number of respondents who were categorised at moderate and high cardiovascular risk was lower than expected (n=155, 17.2%). The disproportionate numbers of respondents in the risk categories meant a lack of power for the statistical tests to detect true differences between the groups. This was due to the small cell sizes for those of moderate and high risk, despite dichotomising risk into two groups: low and moderate/high combined. This also limits the generalisability of the results. However, the lower proportion of respondents with elevated risk is consistent with previous trials, such as the IMPALA (IMproving Patient Adherence to Lifestyle Advice) study that reported only 30% of the sample was at high cardiovascular risk (Koelewijn-van Loon et al. 2010); and a cross-sectional study into the risk perceptions of patients who had discussed their cardiovascular risk during a consultation with their GP, that found that only 17% of the sample were at high cardiovascular risk (van der Weijden et al. 2007).

A reason for the lower numbers of respondents at elevated cardiovascular risk could be due to the component of the trial that required the assessment of actual cardiovascular risk. Some people may have been reluctant to participate due to the fear of the unknown and the risk of potentially finding out something they did not

want to, such as being at higher cardiovascular risk than they originally thought. This may have meant that the people at higher cardiovascular risk, who are aware that they have unhealthy lifestyles, might not have been motivated to participate in these types of health appraisal studies, preferring to take a coping style for health threats that would represent low monitoring (i.e. ignoring threat-relevant information) and high blunting (i.e. distracting oneself from the health threat) (Miller et al. 1988; Williams-Piehota et al. 2005), as opposed to the 'worried well' who participated in the trial, who would be regarded as having a high monitoring and low blunting coping style.

9.5.4 Internal validity

This section will assess the internal validity of the RCT, which concerns the extent that systematic error (or bias) is minimised. The randomisation, intervention, outcome measures and analysis will be considered.

9.5.5 Randomisation

The internal validity of the trial was originally jeopardised at the start of the trial due to selection bias (e.g. bias in the allocation of respondents to the intervention and control groups). This study used computer-generated randomisation, where an algorithm was programmed into the computer which randomised respondents to one of the four conditions when they visited the homepage. However, after the first 100 respondents had been recruited, it became evident that allocation was not entirely

random. This was because the original algorithm was disproportionately allocating respondents to the conditions. Twice as many respondents were allocated to conditions two and three, than to conditions one and four. This was soon rectified by replacing the algorithm and discarding a random half of the data from conditions two and three. This resulted in the loss of 42 completed responses (see Chapter 7 for more detailed explanation).

9.5.6 Intervention

The intervention of this trial involved respondents having their risk of future coronary heart disease calculated by the risk formatter from information they provided regarding their personal characteristics (sex, age, BMI, family history of cardiovascular disease) and health and lifestyle status (GP diagnosis of hypertension, hypercholesterolemia or diabetes, smoking status, level of physical activity); then viewing their risk in one of the three graphical risk representation formats (bar graph, pictogram, metonym). Risk was categorised into low (under 10%), moderate (between 10-20%) or high (over 20%).

The risk categories had wide confidence intervals with a high level of uncertainty. More precise risk estimations, such as those provided by Framingham, SCORE or QRISK2 (Conroy et al. 2003; D'Agostino et al. 2008; Hippisley-Cox et al. 2008) were not possible, due to the absence of physiological measurements including cholesterol and blood pressure levels. The personal heart score is likely to have provided a conservative result leading to a possible underestimation of risk. This

becomes problematic if respondents did not trust or believe the result presented to them.

To consent to taking part in the trial, respondents would have had an interest in their own cardiovascular risk strong enough to motivate them to take part in this study. Perhaps this motivation to monitor their cardiovascular risk existed before this trial, leading them to have already obtained a more accurate risk assessment from their GP or health professional. If their previous risk assessment contradicted the results from the Personal Heart Score, it is possible that they were thinking about this previous result when answering the post-intervention questionnaire, rather than the category that was presented to them by the risk formatter in this trial.

Additionally, a disclaimer statement was presented on the beginning pages of the risk formatter website. This highlighted that the risk prediction of this study was only an indication of risk and users were advised to visit their GP for a more clinical assessment.

Taking these two points into consideration, it is possible that the main aim of the trial was hindered by reducing the impact of the risk message communicated to users via the different risk representation formats. Thus, any true effects resulting from the different cardiovascular risk representation formats would be obscured.

9.5.7 Outcomes measures

There are weaknesses in the outcome measures used in this trial. For example, use of Likert scales, the direct measurement of the TPB components, lack of internal reliability in the TPB questionnaire, modification to the wording of the PANAS scale and omission of a baseline measure of perceived risk. These will be discussed in turn.

Likert scale measurement

The outcomes of this trial were measured using Likert scales. These were chosen as they are commonly used in research questionnaires and are recommended by the Manual for constructing TPB questionnaires (Francis et al. 2004). They have the advantages of providing information of the degree of agreement and disagreement of statements representing the variable of interest, and are easy to construct (Oppenheim 2001). On the other hand, they have been criticised for the lack of reproducibility, where the same score may be achieved in different ways, where it has entirely different meanings, making it difficult to interpret. Additionally, a Likert scale does not offer metric or interval measures and does not have a clear neutral point. Therefore, it cannot be determined whether a score in the middle ranges are due to lukewarm responses (from lack of attitude, lack of knowledge etc.), uncertain responses, or are slightly positive or negative in their direction. These different possibilities make identification and interpretation of these scores difficult (Oppenheim 2001).

In this trial, attempt was made at reducing the possibility of response set bias (tendency to answer a series of questions in a certain direction regardless of the content). This involved reversing the direction of some items to increase the attention that needs to be paid when reading the items (and then reversing the direction of the scoring). Furthermore, in accordance with recommendations from the manual for contrasting TPB questionnaires (Francis et al. 2004), items measuring these components comprised a 7-point Likert scale; whereas the validated scale for measuring positive and negative affect e.g. PANAS-SF (Thompson 2007) comprised a 5-point Likert Scale.

These two inconsistencies in the questionnaire presentation may have aggrieved some respondents who did not like the change in item direction or number of points on the scale, or confused respondents unfamiliar with this type of questionnaire measurement. This may have lead to an increased possibility of respondents dropping out before completing the study. On the other hand, drop-outs could have occurred by the repetitive nature of the scale items, especially as items measuring intention to change behaviour (i.e. exercising more, losing weight and stopping smoking) were similar. Therefore, personal preference is one of the determining factors in whether respondents complete the study, and although attrition can be minimised, it cannot be controlled for completely.

Internal reliability of TPB questionnaire

As already described, items measuring the outcomes of interest were either from previously validated scales or were developed specifically for the purposes of this trial, such as the items measuring intention to change behaviour (*exercising more, losing weight* and *stop smoking*) and the subcomponents of the TPB (*attitudes, subjective norms* and *perceived behavioural control*). Reliability checks were not possible at the piloting stage due to the small sample size. Therefore, the internal reliability was assessed after the main data had been collected, using Cronbach's alpha correlation coefficient.

Out of the 14 components measuring variables for exercising more, losing weight and stopping smoking, 7 failed to reach a satisfactory level of internal consistency as the items did not possess a Cronbach's alpha correlation coefficient of 0.7 or above. The alpha level could have been improved with the removal of one item in two instances (*pre-intervention attitudes towards reducing risk of heart disease* and *intention to exercise more*). However, this would have caused multicollinearity, where items become superfluous if they correlate too highly with each other. Therefore, a decision was made not to remove any items. This means that the findings using the components without adequate internal reliability should be interpreted with caution. Although, all items had face validity as the components they were measuring could be clearly identified. Further reliability and validity checks, in particular construct validity should be used on this questionnaire if it is used in future research.

Direct measure of TPB components

A possible reason for the inadequate internal consistency of the TPB components may be attributable to the direct measure that was used. This comprised items to assess the components of attitudes, subjective norms and perceived behavioural control. This direct approach was taken to keep the number of items in the questionnaire to a minimum, thus reducing cognitive demand of the participants and the possibility of attrition.

An alternative, indirect approach that could have been chosen that considers beliefs contributing to the predictor variables. The indirect approach measures behavioural beliefs and outcome evaluations for the attitude component; normative beliefs and motivation to comply for the subjective norms component; control beliefs and influence of control beliefs for the perceived behavioural control component. This approach consists of using more items to measure the components. It may have increased the internal reliability of the TPB questionnaire in this trial, and may have led to an increased efficacy of the TPB model in predicting intention to change behaviour to reduce cardiovascular risk (e.g. exercise more, lose weight and stop smoking). However, recent research has demonstrated no differences between direct and indirect measures of the TPB at predicting behaviour (Jeong 2011).

Modification to the wording of the PANAS Scale

It should be acknowledged that there is a weakness in the outcome measures of this study, as slight amendments were made to the wording of the PANAS scale (Thompson 2007). This comprised changing the instructions presented at post-intervention to enable a more logical assessment of positive and negative affect after viewing cardiovascular risk. For example, the instructions presented at baseline were '*Thinking about yourself and how you normally feel, to what extent do you feel...?',* whilst the instructions presented at post-intervention were *'At this present moment to what extent do you feel...?'.* Making amendments to the wording of published and validated scales should be avoided if possible, as this can limit the reliability of the results. However, it must be noted in this instance that both baseline and post-intervention scales were internally reliable and possessed acceptable Cronbach's Alpha levels.

Omission of baseline measure of perceived risk

This study is also limited as it did not measure perceived risk at baseline. This decision was made in order to keep the number of items in the pre-intervention questionnaire to a minimum, reducing the possibility of attrition (drop out). However, this meant that it was not possible to determine whether the risk representation formats modified risk perceptions, or whether a respondent's preconceived perception of their cardiovascular risk prevailed after risk was assessed and displayed in one of the selected formats of the study. Therefore, it is important for

future research to take into account a person's preconceived perception of their risk, to see whether this has an influence on the effectiveness of the risk communication intervention.

9.5.8 Analysis

There are weaknesses in the analysis of the trial results. These include deviation from the planned subgroup analysis; analysis on intentions to stop smoking using a small sample of smokers; and the appropriateness of intention to lose weight item.

Subgroup analysis deviation

It was originally stipulated in the analysis plan that a subgroup analysis of each of the risk categories would be conducted to examine whether risk magnitude had any influence over the effects of the graphical risk representation formats. However, due to the disproportionate number of respondents assigned to the low risk category (82.8%, n=748), the analysis deviated from the original plan and risk was dichotomised into low (under 10%), or moderate and high (10% and over). This decision was made to increase the statistical power and increase the likelihood of differences being detected between the risk category groups.

Intention to stop smoking

The sample comprised a smaller than anticipated number of current smokers. This meant one of the assumptions used to assess suitability of the data for the appropriate statistical analyses was violated. The required ratio of cases to independent variables was calculated at between 106-111. However, for the *intention to stop smoking* variable there was only 81 cases. Therefore, the findings regarding respondents' *intentions to stop smoking* should be interpreted with caution due to the small cell sizes.

Appropriateness of intention to lose weight

The *intention to lose weight* component was given to all respondents regardless of their BMI, and whether they actually needed to lose weight. The sample characteristics showed that only 23% of the sample had a BMI of over 30, which is classified as being overweight/ obese, and thus needing to lose weight. However, the mean intention to lose weight was above the mid-point at 4.65 (SD=1.6), suggesting that participants had inappropriate intentions to lose weight (i.e. they had high intentions to lose weight even though they did not need to). This is further evidence of the sample comprising the 'worried well' and may contribute to the lack of differences across the risk representation formats.

Ideally, the *intention to lose weight* items should only have been given to those who needed to lose weight, in the same way that the *intention to stop smoking* items were only given to those who were current smokers. However, there are reasons against

this. Firstly, the BMI classification system for obesity may not be the best method for assessing whether respondents need to lose weight. There are a number of circumstances where the current thresholds provide misleading information about a person's body fat content. For example, athletes have a higher muscle density with lower body fat content because the greater muscle mass elevates their BMI, classifying them as obese. Conversely, as a person ages, muscle density reduces and body fat increases, which means that body weight and BMI can stay the same despite the increase in body fat. Additionally, there are racial differences in total body fat, which demonstrate a need for differing cut-off points for classification of being overweight and obese (Prentice and Jebb 2001). Therefore, more accurate assessment of obesity is needed before judgements can be made regarding a person's need to lose weight. Furthermore, it has also been suggested that cardiovascular risk is associated more with the proportion of saturated fat in the diet, as opposed to the degree of obesity (Keys et al. 1986).

Secondly, if the suitability of items given in the post-intervention questionnaire is assessed on the basis of the risk factor information, then *intention to exercise more* should be assessed in the same way. Items regarding *intention to exercise more* should only be given to respondents who reported seldom or never exercising or playing sport in their spare time (e.g. the item in the risk assessment that assessed level of physical activity). This would lead to smaller numbers of respondents answering the intention to change behaviour questions, where some respondents possessing optimal risk factors might not answer any questions regarding their intentions to change behaviour. This means a much larger sample would be required to ensure that there are adequate numbers of cases to assess each of the variables.

9.5.9 Summary

This section has described the limitations of the trial in terms of internal and external validity, paying particular attention to the randomisation, intervention, outcome measures and analysis. It is concluded that the generalisability of the results (external validity) is limited due to the biased sample, partly resulting from the recruitment methods that were used. Additionally, it was debated whether the internal validity was affected by the algorithm used in the trial that produced results that perhaps were not trusted or believed because of the absence of physiological measurements and precise numerical risk estimates, and also the lack of internal reliability of some of the variables.

If this trial was conducted again, a number of changes could be made to improve the internal and external validity of the findings. For example, generalisability of the findings could be improved by minimising the risk of a biased sample. This could be done by making more of an attempt to target respondents of moderate and high cardiovascular risk, rather than the low risk 'worried well'. This could be achieved by recruiting through general practitioner records or approaching higher risk populations, such as smokers in designated outdoor smoking areas. Additionally, less reliance on certain web-based methods, such as University staff electronic notice boards would result in respondents from differing educational levels that are more representative of the general population, rather than the large proportion of respondents who were educated to degree level, resulting from this trial being advertised across four Universities.

The internal validity (reduction of systematic bias) could be increased by using a more precise algorithm that provides an estimation of risk with smaller confidence intervals (such as an exact probability estimate rather than a risk category). However, it is likely that this would require physiological measurements such as cholesterol and blood pressure, and therefore respondents would be required to attain these measurements before taking part in the trial. This would reduce the benefits of the web-based 'arm-chair' risk assessment conducted in people's own homes, without GP involvement. Furthermore, a bigger sample at the piloting stage would enable more reliability checks to be conducted on the items before commencement of the trial, making sure they reach an adequate level of internal reliability and actually measure the construct they have been designed to measure. Lastly, alternative survey methods, as opposed to the Likert Scale could be considered.

9.6 Implications for policy and practice

This study has shown that online cardiovascular risk prediction tools are successful in reducing *negative affect* and *worry about the future risk of heart disease*, and thus providing reassurance to those individuals at low cardiovascular risk. These users could be described as the 'worried well' and possess inappropriately high intentions to change their behaviour to reduce their cardiovascular risk even though they do not need to. The trial's failure to recruit individuals at moderate and high risk suggest that more needs to be done to encourage these unaware 'at risk' people to use on-line risk prediction tools to assess their risk of cardiovascular risk. This is so that they

can be informed of their risk and make the appropriate decisions about how best to reduce their risk, by making lifestyle changes and/or adhering to treatment/medication.

This trial did not find any significant differences between the graphical risk representation formats, suggesting that there is no one method that is more effective than another; as the way risk is communicated to patients has no influence on behaviours (i.e. changing behaviour to reduce risk), cognitions (in terms of understanding) or emotions. This informs developers of cardiovascular risk prediction tools and risk reduction interventions that getting the message across is the most important aspect of the risk communication, not what format the message is presented in.

9.7 Summary / Conclusion

This chapter has given an evaluation of the RCT of the effects of different cardiovascular risk representation formats. It has compared the primary findings with previous research in the area, critically evaluated the trial by acknowledging its strengths and weaknesses, and has suggested future modifications that could be made to improve the internal and external validity. Also, implications of the trial's main findings for policy and practice have been highlighted.

Chapter 10. Discussion and Conclusions of thesis.

10.1 Introduction

This chapter will summarise the main findings of the studies that comprise this thesis. The primary focus of this thesis was to assess which risk representation formats are currently being used to communicate cardiovascular risk, and design and conduct a trial examining the effects of different cardiovascular risk representation formats on patient-related outcomes. The thesis comprised (1) a critical appraisal of existing web-based cardiovascular risk calculators; (2) a systematic review on ways of presenting cardiovascular risk information to patients; and (3) a randomised controlled trial of the effects of different graphical cardiovascular risk representation formats.

This chapter draws together the findings from each stage of the thesis. The findings will be presented in the context of previous, existing research relevant to the field of cardiovascular risk communication. A critique of the strengths and weaknesses of the thesis as a whole will be summarised. Lastly, implications for practice and policy will be presented, along with possible future directions for research and areas that warrant further research and discussion.

10.2 Aims and summary of thesis findings

The aims of this thesis were firstly to identify what tools are available for the public to use when searching for cardiovascular risk assessment at home, and examine how well these tools present cardiovascular risk and to what extent risk reduction is encouraged; secondly, to review past literature to determine which risk representation formats are most effective in communicating cardiovascular risk to patients; and lastly, to design, conduct and evaluate a web-based RCT to assess the effects of different cardiovascular risk representation formats on patient-based outcomes.

10.2.1 Summary of results from Critical Appraisal of cardiovascular risk prediction tools

The thesis described a critical appraisal of cardiovascular risk prediction tools retrieved when searching for risk assessment tools on-line. The 10 highest ranked cardiovascular risk prediction tools most likely to be found on *Google* were included. A standardised critical appraisal template, designed by adapting existing guidelines and evaluation tools was used. Hypothetical patient profiles were inputted into the risk prediction tools to create a risk output. The quality of the risk communication in the prediction tools was assessed, such as the type of risk representation format and the timeframe/s used. The extent that the tools encouraged risk reduction by providing information about behaviour change and/or treatment options was also

appraised, such as reporting the main contributing risk factors or providing treatment goals.

When the quality of the risk communication was appraised it was found that nearly all tools presented absolute risk, and just over one third presented alternative types of risk (such as comparative or relative risk, which gives context for users to evaluate their risk). The most commonly used numerical risk representation format was percentages, with natural frequencies second. The majority of tools provided more than one way of expressing probability of cardiovascular risk. Under half of the tools provided graphical risk representation. In general, graphical formats used were congruous with the numerical probability estimates presented in the risk outputs (e.g. bar graphs displaying percentages and pictograms displaying natural frequencies). One tool allowed users to choose one of four graphical formats for viewing results. The majority of tools provided risk in a 10-year timeframe only. Two tools demonstrated short-term risk less than 10 years, and one tool projected longer term risk by illustrating 10-year risk if the user added 10, 20 or 30 years to their current age. Three tools had the facility of displaying risk in more than one timeframe option (such as 1, 5 or 10-years).

When the tools were appraised for *how* and *to what extent* they facilitated risk reduction, all tools processed at least one characteristic that focused on cardiovascular risk reduction. The most common features included the option to print out the results, and direction to further information sources about cardiovascular disease and risk reduction. However, the *American Heart Association* tool focused on cardiovascular risk reduction the most and provided all the features deemed

helpful when considering risk reduction, which were compiled in the standardised critical appraisal template designed by adapting existing guidelines and evaluation tools.

To conclude, the critical appraisal of the web-based cardiovascular risk prediction tools found variation in the quality of the risk communication of the cardiovascular risk prediction tools available on the internet. Some tools focused on risk reduction more than others by providing functions that facilitated decisions regarding behaviour change and treatment options. The most common features were the option to print out results and direction to further information regarding cardiovascular risk. However, it was concluded that the tools could incorporate more of the 'best practices' suggested by the research evidence in risk communication, and include more features to facilitate risk reduction; for example, using the option for an individual to revisit their risk profile and record progress as they attempt to reduce their cardiovascular risk.

10.2.2 Summary of results from Systematic Review on ways of presenting cardiovascular risk to patients

The systematic review into effective ways of communicating cardiovascular risk to patients, found that not much research has been conducted to date into how to communicate risk estimates that motivate people to modify their risk of developing heart disease. The review comprised broad inclusion criteria, but only found 15 studies. Only 4 studies dealt with the presentation of patients' real risk, as the

remaining 11 were analogue studies using hypothetical risk profiles. The methodological quality of the studies varied, only two were deemed to be of high methodological quality according to the Downs and Black checklist (Downs and Black 1998). There were two RCTs, 9 were observational designs and 4 were quasi-experimental. There was heterogeneity in the conceptualisation, formats and framing of cardiovascular risk probabilities. This meant only a few meaningful subgroups could be formulated for comparison purposes, such as real versus hypothesised risk and the type of cardiovascular risk manipulation.

Results were summarised in a narrative synthesis, but given the evidence few conclusions could be drawn from the individual studies. These are tentative and need further exploration. For example, (1) making patients aware of their risk can encourage risk reduction action to be taken, especially if this risk is high; (2) numerical presentation of risk as opposed to simple risk categories leads to more accurate risk perceptions and can influence treatment decisions; (3) relative risk reduction format 'encourages' acceptance of treatment the most, and number needed to treat format leads to the least acceptance of treatment; (4) the presentation of absolute and comparative risk, both graphically and numerically, affects risk perceptions and emotions and can lead to reduction in patient risk factors, however, the impact of comparison risk depends on the level of personal risk, e.g. comparative risk is attended to less when personal risk is high; lastly, (5) shorter timeframes (i.e. less than 10 years) lead to more accurate risk perceptions and increased intention to change behaviour, than timeframes longer than 10 years.

Studies were identified that had two different aims when communicating cardiovascular risk. The studies either used risk communication to influence patient awareness and correct inappropriate risk perception to facilitate the decision to reduce risk or not to reduce risk; or the studies aimed to assess the impact of different risk reduction strategies in facilitating decisions on *how* to reduce the risk.

To conclude, the review demonstrated a lack of well-designed studies in cardiovascular risk communication. This was due to a combination of diverse methodological quality, heterogeneity of study characteristics (such as the design, sample and type of cardiovascular risk presented), inconsistency in the risk representation formats used, a wide range of outcomes that have been measured; and contradictory results. It was suggested that compared to the intensive and ongoing investment in the calculation of cardiovascular risk estimates, there is a poverty of research on how to convey these risk estimates in a meaningful way, and further research is needed before drawing any firm conclusions.

10.2.3 Summary of results from RCT

The last main section of this thesis describes the design, piloting, primary and secondary results, and evaluation of a web-based RCT into the effects of cardiovascular risk representation formats on intention to change behaviour to reduce cardiovascular risk, understanding of risk information, positive and negative affect and worry about future risk of heart disease. A website comprising a risk calculation based on the Personal Heart Score (Mainous et al. 2007) and risk

formatter, which randomised users to one of four conditions to receive their results in one of three risk representation formats (bar graph, pictogram or metonym) was used in the trial.

This trial found no significant main effects of graphical representation formats, suggesting that the type of format used to present risk to people has no influence on motivating individuals to making risk-reducing changes to their behaviour. No particular format is more helpful than another in facilitating understanding of risk information, and the formats did not appear to influence affect and worry about future risk of heart disease. This leads to the conclusion that decisions to reduce cardiovascular risk are not significantly influenced by the way risk is communicated, but are dependent on other criteria. Therefore, developers of risk communication interventions need to use clear representation formats in their tools, but may not need to be concerned with subtle differences in formats; furthermore, it may be more beneficial for them to focus more on behaviour change interventions. However, it was noted that this finding is likely to be due to a type II error resulting from a biased and unrepresentative sample.

Furthermore, the trial found that viewing personalised cardiovascular risk alters emotions. *Positive and negative affect* and *worry about future risk of heart disease* were significantly reduced after respondents received their risk output results. The extent of the decrease in emotions depended on the individual's risk magnitude. For example, those told they were of moderate to high cardiovascular risk had greatest reductions in positive emotions, whilst those of low cardiovascular risk had greatest reductions in negative emotions (including worry about future risk of heart disease).

This is in the direction that would be expected when people find out their risk of developing a disease in the future; i.e. low risk individuals feeling less worried and fearful about their future risk, and moderate/high risk individuals feeling less assured about their risk and realising that it is elevated and needs to be reduced. This finding demonstrates the important role that risk magnitude plays in how people feel about their risk, which in turn may influence subsequent behaviours.

A moderate amount of variance in *intention to exercise more* and *intention to lose weight* scores was explained by the variables measured in this trial (11.7% and 3.8% respectively). *Intention to exercise more* and *intention to lose weight* was significantly predicted by *positive affect*, suggesting that increasing positive emotions will facilitate people to adopt protective health behaviours. Level of exercise can also be increased by reducing negative emotions and taking into account the risk magnitude of the individual. Understanding of risk information also made a significant contribution to intentions. However, the negative beta coefficients indicated that intentions decrease with increased understanding. It is highly likely that this is an artefact resulting from the high proportion of respondents who possessed complete or partial understanding of the risk information. Therefore, it should not be taken as evidence that motivating behaviour change results from limiting an individual's understanding of their risk information.

The trial evaluation concluded that the most plausible explanation for the lack of effect and findings contrary to the hypotheses was the biased sample, comprising an over-representation of respondents at low cardiovascular risk, and the possible 'worried well' who reported inappropriate intentions to reduce their cardiovascular

risk, even though it was low and did not need to be reduced. This meant a skew in the majority of the findings, particularly the primary outcome measure used in most of the analyses (intention to change behaviour).

10.3 Strengths and limitations of thesis

The strengths and weaknesses of this thesis will be discussed separately in relation to the three components: the critical appraisal of publicly available cardiovascular risk prediction tools, the systematic review on the effectiveness of cardiovascular risk representation formats and the web-based RCT.

10.3.1 Strengths of thesis

This thesis contributes to the research into the communication of cardiovascular risk, and furthers knowledge of the effects of risk representation. It has investigated how well publicly available web-based cardiovascular risk prediction tools present cardiovascular risk, identifying that internet users searching for on-line cardiovascular risk assessment are likely to find tools varying in the quality of the risk communication and extent that risk reduction is facilitated and encouraged. It has also systematically reviewed and synthesised past research into cardiovascular risk representation formats, highlighting the need for more methodologically sound studies into the effectiveness of risk representation formats (particularly graphical risk representation formats). It has addressed this issue by designing and conducting a RCT using the MRC framework for developing and evaluating complex

interventions (Medical Research Council. 2000; Medical Research Council 2008) as guidance.

The RCT has also addressed the lack of research into cardiovascular risk communication that uses patient's actual risk, rather than analogue designs using hypothetical scenarios asking them to imagine they are have a particular risk profile. This strengthens the validity of the findings as it is known that real patients differ in their responses to participants of hypothetical studies (Lloyd 2001). Furthermore, the primary outcome (intention to change behaviour) was theoretically underpinned by a well established model of behaviour/ behaviour change (Ajzen 1991), and a questionnaire was developed for the purposes of the trial, using already existing validated scales (Thompson 2007) where possible; or constructing new items using published guidelines (Francis et al. 2004). Lastly, it also sought to address the limitations of other studies when measuring understanding by assessing 'subjective understanding', which determines whether respondents had interpreted their risk correctly and know the extent that they should be reducing their risk.

The RCT involved a web-based risk formatter tool comprising an in-built risk calculator predicting 10-year cardiovascular risk, with three possible graphical formats presenting the results. The risk formatter was specifically designed for this trial and went through an extensive piloting procedure assessing usability and internal logic. Data collection was maximised by using a number of different recruitment strategies, both internet-based (such as posting on social networking websites and forums) and non internet-based (such as posters and cards). These

diverse methods enabled a wide audience to be reached, which maximised potential participation in the trial.

10.3.2 Limitations of thesis

This section will describe the weaknesses of this thesis that need to be acknowledged in the interpretation and broader application of the findings.

The critical appraisal of publicly available cardiovascular risk prediction tools assessed the top 10 ranked tools most likely to be retrieved using *Google* search engine. The transient nature of the internet and the secrecy surrounding how *Google* determines which websites appear first on a page according to their SERP rankings, means that it is quite possible that the tools that were appraised in this thesis are no longer the ones that are most likely to be retrieved by users, or worse, no longer available for people to use on-line. Alternatively, new tools may become available that were not found in the tool search. This makes some of the findings of the appraisal 'out-of-date' or redundant. However, it is envisaged that some conclusions, such as the wide variation in the quality of the risk communication found in the tools, and the varying degrees of focus on risk reduction, will hold true due to the unregulated nature of the internet, in terms of what websites are available (particularly regarding health information), and the lack of engagement of the developers of risk prediction tools with the research evidence on risk communication.

A limitation with the systematic review on the effectiveness of cardiovascular risk communication is one that is applicable to all reviews. Literature searches are unable to retrieve all papers that would meet the inclusion criteria of the review. This is due to the way journals index the papers using different subject headings and keywords. Therefore, despite best efforts to maximise study retrieval (by opting for high recall/ low precision), it is likely that some studies eligible for inclusion were not found by the searches and therefore were not included in the review. Furthermore, the review was conducted at the beginning of the PhD, and searches included studies published up to November 2008. Newer relevant studies have been published since, that have not been incorporated into the narrative synthesis. However, throughout the duration of the PhD, attempts have been made to keep up-to-date with the research into cardiovascular risk communication, and relevant studies have been identified and described in this thesis where appropriate.

There are a number of weaknesses with the RCT into the effects of cardiovascular risk representation formats, including the unrepresentative sample leading to a possible type II error of the results, and the selection of the risk representation formats used in the trial, these will be discussed separately.

Unrepresentative sample

The generalisability of the results is limited due to the unrepresentative sample, comprising a highly educated sample (e.g. educated to degree level or equivalent) and those predominantly of low cardiovascular risk (17.2% of the sample being of moderate or high risk). The target audience was not reached, as those with elevated

risk, who would have benefited the most from having a cardiovascular risk assessment, were not motivated to participate in this trial. It was suggested that this may have been because they were aware of their elevated risk, due to an unhealthy lifestyle, but chose not to do anything about it.

Another possible reason may have been due to the web-based nature of the study, which limited participation to those with adequate computer literacy and access to a computer with the internet. This is a concept known as the digital health divide, where the internet is less accessible to certain groups (such as those of low income, low literacy, ethnic minority, disabled or elderly people) (Eng et al. 1998). It relates to the 'inverse information law' suggesting that those in the greatest need of information about preventable or treatable conditions, are least likely to have access to the necessary technologies, which can lead to poorer health outcomes (Eng et al. 1998; Ziebland 2004).

Type II error

After the results of the trial indicated that there were no significant main effects of the cardiovascular risk representation formats, the null hypothesis was accepted. However, based on the previous literature on risk communication (described in Chapter 4) it is surmised that different risk representation formats *do* have differing effects. Therefore, the null hypothesis may have been falsely retained, when it should have been rejected, and the alternative hypothesis retained. This leads to a

false negative result and a type II (or beta) error (Biau et al. 2010) and indicates that the trial was not sensitive enough to detect such differences between the risk representation formats.

The biased and unrepresentative sample may have contributed to the possible type II error, as the low risk, 'worried well' sample did not need to reduce their cardiovascular risk, but had inappropriate intentions to change their behaviour to decrease their risk. They possessed an adequate understanding of the risk information presented to them regardless of the formats that were used, their mean positive affect was reasonably high before viewing risk, negative affect was moderate, and worry about future risk of heart disease was reported as being low. However, respondents must have been slightly concerned about their risk of heart disease otherwise they would not have wanted to participate in the study. Perhaps the 'worried well' had already been to the GP to have their risk assessed and were already adopting behaviours to protect them from heart disease, such as taking statins and cholesterol lowering medications, and therefore were not worried about their future risk of heart disease at the time of study. This would explain the lack of high motivation to exercising more or losing weight, but the subjective understanding responses that suggested that respondents thought that someone of low risk should be 'doing a lot' to reduce their risk of CVD.

Selection and development of the risk representation formats

A novel way of communicating risk was assessed in this trial. This was the metonym format which depicted the seriousness of having a myocardial infarction as an image, rather than graphically representing a numerical risk estimate (as with the bar graph and pictogram formats). The metonym was thought to be particularly helpful to those of lower numeracy/ literacy skills as it provided some context and enabled the individual to see what their risk category actually meant. As this format has not been used in risk communication research before, it would have been useful to conduct some qualitative work beforehand, such as focus groups with patients and the general public, to gauge their opinions and reactions towards the metonym format. This would have ensured that the metonyms representing the different risk categories were understood correctly and communicated the severity of the risk in the appropriate way. However, no unreasonable adverse effects were seen in those who received this format, and therefore, this trial can be regarded as providing a starting point for developing the concept of using metaphors (metonyms in particular) in the communication of personalised risk.

10.3.3 Summary

The strengths and weaknesses of the thesis were discussed in this section, focusing on the critical appraisal of publicly available cardiovascular risk prediction tools, the systematic review on the effectiveness of cardiovascular risk representation formats and the web-based RCT. Strengths of the thesis included identifying the variation in

the quality of the risk communication of on-line cardiovascular risk prediction tools; systematically reviewing and synthesising past research into cardiovascular risk representation formats, highlighting the need for more methodologically sound studies into the effectiveness of risk representation formats; and addressing this issue by designing and conducting a RCT involving actual risk assessment.

Weaknesses of the critical appraisal stemmed from the transient nature of the internet, which changes the tools most likely to be found by users searching for on-line risk assessment, and therefore making some of the findings redundant. The systematic review was not able to be updated to include newer studies published after November 2008. Additionally, it is impossible to retrieve every study eligible for inclusion in literature reviews. Lastly, the RCT comprised an unrepresentative and biased sample, leading to a possible type II error, and there was a lack of preliminary work on the novel metonym format.

10.4 Findings in context of previous research

The findings of this thesis will be compared and contrasted with previous relevant research in this section. Again, the three components of the thesis (critical appraisal, systematic review and RCT) will be discussed separately.

10.4.1 Previous research relating to Critical Appraisal of web-based cardiovascular risk prediction tools

Previous findings relating to the critical appraisal of publicly available web-based cardiovascular risk prediction tools will be discussed in relation to the guidelines and research evidence into the communication of risk, and also previous research into web-based risk prediction tools.

Comparison with guidelines and research evidence

The formats used by the cardiovascular risk prediction tools will be discussed in relation to guidelines and research evidence to determine how well these tools are portraying risk in-line with best practice and recommendations.

1) It has been widely accepted that graphical accompaniments to risk information can help with understanding (Lipkus 2007). However, still nearly half of the risk prediction tools included in the critical appraisal failed to provide any graphical representation with their numerical formats.

Additionally, a tool by the *University of Edinburgh* was the only one to let users choose between four graphical formats to view the risk output. This should be acknowledged as a desirable criterion for publicly available risk prediction tools, because people will have individual preferences for one format over another.

2) Natural frequencies are the natural way people think about risk probabilities and are effective in correcting inappropriate risk perceptions (Cuitie et al. 2008; Gigerenzer and Hoffrage 1995; van der Weijden et al. 2008). Five tools in the critical appraisal gave a probability estimate in the form of a natural frequency. Three tools also used pictograms of smiley faces to demonstrate this; however one did not provide the numerical explanation in accompaniment, and another only provided a graphical format for high-risk patients.

3) Age is the single strongest risk factor for future cardiovascular events (Ridker and Cook 2005). Two tools attempted to illustrate this by showing how risk exponentially increases with the risk score using a line graph; and offering the projection of risk if the user was 10,20 30 years older, demonstrating how risk increases if you do not improve your modifiable risk factors.

4) An alternate method for addressing the timeframe issue in cardiovascular risk communication is by using the cardiovascular age equivalent format ('Heart Age'). This has been shown to be more memorable, emotionally impactful and motivating in making lifestyle changes than more conventional methods such as percentages (Goldman et al. 2006; Soureti et al. 2010). Only one of the cardiovascular risk prediction tools in this critical appraisal provided this as a format for presenting risk (QRISK2).

5) The majority of risk prediction tools in this study used 10-year timeframes and three used timeframes less than 10 years. This is in-line with the findings from the systematic review (Chapter 3) that found shorter timeframes (less than 10 years) lead to more accurate risk perceptions and increased intention to change behaviour, than timeframes longer than 10 years (Asimakopoulou et al. 2008a; Frileux et al. 2004).

6) Communication about risk reduction: In the critical appraisal, just under half of the tools reported the possible options to reduce risk. Some tools did provide means to compare the risk achievable from modifying risk factors (such as the comparison thermometer by *University of Edinburgh* tool). However, provision of material to help with the decision making of changing behaviour and treatment options was scarce; only one tool (American Heart Association) had the option of an 'action plan'. This does not follow current insights such as IPDAS, that provides criteria for good practice in facilitating decision making (IPDAS 2005). Criteria include starting possible treatment options, the comparison of different outcome probabilities, and the provision of tools to enable discussion with others (such as a health professional).

Comparison with previous research into web-based cardiovascular risk prediction tools

Studies into web-based cardiovascular risk prediction tools have found variation in the numbers of tools that readily provided the information needed to assess the

quality and suitability of these tools (Gillois et al. 1999; Quaglini et al. 2005). This was also found in the critical appraisal. For example, different tools had different target populations, measured different risk factors and predicted different endpoints. Some tools did not provide reference to the algorithm used, did not specify exactly what they were predicting (e.g. cardiac risk only or cardiac plus cerebral risk); and did not give advice about the eligible population.

The variation of risk representation formats used by the web-based cardiovascular risk prediction tools found in this critical appraisal is consistent what has been found by pervious research into web-based cancer risk prediction tools (Waters et al. 2009).

To summarise, the cardiovascular risk prediction tools included in this critical appraisal varied in how they communicated risk consistent with the research evidence and best practice guidelines. Some tools provided more features deemed beneficial and helpful in facilitating risk communication than others, and no tool addressed all the issues surrounding cardiovascular risk communication. The variation in quality of the risk communication and the extent that risk reduction is encouraged may lead to confusion in internet users at home, seeking on-line risk assessment independent of their GP. This may contribute to inaccurate risk perceptions. This variation is mirrored across the web-based assessment tools in other contexts, such as cancer risk prediction.

10.4.2 Previous research relating to Systematic Review

The principal findings of the systematic review conducted to assess the effectiveness of cardiovascular risk representation formats confirm previous research in risk communication indicating that:

1) Visual displays have desirable properties that are helpful for representing risk, enhance understanding of risk and are favourably evaluated by patients (Hill et al. 2010; Lipkus and Hollands 1999; Price et al. 2009).

2) Cardiovascular age equivalent formats (i.e. Heart -Age) are clear, memorable and considered an 'eye-opener' or 'wake-up call', and have the potential to motivate people to make beneficial health-related behaviour change. This is in contrast to the more traditional statistical probability formats for communicating risks that were viewed as being confusing and uninspiring (Goldman et al. 2006).

3) Frequencies are the natural way people think about risk probabilities, and are effective in correcting inappropriate risk perceptions (Cuitie et al. 2008; Gigerenzer and Hoffrage 1995; van der Weijden et al. 2008).

Additionally, the results from a randomised trial published after this review was conducted, confirm the positive evaluation of frequencies. When summary statistics for communicating the effects of statins on the risk of coronary heart disease were presented in different formats, natural frequencies were best understood (86% of

participants reported they understood them well or very well) and participants were most satisfied with this information, compared to other the formats, such as absolute risk reduction and number needed to treat (Carling et al. 2009b).

4) The relative risk format is more favourably evaluated than other formats (such as absolute risk or number needed to treat) (Covey 2007; Cranney and Walley 1996).

To summarise, studies into the communication of cardiovascular risk included in the review generally report similar findings to what has already been found by previous studies in risk communication, with the exception of some contradictory findings which are likely to be the result of the variation in methodological quality of the studies and differences in outcomes measured etc.

10.4.3 Previous research relating to Randomised Controlled Trial

The RCT on the effects of cardiovascular risk representation formats will be discussed in relation to previous research that either supports or contradicts the findings. It will focus on the effects of risk representation formats, positive emotions and health, risk perceptions and the psychological effect of screening and risk prediction.

Risk representation formats

This trial did not find any significant differences in the graphical risk representation formats, in terms of intention to change behaviour, understanding of risk information, positive and negative affect and worry about future risk of heart disease. This finding suggests that the representation format used when communicating risk is of little importance (providing reasonable attempts of accuracy are made and no overt framing is used); and no format is better than another at influencing a patient's motivation to reduce cardiovascular risk, enhance understanding of the risk information or altering emotions. This is consistent with some of the previous research into the effects and preferences for different risk formats (Cheung et al. 2010; Edwards et al. 2006b; Fahey et al. 2001; Lipkus et al. 1999).

However, some research evidence has shown differing effects of risk representation formats. For example, risks presented as population diagrams were regarded as the most frightening, worrisome and serious compared to risks presented as percentages and frequencies. The formats also influenced treatment decisions, but not cognitive evaluations, such as how hard the risks were to understand (Timmermans et al. 2008).

Furthermore, those receiving the Heart-Age format (e.g. cardiovascular age equivalent analogy) had more realistic risk perceptions, that were more in-line with their actual risk, but were significantly more worried than those who received the percentage format. The Heart-Age format also led to greater intentions to eat more

healthily and increase level of physical activity those who received the percentage format (Soureti et al. 2010).

When communicating the effects of statins on the risk of coronary heart disease, the relative risk reduction format motivated decisions to choose statins, and natural frequencies were best understood (Carling et al. 2009b).

Lastly, differences in risk representation formats have also been seen for the genetic risk of crohn's disease (Wright et al. 2008), and graphical displays of the benefits of antibiotics for people with sore throat who are deciding whether to seek treatment (Carling et al. 2009a).

It was concluded that the inconsistent research into the effects of risk representation formats is likely to be partly due to previous research comparing different formats, and the different outcomes used to measure their effects. However, the contradictory results do also suggest that there are individual differences in how people respond to risk representation formats (perhaps based on a variety of factors that have not been controlled for in the previous trials). Furthermore, it may never be determined which format is the most effective in terms of motivating behaviour change, facilitating understanding and altering inappropriate emotions, as there is simply no 'magic bullet' for communicating risk to everybody.

Positive emotions and health

Positive affect was the largest contributor to the variance in intention to change behaviour scores. It was the only variable to significantly predict all three behavioural intentions (*exercise more, lose weight* and *stop smoking)*. Positive emotions accounted for 32.9% of the variance in *intention to exercise more* scores, 18.8% of the variance in *intention to lose weight* scores, and 28% of the variance in *intention to stop smoking* scores. This suggests that positive emotions have an influence on decisions to change behaviour.

This supports previous research on 'positivity' that suggests that positive emotions, such as appreciation, hope, gratitude and joy contribute to psychological and physical well-being via more effective coping (Tugade et al. 2004). More specifically, the broaden-and-build theory of positive emotions postulates that positive emotions open the mind and 'broaden' people's ideas about possible actions, in contrast to negative emotions that narrow ideas. This allows for the discovery and building of new skills, new knowledge and new ways of being (Fredrickson 2009), which increases awareness to a wider range of thoughts and actions and acceptable behavioural options, making the person more creative and receptive to information. Meaning a person in a positive frame of mind will be more accepting and willing to make behavioural changes in order to reduce health risks (Fredrickson 2001).

When relating this trial's findings to this theory, it can be suggested that positivity and positive emotions lead to 'a richer appreciation of life' (Tugade et al. 2004, p.1166). This results in a desire for longevity and wanting to be at your best by looking after

your health. Positivity and positive emotions mean people will be more likely to look after themselves, be open to new knowledge and suggestions about how to stay healthy, and be more likely to adopt health protective behaviours.
Additionally, Fredrickson suggests that positivity can help build psychological strength which can facilitate changing 'bad habits into good ones (Fredrickson 2009). The evidence that positive emotions lead to better coping strategies by increasing psychological resilience, means that positive emotions may reduce the need for people rely on behavioural practices that are considered harmful to their health, as a way of coping with life-events and stressful situations, such as smoking, eating unhealthy food, excessive alcohol consumption etc. Therefore, developers of health interventions should focus on increasing a person's positive emotions to effectively increase health protective behaviours.

However, Cameron and Chan 2008 suggest that more research needs to be done into health communications that arouse positive emotions (Cameron and Chan 2008). They suggest that developers of health interventions should consider the goal of the health communication, the affective experience that it will generate and how the emotions aroused by health communications may promote or interfere with the aims of the communication. For example, if the aim is to motivate individuals to take action on a health risk already familiar to them, the message contents should be constructed to induce a positive emotional arousal and a sense of self-efficacy; whereas, if the aim of the communication is to make individuals aware of a health threat and install a sense of risk, then message contents arousing other (less positive) emotions may best promote the aim (Cameron and Chan 2008).

Risk perceptions

This trial provided evidence that people have difficulty in accurately perceiving their risk and found evidence of inappropriate risk perceptions in 'worried well', who are informed about their low risk, but are still anxious to monitor their risk and may feel the urge to ask for diagnostic or therapeutic interventions (van Steenkiste et al. 2004b). Inappropriate risk perceptions, mainly incorrect pessimism, where people overestimate their risk, have been seen in previous research (Alwan et al. 2009; Frijling et al. 2004; van der Weijden et al. 2007). Incorrect optimism, where risk is underestimated has also been found (Aalto et al. 2007). Improving the accuracy of risk perceptions is important as they have been shown to influence emotions (Asimakopoulou et al. 2008b) and behaviours (Ali 2002).

Interventions aimed at correcting patients' risk perceptions have had varying success (Harle et al. 2008; Kreuter and Strecher 1995; Paterson et al. 2002), and may only have short-term effects (Christian et al. 2005). This could be taken as evidence to support findings by van Steenkiste et al (2004) that risk perceptions are rarely based on an understanding of the probable risks at the level of the individual, and are more often based on familiarity with the disease, and how it relates to experiences with family, close friends or colleagues who have suffered from CVD (van Steenkiste et al. 2004b).

Psychological effects of screening and risk prediction

This trial found that viewing cardiovascular risk significantly decreased *negative affect* and *worry about future risk of heart disease*. The greatest reductions were seen for those categorised as low risk. This lends support to previous research that has found risk screening does not lead to adverse psychological effects (Marteau et al. 1996; Pijl et al. 2009). This trial also found a decrease in *positive affect* for all respondents, including those of low cardiovascular risk. This was unexpected, as a low risk outcome could be associated with providing reassurance to the individual, and therefore increase positive emotion, particularly in the 'worried well'. Previous studies have also found a lack of reassurance from favourable (i.e. negative) test results, and suggest that this stems from a disparity between prior risk perceptions and expectations and the actual negative or low risk results, leading them to mistrust the risk information that has been presented to them (Michie et al. 2003; Michie et al. 2002). The decrease in positive affect seen in this trial is likely to be a short-term consequence only, as previous research has shown that negative effects dissipate over time, and there is no evidence of any long-term adverse effects (Shaw et al. 1999).

Summary

To summarise, this trial did not find any significant differences in the graphical risk representation formats, in terms of intention to change behaviour, understanding of risk information, positive and negative affect and worry about future risk of heart

disease. However, the evidence is contradictory and it remains unclear whether the portrayal of risk does have little influence on patient's behaviours, cognitions and emotions, or whether this trial failed to identify true differing effects resulting from the risk representation formats. Therefore, more research is needed before any conclusions can be drawn. This trial supports the body of evidence that individual's have difficulty in accurately perceiving their risk, and demonstrated that risk perceptions influence emotions and subsequent intentions and behaviour. Lastly, viewing cardiovascular risk was found to decrease negative affect and worry about future risk of heart disease, this lends support to previous research that has found risk screening does not cause adverse psychological effects.

10.4.4 Summary

This section has compared the findings of notable interest in this thesis with previous literature. The critical appraisal of web-based cardiovascular risk prediction tools found that publicly available tools most likely to be retrieved by *Google* varied in how they communicated risk consistent with the research evidence and best practice guidelines. Some tools provided more features deemed beneficial and helpful in facilitating risk communication than others, and no tool addressed all the issues surrounding cardiovascular risk communication. The variation is mirrored across the web-based assessment tools in other contexts, such as cancer risk prediction.

The systematic review on the effectiveness of cardiovascular risk representation formats found that studies into the communication of cardiovascular risk generally support the findings from past risk communication research. However, contradictory findings do exist, which are likely to be the result of the variation in methodological quality of the studies and differences in outcomes measured etc.

The RCT into graphical cardiovascular risk representation formats supports the body of evidence that individual's have difficulty in accurately perceiving their risk. It lends support to previous research that has found risk screening does not cause adverse psychological effects, as viewing cardiovascular risk was found to decrease negative emotions (including worry about future risk of heart disease). However, the trial found no significant main effects of the cardiovascular risk representation formats, but the past evidence is inconsistent with regards whether risk representation formats do influence people's perceptions, cognitions, emotions or behaviours. Therefore, more research is needed before any firm conclusions can be made.

10.5 Implications for Practice and Policy

This section will discuss important aspects that have been highlighted during the research for this thesis that have implications on practice and policy. These include the identification of differing aims of risk communications, and engaging those who may be of unaware of their elevated cardiovascular risk to have a risk assessment. Wider implications such as the way society has contributed to the difficulties people

have in adopting healthier lifestyles, and the preference of medication to reduce risk over lifestyle change will also be discussed.

10.5.1 Research into cardiovascular risk communication

The critical appraisal into web-based cardiovascular risk prediction tools and the systematic review into cardiovascular risk representation formats highlighted that determining how best to present cardiovascular risk information to patients strongly depends on the intended aims of the communication. The complexity surrounding the area of research could be reduced if the communicators of risk were clearer about their intended aims of the communication. Two purposes of risk communication became apparent: (1) raising awareness and improving understanding; and (2) persuading those at risk to adopt new behaviours to reduce risk. If communication informs patients that their risk is higher than average due to increased but modifiable risk factors, it seems important to ensure that balanced information about how to change lifestyle and/or add drug treatment, should be provided.

Synthesis of the previous research conducted into the effects of different risk representation formats enable guidelines for the 'gold standard' of communication of health risks to be developed and used during consultations between health professionals and patients, and also for the developers of risk prediction tools available on the World Wide Web.

10.5.2 Risk awareness

The failure in the RCT to recruit more people of moderate and high risk suggest that more needs to be done so that people at high risk are appropriately identified and helped to consider their risk, by methods such as interactive counselling using on-line risk prediction tools. This is so they can make informed decisions regarding how best to reduce their risk through making lifestyle changes and/or adhering to treatment/medication.

This trial did not find any significant differences between the graphical risk representation formats, suggesting that there is no method that is more effective than another; as the way risk is communicated to patients has no influence on behaviours (i.e. changing behaviour to reduce risk), cognitions (in terms of understanding) or emotions. This informs developers of cardiovascular risk prediction tools and risk reduction interventions that getting the message across is the most important aspect of the risk communication, not what format the message is presented in.

10.5.3 Failure to motivate behaviour change

This thesis has found that cardiovascular risk prediction tools do not support efforts to achieve behaviour change. The focus has been on the accuracy of the risk prediction and increasing people's awareness of their risk. The tools present cardiovascular risk in a variety of ways, but it is questionable whether this alone, can

encourage people with elevated risk to do something about it and attempt to reduce it.

The trial conducted as part of this thesis found that when people were shown their risk category; this had little or no influence in motivating behaviour change. This is supported by a recent RCT by Price et al (2011), which aimed to determine if personalised 10-year cardiovascular risk estimates could increase risk reduction behaviours. 194 high risk adults (i.e. over 20%) from four general practices, were randomised to the intervention group (receiving personalized 10-year CVD risk estimate based on the UK Prospective Diabetes Study Risk Engine), or the control (told they had elevated risk factors according to guidelines). At one month follow-up there was no increase in physical activity or significant change in estimated 10-year CVD risk in those receiving personalised CVD risk estimates. Furthermore, there were no within or between-group differences in anxiety, quality of life, self-regulation, worry about future risk of heart attacks, or intention to increase physical activity. This shows that the risk estimates had no effect in comparison to being informed of elevated risk factors. However, the sample has been criticised as being unrepresentative of the general population, as those who participated in the study as could have been more motivated and interested in reducing cardiovascular disease risk than those who did not; they were also more physically active at baseline than was expected (Price et al. 2011).

This is supported by risk prediction tools designed for use in GP consultations. Montgomery et al (2000) developed a computer-based clinical decision support system with cardiovascular risk chart (presenting 5-year absolute risk of a fatal or

non-fatal cardiovascular event based on the New Zealand guidelines for the management of hypertension. The risk chart and computer-based clinical decision support system were no better than usual care at reducing absolute cardiovascular risk, in those with a risk higher than 10%, nor conferred any benefit in blood pressure control at 12 month follow-up (Montgomery et al. 2000).

10.5.4 Medication versus lifestyle change

A reason for the failure of cardiovascular risk prediction tools to motivate lifestyle behaviour change could be due to difficulty people have in changing their lifestyle. It is estimated that adherence to lifestyle advice and medication varies between 20 and 90%, with most estimates averaging in the region of 50% (Ashenden et al. 1997; Burke et al. 1997; Koelewijn-van Loon 2010; World Health Organisation 2003). A meta-analysis found that interventions comprising educational and behavioural components can be effective in improving adherence (Roter et al. 1998). However, intervention programs have been successful in promoting short-term adherence to physical activity and dietary regimes for promoting health (Wylie-Rosett et al 1994; Svendsen et al 1994; Stevens et al 2002). Few have long-term success (Burke et al. 1997; Orleans 2000) as most people who succeed in making changes revert back to their previous more unhealthy behaviour within 6-12 months (Orleans 2000).

The trial by Price et al (2011) described above, gives support to the notion that people prefer medication over lifestyle changes. Receiving personalised 10-year cardiovascular risk estimate was associated with a clinically significant reduction in

lipids and an increase in the number of cardiovascular disease risk-reduction therapies prescribed but no increase in physical activity (Price et al. 2011).

Furthermore, a focus group study exploring how individuals respond to global CHD risk and use it in combination with treatment information to make decisions regarding initiating and maintaining risk reducing strategies, found that most participants would accept medication under certain circumstances, such as when the medication was safe, the easier option, a bridge to lifestyle changes. When evaluating decisional factors that influence risk reduction, participants expressed a preference for risk-reducing options that did not interfere with their enjoyment of life. They also wanted risk reducing options that had quick and tangible results, that had been extensively researched by trusted sources (Sheridan et al. 2009).

The variable success of lifestyle interventions and the increasing incidence of obesity suggests that people find it difficult to make changes to their health-behaviours and habits, i.e. social determinants are more powerful than individual choices. However, the steady decrease in the incidence of CVD, confirmed by the 40% decrease in death rates from CVD in people under 75 in the last decade (Allender et al. 2008), indicates some degree of societal shift in disease prevalence. The British Heart Foundation statistics report that prescriptions for the prevention and treatment of CVD have increased steadily since 1980. In 2008, 266 million prescriptions were issued, this was nearly 5 times as many prescriptions than issued in 1986, and 6% more than in 2007 (Scarborough et al. 2010). More specifically, the number of prescriptions issued for antihypertensive therapy was 21,075 in 2000 and increased

to 57,823 in 2008. Additionally, 10,331 prescriptions for lipid-lowering drugs were issued in 2000, and rose to 52,190 in 2008 (Office of National Statistics 2009).

These statistics show that more and more people are opting for medication to reduce their risk of CVD, or that this is the most commonly used strategy in CVD prevention. A reason for this could be the Inverse Benefit Law (Brody and Light 2011). This law proposes that the ratio of benefits and harms among patients taking new drugs varies inversely with how extensively the drugs are marketed (Brody and Light 2011, p.399). The marketing works because it is believed that heavily marketed drugs are more efficacious and safer than older, less marketed drugs.

The Inverse Benefit Law assumes that low and high risk populations receive different degrees of benefit and harm from administration of a drug. Patients at the highest risk or with most severe symptoms have the greatest chance of benefiting from the drug (represented as a low NNT). However, this means that only a small percentage of the population are eligible to receive the drug and therefore, there is a low yield of sales. Marketing increases drug use by extending the use of the drug beyond the proper evidence-based threshold for beginning the drug therapy, and less at-risk or less severely affected patients are given the drug. This means many more patients need to be treated for one patient to benefit (increasing the NNT). The benefit-to-harm ratio worsens as more adverse reactions occur due to more people being exposed to the drug.

Furthermore, guidelines for risk factors such as cholesterol, recommend drug therapy for groups with progressively lower low-density lipoprotein levels, despite

very high NNTs and lack of evidence of benefit of drug therapy as primary prevention. The writers of these guidelines often have conflicts of interest (Brody and Light 2011). Therefore, risk assessment may be a marketing ploy for pharmaceutical companies, generating a 'risk society' as a tool for marketing exercises.

The prognostic models used to predict CVD may be redundant and no longer used to estimate outcome risk and to influence patient management, due to the suggestion to give everyone over the age of 55 the 'polypill' (e.g. combinations of statins such as atorvastatin or simvastatin, blood pressure lowering drugs such as thiazide, a beta blocker, and an angiotensin converting enzyme inhibitor, folic acid and aspirin) to reduce cardiovascular risk (for example, ischaemic heart disease by 88% and stroke by 80%) (Moons et al. 2009; Wald and Law 2003).

10.5.5 Society contributing to lifestyle choices and health outcomes

Societal norms make a significant contribution how we live our lives. It is an accepted paradigm in developed countries that individuals of lower socio-economic status (SES) tend to have poorer health than those of higher SES. For example, lower SES groups have a higher incidence of CVD and some forms of cancer and a higher prevalence of risk factors for CVD and type 2 diabetes (Kuhle and Veugelers 2008). This is known as the 'social gradient' and is thought to reflect the fact that 'lower SES is associated with barriers in access to quality health care; environmental exposures; and limitations in knowledge, time and opportunity for making healthy lifestyle choices' (Kuhle and Veugelers 2008, p.7).

However, the extent of this paradigm is less obvious in obesity. The lack of variation in rates of obesity across the social-economic gradients is demonstrated in a report by the British Heart Foundation (Allender et al. 2008). In 2006, 65% of men in the lowest household income quintile were classified as overweight/obese (BMI $\geq$25 kg/m^2) compared to 68% of men in the highest household income quintile; and 50% of women in the highest quintile compared to 64% in the lowest quintile (Allender et al. 2008). Further evidence against the social gradient for obesity is demonstrated by Kuhle and Veugelers (2008) who found a negative association between SES and overweight/obesity for women and an inconsistent relationship for men (Kuhle and Veugelers 2008). This supports previous research from a number of industrialised countries (Ball et al. 2002; Robert and Reither 2004; Wardle et al. 2002; Wolff et al. 2006; Zhang and Wang 2004).

Food consumption patterns have been suggested as a contributing factor to the obesity rates across all social gradients. For example, those of higher SES are more likely to eat outside of the home compared to lower SES groups (Kuhle and Veugelers 2008). The limited success of risk factor interventions using counselling or educational methods leads to the conclusion that different approaches to promoting health protective behaviours, such as better access to recreational and sporting facilities and availability of healthier foods, may be more successful than advice from health professionals (Ebrahim et al. 2006). Additionally, public health campaigns should address lifestyle choices at an earlier age, so healthy behaviour patterns become habitual, as it is very difficult for people to change their bad habits after they have had them for years.

10.5.6 Summary

To summarise, this section has discussed the research conducted for this thesis in relation to the implications it has on practice and policy. It has described important issues such as the conflicting aims of risk communication and the lack of engagement of 'at risk' groups to participate in cardiovascular risk assessment. The limited success of lifestyle interventions to reduce risk were described, and possible reasons were put forward. These included the fact that people find lifestyle changes hard to achieve, sometimes reverting back to their old habits after a few months; and the preference for medication over lifestyle change, which is partially due to aggressive pharmaceutical marketing and the lowering of treatment thresholds. It was concluded that public health campaigns may need to look at the bigger picture and make changes on a societal level, facilitating the adoption of lifestyles that lead to a decreased risk of CVD.

10.6 Directions for future research

This section identifies areas where further work would be of value, building on the current research. It also describes research that is already being conducted into cardiovascular risk prediction that addresses some of the issues relating to the problems in communicating cardiovascular risk to patients.

10.6.1 General consideration for the improvement of future research

To further expand on the work into the effects of risk representation formats, more methodologically sound studies (such as RCTs) need to be conducted that measure patient-related outcomes. Past research in risk communication has over-relied on hypothetical risk profiles. Therefore, it would be useful if future studies assessed patient outcomes resulting from the presentation of their actual risk. If future research in risk communication aims to improve the consistency in terms of study design, sample, type of risk predicted and outcomes measured, this will allow reviews of the literature comprising a more in-depth synthesis of results, than was achieved by the systematic review conducted for this thesis. Thus enabling a consensus as to which formats are most effective for communicating risk, and will provide a basis for compiling risk communication guidelines based on the research evidence.

The systematic review found that further investigation is needed into the framing of information regarding the benefits and harms of treatment and the provision of comparative risk information (e.g. risk compared with the average person of the same age and sex), that shows baseline risk and puts personal risk into context.

More attention needs to be paid to the quality of the risk communication that is being presented in on-line risk assessment tools. Poor quality information has the potential to mislead and confuse by providing an inaccurate and unbalanced picture. This leads to inappropriate risk perceptions, such as incorrect pessimism or optimistic bias. It is even more important that this is avoided if these tools are designed for use

outside of the healthcare setting, without guidance from a GP or health professional. The value of web-based risk prediction tools intended to be used outside of consultations with health practitioners is reduced if users do not fully understand or appreciate the reasons behind their risk result. Although some tools included in the critical appraisal did attempt to define and explain the risk result, more tools should consider doing this. Also, the tools need to have consensus in the endpoints they predict, so that results are more consistent across tools. Users of more than one tool will have their risk result validated and will have more faith in the results.

The creators of these risk prediction tools need to incorporate more of the 'best practice' criteria found by the research evidence in the communication of cardiovascular risk. Tools could also be improved by incorporating important features that help with the decision making process of cardiovascular risk reduction, such as the option to revisit the tools and record progress as attempt is made at reducing cardiovascular risk. This will enable the development of a fully comprehensive risk prediction tool that could be considered the 'gold standard' for cardiovascular risk communication.

10.6.2 New directions for future research into cardiovascular risk communication

There are a number of issues that need to be addressed with regards the conventional methods of communicating cardiovascular risk. These include: (1) the presentation of abstract numerical risk estimates, rather than more salient outcomes

that provide context and meaning to the risk; and (2) the 10-year timeframe over which cardiovascular risk is predicted, which due to the nature of cardiovascular risk, predicts absolute risk of a younger person with modifiable risk factors as 'low' due to the protection of age. Each will be discussed separately below, and will highlight relevant research that has just started to address these issues.

Presenting risk as more salient outcomes

People have difficulty in forecasting their future risk, and more meaningful projections should be used instead of presenting risk in an abstract 10-year horizon. This could be in the form of more salient outcomes and forecasts of loss in the future, such as not being able to achieve important milestones, birth of grandchildren or similar. The RCT conducted for this thesis assessed the effect of presenting risk as a salient outcome, by using a metonym image depicting the seriousness of having a myocardial infarction. This deviates away from the more conventional methods involving representations of numerical risk estimates and provides context for interpreting the risk information. Although, the trial did not find that this format differed in its effectiveness of communicating risk compared to the more traditional methods (i.e. percentage bar graphs and natural frequency pictograms/ icon arrays), it should not be ruled out as a possible way of presenting cardiovascular risk (or any other risk), as people (particularly those of lower numeracy and literacy skills) may find this format easier to understand than the numerical risk estimates currently being favoured for the communication of risk.

Support for presenting risk as more salient outcomes comes from a RCT described earlier (Soureti et al. 2010), which examined the effects of presenting patients with their 'Heart-Age' (an analogy also known as cardiovascular age equivalent). This was calculated using the equivalent risk of a person who has no modifiable risk factors. Those who received the Heart-Age format had more accurate risk perceptions in-line with their actual risk, than those who received the percentage format. The Heart-Age format was more emotionally impactful in younger individuals at higher CVD risk, as they were significantly more worried and were more likely to view it as a 'wake-up' call (Soureti et al. 2010).

Further evidence of the effects of showing patients how their lifestyle has affected their health in a salient way comes from a RCT into smoking cessation (Parkes et al. 2008). Spirometry (which assesses lung function, detects obstructive lung damage and premature ageing) was used to calculate 'lung age' by comparing an individual's results, to work out the age of a healthy individual who would perform similar to them on spirometry. The impact of this salient message on smoking cessation was determined by salivary cotinine testing at 12 month follow-up. 561 participants, over the age of 35, who had smoked for the past 12 months were randomised to either the intervention group to receive their 'lung age', or the control group where they were advised that they would be tested again in 12 months to see if there had been any change in their lung function. Those shown their 'lung age' were significantly more likely to quit smoking than those who were not. 13.6% of patients in the intervention group had quit smoking within 12 months, compared to 6.4% of the control group (difference 7.2%. p=.005, 95% CI 2.2%-12.1%) (Parkes et al. 2008).

Additional support of presenting risk in more salient outcomes comes from a recent randomised trial aimed to determine the motivating effects of web-based animation technology depicting a three-dimensional heart (Lee et al. 2011). Images showed the condition of the heart over time if a healthy diet and regular exercise was maintained, contrasted with an 'unhealthy' heart in the future, resulting from a lack of exercise and a poor diet (e.g. increased heart rate, damage to heart wall, enlarged chambers, plaque build-up, few capillaries). Sedentary university students and staff, under 35 years of age were randomised to receive either: imagery and descriptive text, image only, text only or control (no imagery or text). Understanding of risk, worry, intentions and behaviours towards physical activity and healthy diet were assessed at baseline, 2 days, 2 weeks and 4 weeks post-intervention. The heart imagery increased understanding, worry and intentions to improve physical activity and diet. However, only understanding and worry were sustained at 4 week follow-up (Lee et al. 2011). This work should be extended further by using a sample older than 35 years of age and providing detail about a person's own major risk factor levels.

In a study investigating the framing effects of presenting the consequences of health-related behaviour (Galesic and Garcia-Retamero 2011), numerical information about the relationship between CVD risk and exercise and weight was presented as risk estimates (e.g. '*people who are overweight have a 36 percent risk of heart failure- 18 percent higher than an average person.*' and '*people who exercise regularly have a 27 percent risk of cardiovascular disease- 13 percent lower than an average person*') or life-expectancy (e.g. '*people who are overweight have a life expectancy of 73*

years- 60 months shorter than an average person' and '*people who exercise regularly have a life expectancy of 81 years- 36 months longer than the average person*'). Respondents of high and low numeracy, who received the information framed as life-expectancy, recalled the information significantly better than the risk estimates, both immediately after and later at three week follow up (Galesic and Garcia-Retamero 2011).

It was suggested that effectiveness of salient outcomes may be attributable to imaginability (e.g. imagining life expectancy), where people are better able to connect the risk representation to their everyday life. According to Paivio's dual-coding hypothesis, imaginability of the information is based on cognitive processes where concrete portrayals invoke mental images more readily than abstract portrayals. Greater imaginability leads to better encoding and a richer memory trace, enabling both verbal and visual encoding in memory and enhance recall of information (Paivio 1969). Additionally, the undesirability of the risk (e.g. perception of risk of the undesired event) may also be attributable. This is an emotional process, where more emotion is evoked (negative emotion in particular) with increasing distinctiveness of the event in memory and subsequently improves its recall (Galesic and Garcia-Retamero 2011).

Time orientation

The interpretation of a person's cardiovascular risk is likely to be affected by their 'time orientation'. This is a psychological characteristic that describes the different preferences people have for certain timeframes which influence their information processing, and evaluation of actions and the possible outcomes of those actions (Crockett et al. 2008). The two most common of these are 'future' and 'present' orientation. Those with a high 'present' orientation think about immediate consequences of their behaviour, and take a fatalistic approach with a limited sense of control over life events. They are also more likely to engage in practices that have immediate gains, such as substance abuse. In contrast, people with high 'future' orientation think more about the future and have an awareness of current actions on future outcomes. They are likely to engage in practices that have an immediate cost for a future gain, such as physical activity and healthy eating (Crockett et al. 2008; Keough et al. 1999; Rothspan and Read 1996).

Support for the differences in time orientation comes from a focus group study into the attitudes about CVD (Gabhainn et al. 1999). This revealed that despite good knowledge about risk factors for heart disease, participants had a low motivation to change lifestyle behaviour. One of the reasons suggested for this was that age was seen to be an important motivating factor for change. Older participants (especially men) thought it was too late to make lifestyle changes to reduce their future risk, and younger participants thought it was too soon and therefore not necessary to change (Gabhainn et al. 1999). Research has identified additional factors that may affect a

person's time orientation. For example, work on screening for diabetes found that socially disadvantaged groups are more 'present' rather than 'future' oriented (Crockett et al. 2008).

This work suggests that the presentation of future risk of developing CVD is likely to have a differential impact on those with different time orientations; being more effective for those with a high 'future' orientation. Alternative methods need to be devised for those with a high 'present' orientation, particularly younger people, such as projecting short-term risk over longer time horizons.

Projection of short-term risk over longer time horizons

Current cardiovascular risk prediction algorithms usually predict future risk over a 10-year timeframe. However, this makes managing younger patients with multiple cardiovascular risk factors a challenge. For example, according to these cardiovascular risk calculators, a 40 year old male smoker, who is overweight and has high HDL cholesterol and blood pressure, has a 5% risk of having a heart attack or stroke in the next 10 years. Therefore, has not reached the threshold considered for initiating risk reduction. This is because these calculators are strongly dependent on age and do not capture the importance of younger patients longer term risk and what the future holds. A solution to this problem is forecasting short-term risk throughout the lifespan (Jackson 2010).

This has been attempted by the QRISK lifetime risk calculator (Hippisley-Cox et al. 2010), comprising graphs representing a continuous prediction of patients' cumulative cardiovascular risk throughout their lifetime, based on both current risk profiles and if their risk profiles improve. Time (which is the most important risk factor) is incorporated into the graph and the predicted risk for any time period can be read (see Figure 10.1).

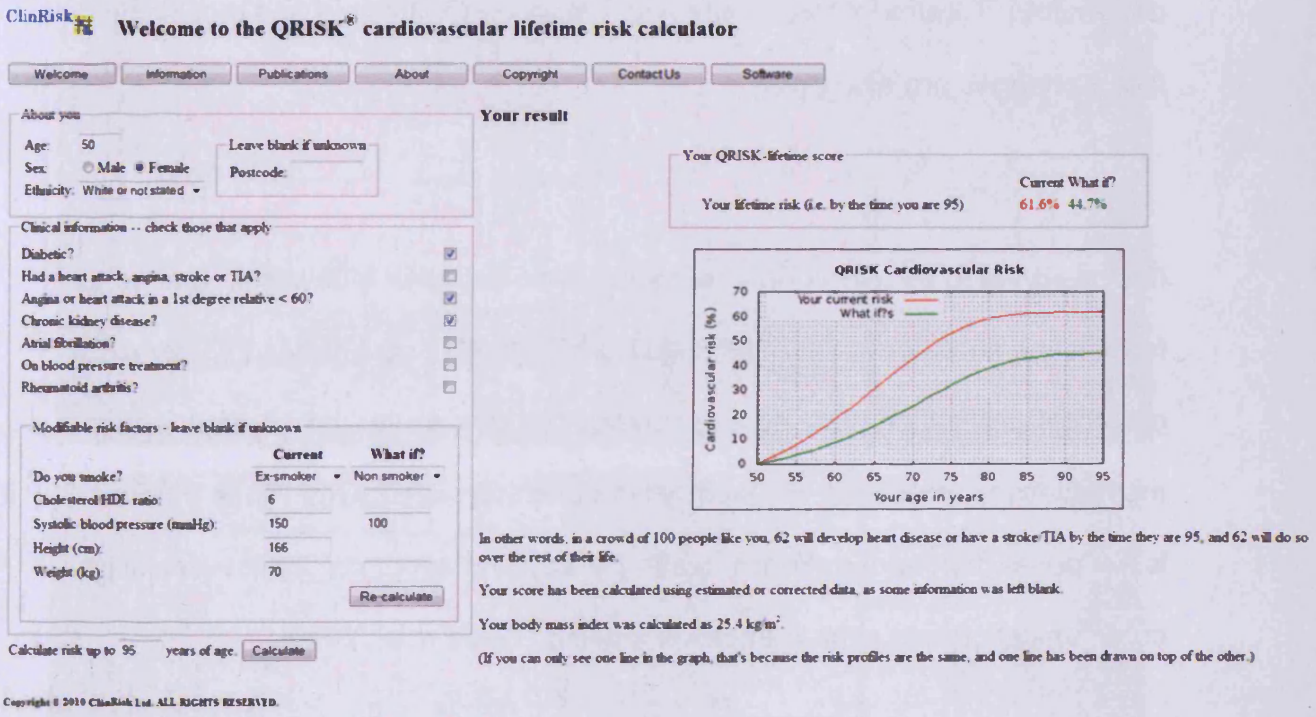


Figure 10.1 Example of the QRISK® cardiovascular lifetime risk calculator output with cumulative graph.

A similar concept has been adopted by a risk calculator developed by the New Zealand Heart Foundation and the University of Auckland called the 'Heart Age Forecast tool' (Wells et al. 2010).

This tool incorporates both short-term and long-term risk in one display, which has advantages over separate 10-year and lifetime cardiovascular risk calculators (such as the QRISK lifetime risk calculator). It also has the added dimension of 'arterial age' (heart age), with long-term risk demonstrating how the arterial age is determined. Treatment thresholds and scenarios for lifestyle and modifiable risk factor changes are also given.

It is designed to be used during a consultation between a physician and patient forecasting short-term risk at all ages from 35 to 75 years. It has an interactive graphical application that conveys several cardiovascular risk communication messages individualised for each patient in a stepwise fashion (See Figure 10.2). It is not dependent on a patient's health literacy and supports cardiovascular risk communication and shared decision making (Wells et al. 2010).

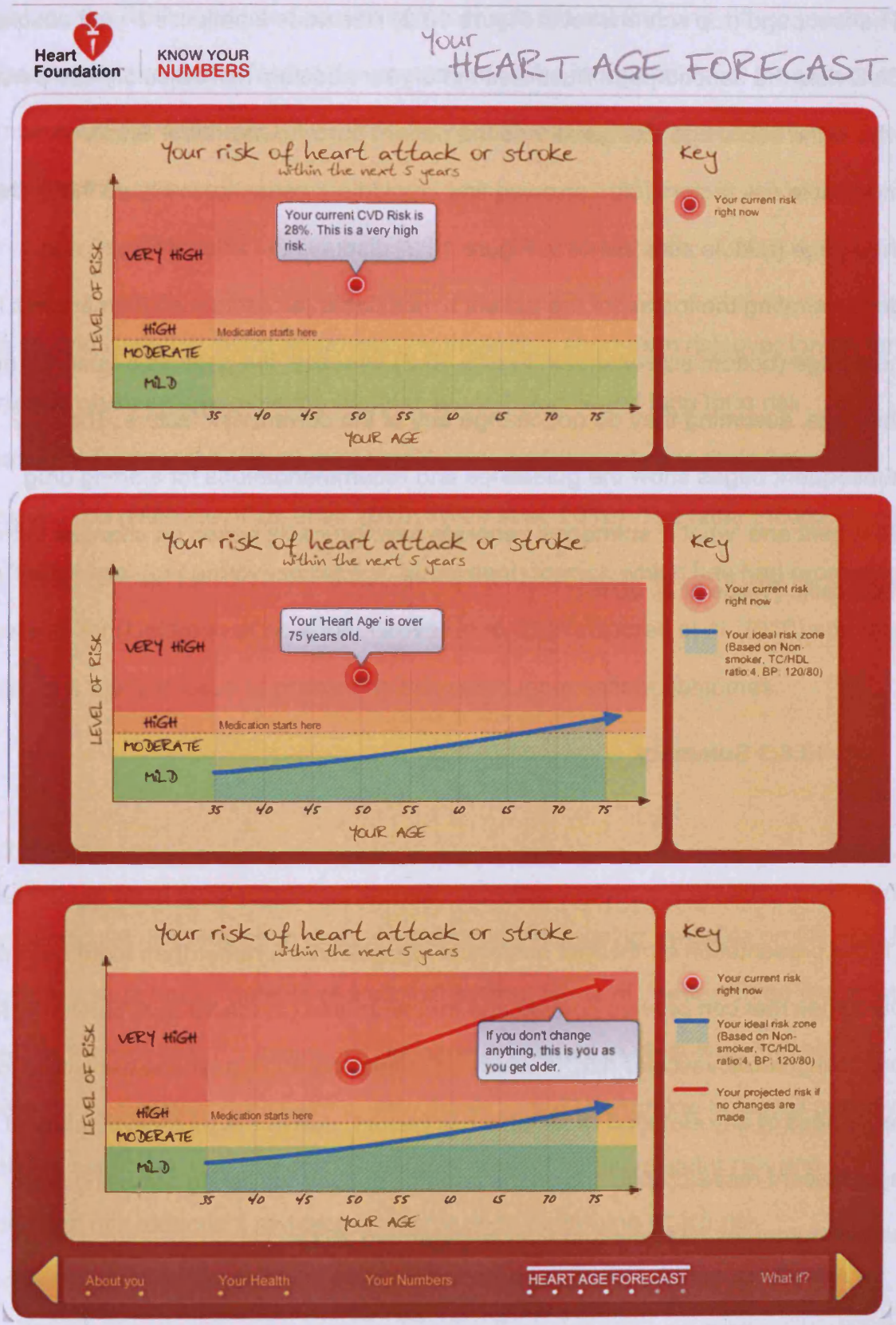


Figure 10.2 Example of Heart Age forecast tool output.

The first page (top screenshot in Figure 10.2) illustrates a patient's 5-year absolute CVD risk, the second page illustrates the 5-year absolute risk trajectory of a person who is the same age and gender as the patient but who has 'ideal' levels of modifiable risk factors (blue arrowed line in middle screenshot in Figure 10.2), the third page (middle screenshot in Figure 10.2) displays the arterial (heart) age demonstrating the impact of the patient's modifiable risk factors on their arteries. The next page (bottom screenshot in Figure 10.2) forecasts the patients 5-year risk as they age, assuming they do not change any of the current risk factors. The subsequent pages show the guidelines and recommendations for starting drug treatment and 'what if' scenarios generate new forecasts based on changes to the risk profile (Wells et al. 2010).

10.6.3 Summary

Two main issues with current cardiovascular risk prediction have been highlighted: (1) the presentation of abstract numerical risk estimates, rather than more salient outcomes that can provide context and meaning; and (2) the 10-year timeframe for predicting cardiovascular risk, in which a younger person's absolute risk will be low regardless of any elevated modifiable risk factors, due to the protective nature of age. Recent research has shown the benefits of communicating risk using more salient outcomes (Galesic and Garcia-Retamero 2011).

However, the RCT conducted as part of this thesis did not find any differences in presenting an alternative format (i.e. metonym) to the more traditional formats based on numerical risk estimates. Therefore, more methodologically sound trials are needed in this area.

The second issue has been addressed by projecting short-term risk over longer time horizons, which incorporates the benefits of relative risk and long term risk measures. Two recently developed cardiovascular risk prediction tools have achieved this (Hippisley-Cox et al. 2010; Wells et al. 2010). The latter incorporating the 'Heart-Age' (or cardiovascular age equivalent) format, which has had promising results so far (Goldman et al. 2006; Grover et al. 2007; Soureti et al. 2010) and also addresses the first issue of presenting risk using more salient outcomes.

10.7 Conclusions

Cardiovascular risk prediction tools are becoming increasing available on the web for people to use at home, outside of a clinical setting. However, research on the most effective ways of communicating cardiovascular risk has been scarce and patchy, leading to inconsistent conclusions. This thesis aimed to examine how well publicly available cardiovascular risk prediction tools present cardiovascular risk and encourage risk reduction; review past literature to determine which risk representation formats are most effective in communicating cardiovascular risk to patients; and lastly to design, conduct and evaluate a web-based RCT assessing the

effects of different cardiovascular risk representation formats on patient-based outcomes.

The thesis found that the publicly available web-based cardiovascular risk prediction tools vary in the quality of their risk communication and the extent that they encourage risk reduction by incorporating features that facilitate decisions to be made to regarding lifestyle change and treatment. This was considered to be an issue for the users of these tools, who carry out risk assessments at home without the support of GPs or health professionals. The conflicting and poor quality information can lead to inaccurate risk perceptions, such as incorrect pessimism or false optimism. This has been shown to influence health behaviour and treatment decisions, leading to dissatisfaction in a consultation with the GP, when perceived risk is not consistent with actual risk.

Review of the literature on cardiovascular risk representation formats highlighted the need for more methodologically sound studies into the effectiveness of risk representation formats, particularly using actual risk assessment, rather than analogue studies that rely on hypothetical risk scenarios. This issue was addressed by the RCT into the effects of different graphical cardiovascular risk representation formats.

The RCT found that viewing cardiovascular risk significantly reduces negative emotions and worry about future heart disease in the 'worried well', thus helping to

correct inaccurate risk perceptions. There were no main effects of graphical risk representation formats, suggesting that the way cardiovascular risk is presented does not make a difference in motivating behaviour change, facilitating understanding of risk information, or altering emotions (including worry about future heart disease). However, a possible type II error occurred, as the sample was unrepresentative and biased towards those of low cardiovascular risk and those who were highly educated. Further research is needed to reach target audiences and engage those who would benefit the most to participate in risk assessments.

This thesis discussed the findings in relation to policy and practice. It was concluded that it is difficult to reach 'at risk' groups and motivate them to adopt healthier lifestyles. This is because people find it hard to change their behaviour, and cease their bad habits. Therefore, public health campaigns may need to look at the bigger picture, and make changes on a societal level when developing strategies to prevent future CVD.

Limitations with current methods used for presenting future cardiovascular risk were also described in this thesis. These included the use of abstract numerical risk estimates and the 10-year timeframe. It was suggested that more salient outcomes should be used that can provide context and meaning. Recent research has shown the benefits of communicating risk in this way. Additionally, projecting short-term risk over longer time horizons addresses the problem with the 10-year timeframe in younger people, where absolute risk will be low regardless of any elevated

modifiable risk factors, due to the protective nature of age. This incorporates the benefits of relative risk and long term risk measures, and has already been incorporated into two popular web-based cardiovascular risk prediction tools. The deviation from conventional risk presentation is promising and may change the way cardiovascular risk is communicated to patients. This will potentially lead to better understanding of risk and increased motivation to change lifestyle in order to prevent future cardiovascular disease.

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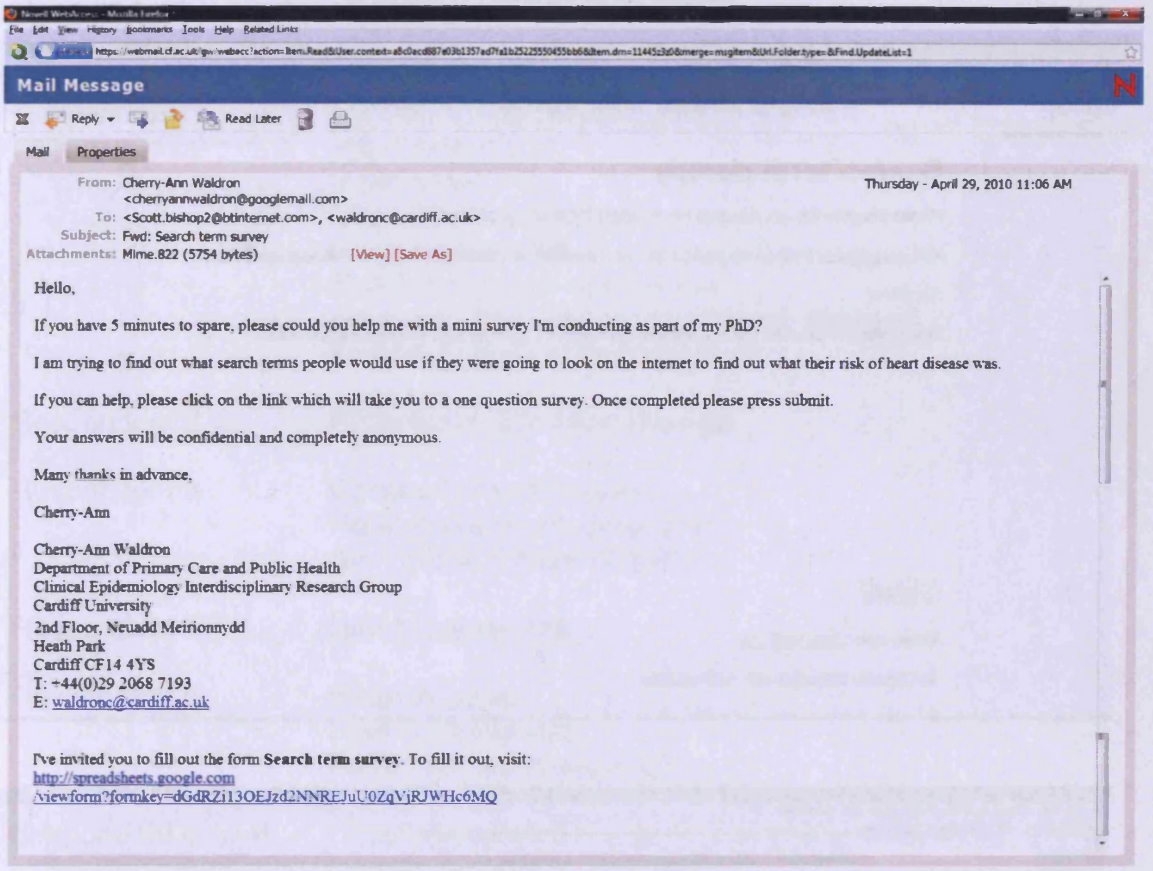
Appendix 1. Email invitation sent to respondents in search term elicitation survey.



Mail Message

Reply | Read Later

Mail | Properties

From: Cherry-Ann Waldron <cherryannwaldron@googlemail.com>
Thursday - April 29, 2010 11:06 AM
To: <Scott.bishop2@btinternet.com>, <waldronc@cardiff.ac.uk>
Subject: Fwd: Search term survey
Attachments: Mime.822 (5754 bytes) [View] [Save As]

Hello,

If you have 5 minutes to spare, please could you help me with a mini survey I'm conducting as part of my PhD?

I am trying to find out what search terms people would use if they were going to look on the internet to find out what their risk of heart disease was.

If you can help, please click on the link which will take you to a one question survey. Once completed please press submit.

Your answers will be confidential and completely anonymous.

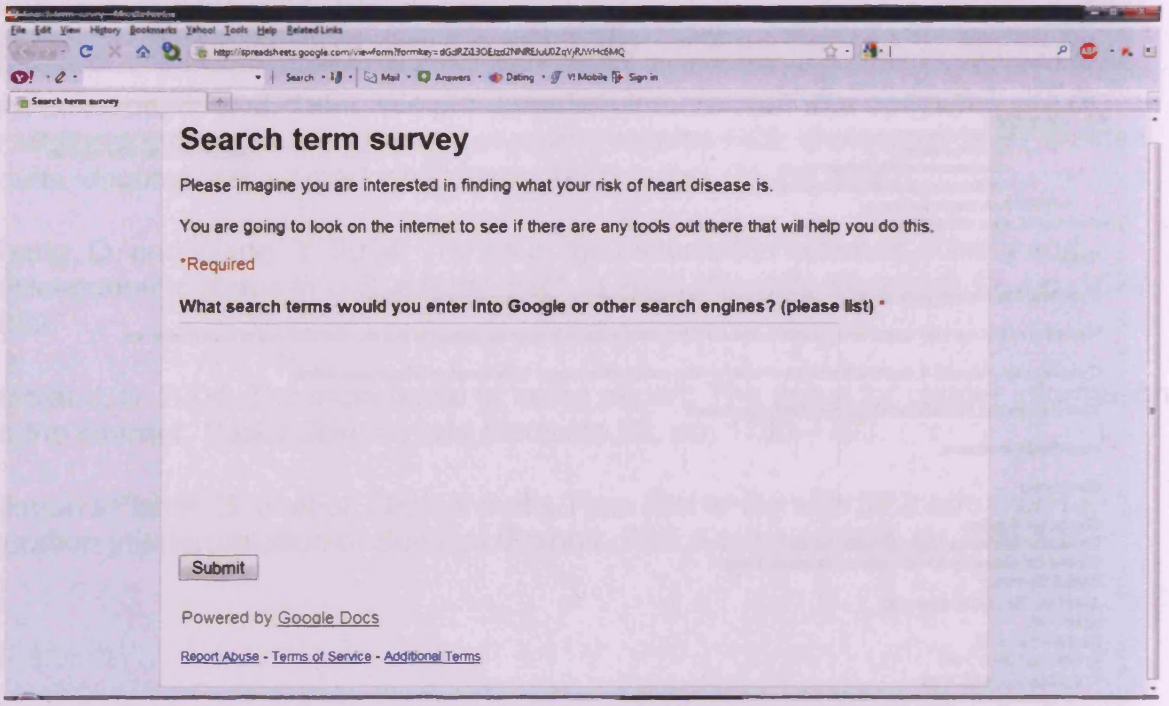
Many thanks in advance,

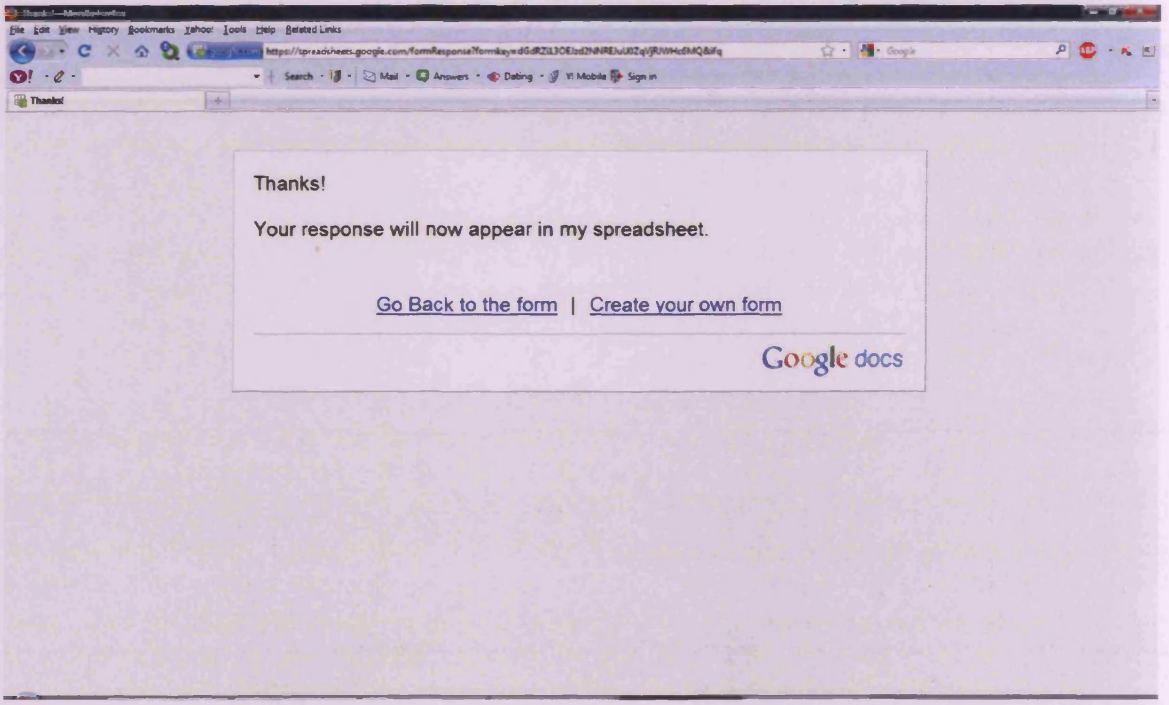
Cherry-Ann

Cherry-Ann Waldron
Department of Primary Care and Public Health
Clinical Epidemiology Interdisciplinary Research Group
Cardiff University
2nd Floor, Neuadd Meirionnydd
Heath Park
Cardiff CF14 4YS
T: +44(0)29 2068 7193
E: waldronc@cardiff.ac.uk

I've invited you to fill out the form **Search term survey**. To fill it out, visit:
http://spreadsheets.google.com
/viewform?formkey=dGdRZi13OEJzd2NNREJuU0ZqVjRJWHc6MQ

Appendix 2. Example of survey page when respondents click on link to participate in the search term elicitation survey.





Appendix 3. Results from search term elicitation survey.

Respondent no.	*Response to Question: What search terms would you enter into Google or other search engines? (please list).*
Respondent 1	My risk of heart attack Heart failure risk Heart attack risk Chance of heart attack Heart disease risk Risk factors for heart disease How can I find out my risk of heart disease? What is my risk of heart attack?
Respondent 2	Risks leading to heart disease
Respondent 3	Causes of heart disease Heart disease risk calculator Am I at risk if heart disease?
Respondent 4	Heart disease risk
Respondent 5	Heart disease Heart disease info Have I got heart disease?
Respondent 6	Heart disease Cardiac failure
Respondent 7	Heart disease risk factors Causes of heart disease
Respondent 8	Heart disease risk
Respondent 9	Myocardial infarction Cardiac arrest
Respondent 10	Heart disease risk assessment
Respondent 11	Risk of heart disease
Respondent 12	Heart risk advice
Respondent 13	Risk heart
Respondent 14	Heart attack Cardiac arrest Heart disease

Respondent 15	Cardiovascular risk calculator Cardiovascular risk score Heart risk calculator Heart risk score Heart disease risk management Cardiac risk score
Respondent 16	Calculate my risk of heart disease Identify my risk of heart disease Work out my risks of heart disease Risk of heart disease
Respondent 17	My risk of heart disease Risk factors and heart disease
Respondent 18	Heart disease risk Heart disease risk factor Heart disease risk assessment
Respondent 19	Heart disease risk Cardiac disease risk Heart attack risk
Respondent 20	Heart disease risk What is my risk of heart disease? Calculate heart disease
Respondent 21	Risk heart attack Risk cardiac Heart disease Risk factors cardiac condition Risk tool heart condition Questionnaire risk factors heart disease Am I at risk of heart disease?
Respondent 22	Heart disease risk Heart risk Risk of heart disease Heart disease risk Risk factors heart Developing heart disease
Respondent 23	Heart disease risk What is my risk of heart disease? Calculate heart disease
Respondent 24	Heart risk Heart disease Heart attack What is my risk of heart disease?

Appendix 4. Frequency of search terms generated by the search term elicitation survey.

Search term	n
Heart disease risk	11
Heart disease	4
Risk of heart disease	3
What is my risk of heart disease?	3
Am I at risk of heart disease?	2
Calculate heart disease	2
Heart attack risk	2
Heart disease risk assessment	2
Heart disease risk calculator	2
Heart disease risk factors	2
Heart risk	2
Calculate my risk of heart disease	1
Cardiac arrest	1
Cardiac disease risk	1
Cardiac failure	1
Cardiac risk score	1
Cardiovascular risk calculator	1
Cardiovascular risk score	1
Chance of heart attack	1
Causes of heart disease	1
Developing heart disease	1
Have I got heart disease?	1
Heart attack	1
Heart disease info	1
Heart risk advice	1
Heart disease risk management	1
Heart failure risk	1
Heart risk calculator	1
Heart risk score	1
How can I find out my risk of heart disease?	1
Identify my risk of heart disease	1
My risk of heart attack	1
My risk of heart disease	1
Myocardial infarction	1
Questionnaire risk factors heart disease	1
Risk cardiac	1
Risk factors cardiac condition	1
Risk factors for heart disease	1
Risk factors heart	1
Risk factors and heart disease	1
Risk heart	1
Risk heart attack	1
Risks leading to heart disease	1
Risk tool heart condition	1
What is my risk of heart attack?	1
Work out my risk of heart disease	1

Appendix 5. Results from the pilot testing of the search term word stems for the tailored search specific to cardiovascular risk prediction tools.

Google heart risk calculator Search Advanced Search

Search: the web pages from the UK

Web Show options... Results 1 - 10 of about 514,000 for heart risk calculator. (0.27 seconds)

Taking Books History Blog Power Space WOT Safe Search [x]

Heart Risk Calculator
You can use this **calculator** to estimate your **risk** of developing coronary **heart** disease (CHD) during the next ten years. To get your personal **risk** you need ...
bhgp.co.uk/precc.htm - Cached

Primary Cardiovascular **Risk Calculator** | Doctor | Patient UK
30 Jun 2009 ... Primary Cardiovascular **Risk Calculator** - Cardiovascular **Risk Calculator** ... plus congestive **heart** failure and peripheral vascular disease. ...
www.patient.co.uk › PatientPlus - Cached - Similar

Cardiovascular **risk** score
13 Jun 2006 ... For any technical issues with the **calculator** or these web pages, please e-mail ... increase **risk** as does a previous stroke or **heart** attack. ...
riskscore.lshtm.ac.uk/ - Cached

10-year CVD **Risk Calculator** (Risk Assessment Tool for Estimating ...
This tool is designed to estimate **risk** in adults aged 20 and older who do not have **heart** disease or diabetes. Use the **calculator** below to estimate 10-year ...
hp2010.nhlbihin.net/atpiii/**calculator**.asp?usertype=prof - Cached

10-year CVD **Risk Calculator** (Risk Assessment Tool for Estimating ...
To find your **risk** score, enter your information in the **calculator** below. ... The higher your total cholesterol, the greater your **risk** for **heart** disease. ...
hp2010.nhlbihin.net/atpiii/**calculator**.asp - Cached - Similar

Show more results from hp2010.nhlbihin.net

Heart Attack - Coronary **Heart** Disease - Metabolic Syndrome **Risk** ...
20 Feb 2009 ... Calculate your **risk** of having a **heart** attack or dying from coronary **heart** disease in the next 10 years.
www.americanheart.org/presenter.jhtml?identifier=3003499 - Cached - Similar

Cardiovascular **Risk Calculator** and Chart v2.0
31 Mar 2008 ... This cardiovascular **risk calculator** can be used to estimate the risk of a ... MI - risk of suffering a myocardial infarction (a "**heart** ...
cvrisk.mvm.ed.ac.uk/help.htm - Cached - Similar

Heart disease **calculator**
Heart disease **calculator**. **Heart** disease is one of the country's biggest killers and many factors can increase your **risk**. What's more, the **risk** factors don't ...
www.nhs.uk/healthprofile/Pages/**HeartDiseaseCalculator**.aspx - Cached - Similar

Tool: **Heart** disease **risk calculator** - MayoClinic.com
Heart disease **risk**: Use this tool to calculate your **risk** of having a **heart** attack.
www.mayoclinic.com/.../**heart**...**risk**/HB00047 - 45 minutes ago - Cached - Similar

Links to **heart** disease **risk calculators**
Links to sites providing **risk calculators** for **heart** disease.
heartdisease.about.com/cs/**riskcalculators**/ - Cached - Similar

Searches related to **heart risk calculator**

coronary heart disease risk calculator	heart attack risk calculator	heart risk factors	cardiac risk factors
american heart risk calculator	cardiovascular risk factors	goldman cardiac risk calculator	cardiac surgery risk calculator

Google calculate heart risk Search Advanced Search

Search: the web pages from the UK

Web Show options... Results 1 - 10 of about 3,890,000 for calculate heart risk. (0.47 seconds)

Heart Attack Cholesterol Risk Factors Stroke Estimate WOT Safe Search [x]

10-year CVD Risk Calculator (Risk Assessment Tool for Estimating ...
The risk assessment tool below uses recent data from the Framingham Heart Study to estimate 10-year risk for "hard" coronary heart disease outcomes ...
hp2010.nhlbihin.net/atpiii/calculator.asp?usertype=prof - Cached

10-year CVD Risk Calculator (Risk Assessment Tool for Estimating ...
Risk Assessment Tool for Estimating Your 10-year Risk of Having a Heart Attack ... The higher your total cholesterol, the greater your risk for heart ...
hp2010.nhlbihin.net/atpiii/calculator.asp - Cached - Similar

Show more results from hp2010.nhlbihin.net

Heart Attack - Coronary Heart Disease - Metabolic Syndrome Risk ...
20 Feb 2009 ... Calculate your risk of having a heart attack or dying from coronary heart disease in the next 10 years.
www.americanheart.org/presenter.jhtml?identifier=3003499 - Cached - Similar

HOW TO CALCULATE THE RISK OF A HEART ATTACK « USMLEMD
12 Feb 2008 ... National Cholesterol Education Program provides a calculator for assessment of the 10-ear risk of having a heart attack. ...
usmlemd.wordpress.com/.../how-to-calculate-the-risk-of-a-heart-attack/ - Cached - Similar

Cardiovascular risk score
13 Jun 2006 ... To calculate the risk score you need to know the following: ... hypertrophy increase risk as does a previous stroke or heart attack. ...
riskscore.lshtm.ac.uk/ - Cached

Reynolds Risk Score
To calculate your risk, fill in the information below with your most recent ... from a heart attack or stroke before age 60 years, the Reynolds Risk Score ...
www.reynoldsriskscore.org/ - Cached - Similar

Calculate Heart Attack Risk
What's your risk of having a heart attack or stroke in the next 10 years? The August issue of Mayo Clinic Women's HealthSource tells how you can calculate ...
www.innovations-report.com/html/.../report-32045.html - Cached - Similar

Heart Attack Risk Calculator - Calculate your Risk of Heart Attack ...
Calculate your risk of having a heart attack or dying from coronary heart disease in the next 10 years.
www.myoptumhealth.com/portal/.../Heart+Attack - Cached - Similar

CHD
For the CHD Risk Prediction Group. Validation of the Framingham Coronary Heart Disease Prediction Scores: Results of a Multiple Ethnic Groups Investigation. ...
calculators.epnet.com/CalcCHD.aspx?token... - Cached - Similar

Your Disease Risk
Welcome to Your Disease Risk, the source on prevention. Here, you can find out your risk of developing five of the most important diseases in the United ...
www.yourdiseaserisk.wustl.edu/ - Cached - Similar

Searches related to calculate heart risk

cardiovascular risk calculator | heart attack risk calculator | american heart risk calculator | cardiac surgery risk calculator
aha cardiac risk calculator | goldman cardiac risk calculator | nz cardiovascular risk calculator | jbs cardiovascular risk calculator


Google
heart disease assessment
Search
Advanced Search
Search: the web pages from the UK
Web Show options...
Results 1 - 10 of about 7,300,000 for heart disease assessment. (0.58 seconds)
Scholarly articles for heart disease assessment
... replacement therapy and coronary heart disease: ... - Stampfer - Cited by 1393
Ischemic heart disease: assessment with ... - Eichenberger - Cited by 131
Improving coronary heart disease risk assessment in ... - Greenland - Cited by 350
Variety Credible Health WOT Safe Search
Heart Attack - Coronary Heart Disease - Metabolic Syndrome Risk ...
20 Feb 2009 ... This risk assessment tool can be used by anyone age 20 or older who doesn't already have heart disease or diabetes. ...
www.americanheart.org/presenter.jhtml?identifier=3003499 - Cached - Similar
Heart Disease: Assessing Your Risk – familydoctor.org
Information about assessing your risk for heart disease from the American Academy of Family Physicians.
familydoctor.org › ... › Conditions AZ › Heart Disease & Stroke - Cached - Similar
Your Disease Risk
Welcome to Your Disease Risk, the source on prevention. Here, you can find out your risk of developing five of the most important diseases in the United ...
www.yourdiseaserisk.wustl.edu/ - Cached - Similar
10-year CVD Risk Calculator (Risk Assessment Tool for Estimating ...
Risk Assessment Tool for Estimating Your 10-year Risk of Having a Heart Attack ... A person with this level has more than twice the risk of heart disease ...
hp2010.nhlbihin.net/atpiii/calculator.asp - Cached - Similar
Coronary artery disease risk assessment : Healthline.com
Coronary Artery Disease Assessment. Quizzes. Dietary Guidelines Quiz · Cholesterol Quiz · Fat Quiz · Coronary Artery Disease and Angioplasty Quiz · Heart ...
www.healthline.com/.../risk-coronary-artery-disease-assessment - Cached - Similar
CardioSmart: Heart Disease Risk Assessment
The Heart Disease Risk Assessment Tool is based on findings from a major research project called the "Framingham Heart Study," in which three generations of ...
www.cardiosmart.org/CardioSmart/Default.aspx?id=298 - Cached - Similar
WHO | Prevention of cardiovascular disease: Pocket guidelines for ...
Prevention of cardiovascular disease: Pocket guidelines for assessment and ... of first and recurrent clinical events due to coronary heart disease (CHD), ...
www.who.int › ... › Cardiovascular disease › Guidelines - Cached - Similar
Necessity of early identification of coronary heart disease ...
Necessity of early identification of coronary heart disease. Assessment of hospital practice in Spain. Villar E, Lacalle JR, Alvarez R, Perez MJ, Briones E, ...
gateway.nlm.nih.gov/MeetingAbstracts/102194172.html - Cached
Boston Scientific : Close The Gap : Assess Your Risk
Heart Disease Assessment Tool ... Does anyone in your immediate family have a history of heart disease or diabetes? Are you black American or Latino ...
www.bostonscientific.com › Close the Gap - Cached - Similar
Heart disease risk assessment - myDr.com.au
This tool estimates your chance of developing coronary heart disease over the next 10 years. This is your risk of developing angina, having a heart attack ...
www.mydr.com.au/tools/heart-disease-risk-test - Cached - Similar
Searches related to heart disease assessment
coronary heart disease cardiovascular disease
high blood cholesterol heart disease
hdl heart disease
heart disease heart attack
cholesterol levels heart disease
chd heart disease
diabetes heart disease
heart disease calculator

Google assess heart disease Search Advanced Search

Search: the web pages from the UK

Web Show options... Results 1 - 10 of about 5,780,000 for assess heart disease. (0.33 seconds)

Scholarly articles for assess heart disease

... replacement therapy and coronary heart disease: ... - Stampfer - Cited by 1393

Is pulse pressure useful in predicting risk for coronary ... - Franklin - Cited by 1457

Prognostic impact of coronary vasodilator dysfunction ... - Schachinger - Cited by 1754

Variety Credible Health WOT Safe Search (x)

Heart Attack - Coronary Heart Disease - Metabolic Syndrome Risk ...

20 Feb 2009 ... Use this tool to help you assess your risk of having a heart attack or dying from coronary heart disease in the next 10 years. ...

www.americanheart.org/presenter.jhtml?identifier=3003499 - Cached - Similar

Heart Disease: Assessing Your Risk – familydoctor.org

Information about assessing your risk for heart disease from the American Academy of Family Physicians.

familydoctor.org › ... › Conditions AZ › Heart Disease & Stroke - Cached - Similar

Aim for a Healthy Weight: Assess your Risk

Part 1: Assessing Your Risk. According to the NHLBI guidelines, assessment of overweight ... waist measurement, and others risk factors for heart disease. ...

www.nhlbi.nih.gov/health/public/heart/obesity/lose.../risk.htm - Cached - Similar

arc :: New imaging technique 'good to assess heart disease in ...

28 Jan 2009 ... Doctors should consider myocardial perfusion imaging to assess the risk of coronary artery disease in women with systematic lupus ...

www.arc.org.uk/news/DirectNews/Article.asp?ID...Year... - Cached

10-year CVD Risk Calculator (Risk Assessment Tool for Estimating ...

A person with this level has more than twice the risk of heart disease compared to someone ... Less than 40 mg/dL A major risk factor for heart disease ...

hp2010.nhlbihin.net/atpiii/calculator.asp - Cached - Similar

Assess Your Risk for Heart Disease – LIPITOR.com

Enter your cholesterol levels to assess your risk for heart disease.

www.lipitor.com/tools/assess-your-risk.aspx - Cached

Can CT Scans Accurately Assess Heart Disease Risk? on Yahoo! Health

22 Apr 2007 ... At a cost of about $1000 per procedure, CT angiography is cheaper than conventional angiography but it has several serious drawbacks.

health.yahoo.com › Experts › Your Healthy Heart - Cached - Similar

A Bayesian approach to assess heart disease mortality among ...

by BL Cadwell - 2007 - Cited by 2 - Related articles

A Bayesian approach to assess heart disease mortality among persons with diabetes in the presence of missing data. Betsy L. Cadwell & James P. Boyle ...

www.springerlink.com/index/V50Q28160723680P.pdf

Standardized tests encouraged to assess children's arteries for ...

3 Sep 2009 ... Standardized tests encouraged to assess children's arteries for heart disease. Statement highlights: The American Heart Association has ...

americanheart.mediaroom.com/index.php?s=43&item... - Cached - Similar

Boston Scientific : Close The Gap : Assess Your Risk

Does anyone in your immediate family have a history of heart disease or ... American Heart Association. Heart Disease and Stroke Statistics 2007 Update. ...

www.bostonscientific.com › Close the Gap - Cached - Similar

Searches related to assess heart disease

diabetes heart disease	coronary artery heart disease	heart disease stroke	ldl cholesterol heart disease
heart attack disease	high blood cholesterol heart disease	coronary heart disease cardiovascular disease	hdl heart disease

Appendix 6. List of search terms used in the tailored search specific to cardiovascular risk prediction tools.

1	Heart risk calculator
2	Heart risk prediction
3	Heart risk assessment
4	Heart risk tool
5	Heart disease calculator
6	Heart disease prediction
7	Heart disease assessment
8	Heart disease tool
9	Heart attack calculator
10	Heart attack prediction
11	Heart attack assessment
12	Heart attack tool
13	Heart attack risk tool
14	Calculate heart risk
15	Calculate heart disease
16	Calculate heart attack
17	Predict heart risk
18	Predict heart disease
19	Predict heart attack
20	Assess heart risk
21	Assess heart disease
22	Assess heart attack

Appendix 7. Template of questions used in Critical Appraisal.

Name of web-based prediction tool:	
Web address:	
Notes:	

Characteristics of risk prediction tool.

1.1	What is the risk prediction tool? *e.g. algorithm, chart, questionnaire etc.*	
1.2	Is the algorithm used in the prediction tool reported? *-if so, what?*	
1.3	What risk factors are measured?	
1.4	Are details given on the development and validation of the prediction tool? *- if so, what?* *- is the context reported? (E.g. university, general practice)*	
1.5	Is there reference to academic papers relating to the prediction tool? *– if so, what and how is this evidence accessed (pdf, link etc)*	
1.6	Are authors qualifications/ credentials reported? *- if so, what are they?*	
1.7	Is any affiliation/ funding reported? *- if so, what is it?*	
1.8	Is any conflict of interest declared? *– if so, what is it?*	
1.9	Are commercial advertisements present? *- if so, how many?* *- what are they for?*	
1.10	Does the site say when it was last updated?	
1.11	Does the user have to register as a member	

	before accessing the prediction tool?	
1.12	Is security provided when users enter their personal information?	
1.13	Is the target audience identified? *If so, who?*	
1.14	Does the site state who the prediction tool is not suitable for? *If so, who?*	
1.15	Is plain language used that can be easily understood by the majority of the target audience?	
1.16	Are external links to additional useful information given? *If so, what are these for?* *If so, Is it easy for the user to return to the site after visiting the external links?*	
1.17	Is there option to contact the authors for additional help or information? *If so, how can this be done?*	

Risk Communication questions		
2.1	What type of cardiovascular risk is predicted?	
2.2	Is this type of risk defined?	
2.3	What is the main time frame that is used?	
2.3	Is there more than one timeframe option? *If so, what are they?*	
2.4	What is the main format used to express the risk output?	
2.5	Is there more than one way that the risk is presented? *If so, what are they?*	
2.6	Can the user choose their preferred method of presentation?	
2.7	How is the risk framed? (Absolute, relative etc)	
2.8	Is there a comparison with peer risk?	
2.9	Is the risk graphically summarised? *If so, how?*	
2.10	Is there an option for printing out the results?	
2.11	Can you save the risk output and return at a later date?	
2.12	Can the risk output be re-calculated by modifying the risk profile?	
2.13	Is there mention of the uncertainty regarding the risk estimate presented?	

Focus on behaviour change/ treatment questions		
3.1	Does the output report the main contributing factors to the risk?	
3.2	Are possible options to reduce risk reported?	
3.3	Is the user directed to further information sources about reducing risk? *If so, in what form? (external links, online pamphlets etc.)* *Who are they by?*	
3.4	Is contacting a Healthcare Practitioner recommended / advised ?	
3.5	Is the risk reduction achieved by behaviour change/ treatment options reported? *If so, what format is it given in?* *How is it framed (positive/ negative/both)?*	
3.6	Are the different risks displayed together to enable comparison?	
3.7	Are treatment goals provided? *If so, how?*	
3.8	Is there the option to record progress as user attempts to reduce their risk?	
3.9	Are tools (e.g. worksheets, question lists) provided that enable the user to make notes and discuss options with others.	

Appendix 8. Ranking scores for the eligible web-based cardiovascular risk prediction tools retrieved by all search terms tailored to cardiovascular risk prediction tools.

Search term	Risk prediction tool	Position on 1st page of SERP											
		Day 1		Day 2		Day 3		Day 4		Day 5		Overall rankings	
		Position	Rank	Position	Rank	Position	Rank	Position	Rank	Position	Rank		
Assess heart attack	American Heart Association	2nd	**11**	2nd	**9**	3rd	**8**	3rd	**8**	3rd	**8**	44/5 = 8.8	9
	Healthwise MSN	5th	**8**	5th	**8**	5th	**8**	6th	**7**	5th	**8**	39/5= 7.8	8
Assess heart disease	American Heart Association	2nd	**11**	3rd	**10**	3rd	**10**	5th	**8**	2nd	**11**	50/5 = 10	10
	Healthwise MSN	-	**0**	10th	**3**	10th	**3**	9th	**4**	10th	**3**	13/5 =2.6	3
Assess heart risk	American Heart Association	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 =12	12
	NCEP professional use	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	London School of Hygiene and Tropical Medicine	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5 =10	10
	Healthwise MSN	9th	**4**	9th	**4**	9th	**4**	10th	**3**	10th	**3**	18/5 = 3.6	4
Calculate heart attack	e-Tools Age	1st	**12**	1st	**12**	2nd	**11**	2nd	**11**	2nd	**11**	57/5 = 11.4	11
	NCEP public use	2nd	**11**	2nd	**11**	3rd	**10**	4th	**9**	3rd	**10**	51/5 =10.2	10
	My Optum Health	3rd	**10**	3rd	**10**	4th	**9**	3rd	**10**	4th	**9**	48/5 =9.6	10
	Reynolds risk score	4th	**9**	4th	**9**	5th	**8**	5th	**8**	6th	**7**	41/5 =8.2	8
	Prevent disease.com	8th	**5**	8th	**5**	8th	**5**	8th	**5**	9th	**4**	24/5 =4.8	5
	American Heart Association	-	**0**	9th	**4**	9th	**4**	9th	**4**	8th	**5**	17/5 =3.4	3

Calculate heart disease	NCEP public use	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 =12	12
	Reynolds risk score	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5= 11	11
	e-Tools Age	3rd	**10**	3rd	**10**	4th	**9**	5th	**8**	5th	**8**	45/5= 9	9
	My Optum Health	4th	**9**	4th	**9**	5th	**8**	5th	**8**	4th	**9**	43/5= 8.6	9
	London School of Hygiene and Tropical Medicine	9th	**4**	9th	**4**	-	**0**	-	**0**	-	**0**	8/5=1.6	2
Calculate heart risk	London School of Hygiene and Tropical Medicine	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 =12	12
	NCEP professional use	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	NCEP public use	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5 =10	10
	My Optum Health	6th	**7**	6th	**7**	6th	**7**	6th	**7**	6th	**7**	35/5 =7	7
	American Heart Association	8th	**5**	9th	**4**	9th	**4**	10th	**3**	10th	**3**	19/5 =3.8	4
	The University of Edinburgh (calculator info page)	9th	**4**	8th	**5**	8th	**5**	9th	**4**	9th	**4**	22/5 =4.4	4
Heart attack assessment	American Heart Association	1st	**12**	3rd	**10**	3rd	**10**	1st	**12**	1st	**12**	56/5 =11.2	11
	NCEP public use	2nd	**11**	1st	**12**	1st	**12**	2nd	**11**	2nd	**11**	57/5 =11.4	11
	NCEP professional use	3rd	**10**	2nd	**11**	2nd	**11**	3rd	**10**	-	**0**	42/5 =8.4	8
	Healthwise MSN	9th	**4**	9th	**4**	8th	**5**	8th	**5**	7th	**6**	24/5 =4.8	5
	CardioSmart (American College of Cardiology)	10th	**3**	-	**0**	10th	**3**	-	**0**	10th	**3**	9/5 =1.8	2
Heart attack calculator	NCEP public use	1st	**12**	1st	**12**	1st	**12**	1st	**12**	2nd	**11**	59/5 =11.8	12

	My Optum Health	2nd	11	2nd	11	2nd	11	2nd	11	1st	12	56/5 =11.2	11
	American Heart Association	4th	9	6th	7	6th	7	6th	7	6th	7	37/5 =7.4	7
	Everyday Health	5th	8	4th	9	4th	9	4th	9	4th	9	44/5= 8.8	9
	Med India	6th	7	5th	8	5th	8	5th	8	5th	8	39/5 =7.8	8
	QRisk 2	8th	5	8th	5	8th	5	8th	5	8th	5	25/5 =5	5
	Mayo Clinic	9th	4	9th	4	9th	4	9th	4	9th	4	20/5 =4	4
Heart attack prediction	NCEP professional use	5th	8	5th	8	5th	8	5th	8	5th	8	40/5 =8	8
Heart Attack Risk Tool	NCEP public use	1st	12	1st	12	1st	12	2nd	11	2nd	11	58/5 =11.6	12
	NCEP professional use	2nd	11	2nd	11	2nd	11	3rd	10	3rd	10	53/5 =10.6	11
	Healthwise AOL	3rd	10	3rd	10	3rd	10	5th	8	5th	8	46/5 =9.2	9
	American Heart Association	4th	9	4th	9	4th	9	4th	9	4th	9	45/5 =9	9
	Healthwise Yahoo health	5th	8	5th	8	5th	8	6th	7	6th	7	38/5 =7.6	8
	Mayo Clinic	8th	5	8th	5	8th	5	9th	4	9th	4	23/5= 4.6	5
	Cleveland Clinic	10th	3	10th	3	10th	3	10th	3	10th	3	15/5 =3	3
	Myheartrisk.net	-	0	-	0	-	0	1st	10	1st	10	20/5 =4	4
	Prolipid	-	0	-	0	-	0	11th	2	11th	2	4/5 = 0.8	1
Heart attack tool	NCEP public use	1st	12	1st	12	1st	12	1st	12	1st	12	60/5 =12	12
	NCEP professional use	2nd	11	2nd	11	-	0	2nd	11	2nd	11	44/5 =8.8	9
	Healthwise Yahoo health	5th	8	5th	8	4th	9	3rd	10	4th	9	44/5 =8.8	9
	Mayo Clinic	6th	7	6th	7	5th	8	5th	8	5th	8	38/5 =7.6	8
	American Heart Association	7th	6	7th	6	6th	7	6th	7	6th	7	33/5 =6.6	7
	Healthwise MSN	9th	4	9th	4	8th	5	8th	5	8th	5	23/5 =4.6	5
	Cleveland Clinic	-	0	-	0	-	0	10	3	-	0	3/5=0.6	1

Heart Disease Assessment	American Heart Association	3rd	**10**	6th	**7**	6th	**7**	6th	**7**	4th	**9**	40/5 =8	8
	NCEP public use	5th	**8**	4th	**9**	4th	**9**	4th	**9**	6th	**7**	42/5 =8.4	8
	NCEP professional use	6th	**7**	5th	**8**	5th	**8**	5th	**8**	-	**0**	31/5 =6.2	6
	Siteman Cancer Center (Washington University) Homepage	7th	**6**	7th	**6**	7th	**6**	7th	**6**	5th	**8**	32/5 =6.4	6
	CardioSmart (American College of Cardiology)	10th	**3**	10th	**3**	10th	**3**	10th	**3**	9th	**4**	16/5 = 3.2	3
Heart Disease Calculator	My Optum Health	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	Patient UK	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5=10	10
	London School of Hygiene and Tropical Medicine	4th	**9**	4th	**9**	4th	**9**	4th	**9**	4th	**9**	45/5=9	9
	Ethrisk (Framingham)	5th	**6**	5th	**6**	5th	**6**	5th	**6**	5th	**6**	30/5 =6	6
	The University of Edinburgh (calculator info page)	6th	**7**	6th	**7**	6th	**7**	6th	**7**	6th	**7**	35/5 =7	7
	NCEP public use	7th	**6**	7th	**6**	7th	**6**	7th	**6**	7th	**6**	30/5 = 6	6
	QRisk 2	8th	**5**	8th	**5**	8th	**5**	8th	**5**	8th	**5**	25/5 = 5	5
	American Heart Association	9th	**4**	-	**0**	-	**0**	-	**0**	9th	**4**	8/5 =1.6	2
	Mayo Clinic	-	**0**	10th	**3**	10th	**3**	10th	**3**	10th	**3**	12/5 =2.4	2
Heart disease tool	Mayo Clinic	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 =12	12
	NCEP public use	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	3rd	**10**	54/5 =10.8	11
	Weight loss advisory.com	6th	**7**	7th	**6**	6th	**7**	6th	**7**	7th	**6**	33/5 =6.6	7
	Healthwise Yahoo health	7th	**6**	8th	**5**	7th	**6**	7th	**6**	8th	**5**	28/5= 5.6	6
	Open Clinical	8th	**5**	9th	**4**	8th	**5**	8th	**5**	9th	**4**	23/5 =4.6	5
	American Heart Association	10th	**3**	-	**0**	-	**0**	9th	**4**	10th	**3**	10/5= 2	2

Heart risk assessment	Patient UK	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	American Heart Association	3rd	**10**	8th	**5**	8th	**5**	8th	**5**	9th	**4**	29/5 =5.8	6
	Heart Institute of the Cascades	5th	**8**	5th	**8**	6th	**7**	6th	**7**	6th	**7**	37/5 =7.4	7
	NCEP professional use	7th	**6**	6th	**7**	7th	**6**	7th	**6**	7th	**6**	31/5= 6.2	6
	Assign	9th	**4**	10	**3**	10	**3**	9	**4**	10	**3**	17/5= 3.4	3
	Ethos Heart Aware	-	**0**	-	**0**	-	**0**	10	**3**	-	**0**	3/5 =0.6	1
Heart risk calculator	Patient UK	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 = 12	12
	The University of Edinburgh (calculator info page)	4th	**9**	4th	**9**	4th	**9**	4th	**9**	4th	**9**	45/5= 9	9
	QRisk 2	5th	**8**	5th	**8**	5th	**8**	5th	**8**	5th	**8**	40/5 =8	8
	London School of Hygiene and Tropical Medicine	7th	**6**	6th	**7**	6th	**7**	6th	**7**	6th	**7**	34/5= 6.8	7
	American Heart Association	9th	**4**	9th	**4**	9th	**4**	9th	**4**	-	**0**	16/5= 3.2	3
	NCEP professional use	10th	**3**	10th	**3**	10th	**3**	-	**0**	-	**0**	9/5 = 1.8	2
Heart risk tool	NCEP professional use	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5=12	12
	NCEP public use	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	American Heart Association	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5 =10	10
	Mayo Clinic	6th	**7**	6th	**7**	5th	**8**	5th	**8**	5th	**8**	38/5 = 7.6	8
	Healthwise MSN	10th	**3**	10th	**3**	10th	**3**	9th	**4**	9th	**4**	17/5 =3.4	3
	Open Clinical	-	**0**	-	**0**	9th	**4**	-	**0**	-	**0**	4/5 =0.8	1

Appendix 9. Ranking scores for the eligible web-based cardiovascular risk prediction tools retrieved by the general layman search terms.

Search term	Risk prediction tool	Position on 1st page of SERP											
		Day 1		Day 2		Day 3		Day 4		Day 5		Overall rankings	
		Position	Rank	Position	Rank	Position	Rank	Position	Rank	Position	Rank		
Am I at risk of heart disease?	American Heart Association	2nd	**11**	-	**0**	-	**0**	-	**0**	-	**0**	11/5 = 2.2	2
	My Optum Health	-	**0**	-	**0**	9th	**4**	-	**0**	-	**0**	4/5= 0.8	1
Calculate heart disease	NCEP public use	1st	**12**	1st	**12**	1st	**12**	1st	**12**	2nd	**11**	59/5 = 11.8	12
	Reynolds risk score	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	1st	**12**	56/5 = 11.2	11
	e-Tools Age	3rd	**10**	3rd	**10**	4th	**9**	5th	**8**	5th	**8**	45/5 = 9	9
	My Optum Health	4th	**9**	4th	**9**	5th	**8**	4th	**9**	4th	**9**	44/5 = 8.8	9
	London School of Hygiene and Tropical Medicine	9th	**4**	10th	**3**	-	**0**	-	**0**	-	**0**	7/5 = 1.4	1
Calculate my risk of heart disease	NCEP public use	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5= 12	12
	Siteman Cancer Center (Washington University) Homepage	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	American Heart Association	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5 =10	10
	Revolution Health	4th	**9**	4th	**9**	4th	**9**	4th	**9**	4th	**9**	45/5 =9	9
	My Optum Health	6th	**7**	6th	**7**	6th	**7**	6th	**7**	6th	**7**	35/5 =7	7
	Heart Healthy Women Org	8th	**5**	8th	**5**	8th	**5**	8th	**5**	8th	**5**	25/5 =5	5

Cardiac Disease risk	London School of Hygiene and Tropical Medicine	6th	**7**	6th	**7**	5th	**8**	6th	**7**	6th	**7**	36/5=7.2	7
	University of Maryland Health Center	10th	**3**	10th	**3**	9th	**4**	12th	**1**	11th	**2**	13/5=2.6	3
	Medical college of Winconsin	12th	**1**	-	**0**	-	**0**	-	**0**	-	**0**	1/5=0.2	0
Cardiac risk score	Md + Calc	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 =12	12
	NCEP professional use	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5=10	10
	London School of Hygiene and Tropical Medicine	4th	**9**	4th	**9**	4th	**9**	4th	**9**	4th	**9**	45/5 =9	9
	American Heart Association	7th	**6**	7th	**6**	5th	**8**	5th	**8**	5th	**8**	36/5 =7.2	7
Cardiovascular risk calculator	The University of Edinburgh (calculator info page)	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 =12	12
	The University of Edinburgh (calculator page)	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	Patient UK	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5 = 10	10
	QRisk 2	5th	**8**	5th	**8**	5th	**8**	5th	**8**	5th	**8**	40/5 =8	8
	UCL Hospital	6th	**7**	6th	**7**	6th	**7**	6th	**7**	6th	**7**	35/5 =7	7
	GP training.net	7th	**6**	7th	**6**	7th	**6**	7th	**6**	7th	**6**	30/5 = 6	6
	London School of Hygiene and Tropical Medicine	9th	**4**	9th	**4**	9th	**4**	9th	**4**	9th	**4**	20/5 = 4	4
	The Filey Surgery /Black Heath Medical Centre	10th	**3**	10th	**3**	10th	**3**	10th	**3**	10th	**3**	15/5 = 3	3

Cardiovascular risk score	London School of Hygiene and Tropical Medicine	3rd	**10**	4th	**9**	4th	**9**	5th	**8**	5th	**8**	44/5 =8.8	9
	Assign	6th	**7**	7th	**6**	7th	**6**	7th	**6**	6th	**7**	32/5= 6.4	6
	NCEP professional use	7th	**6**	8th	**5**	8th	**5**	8th	**5**	7th	**6**	27/5 =5.4	5
	Patient UK	8th	**5**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	45/5 =9	9
	NCEP public use	10th	**3**	9th	**4**	9th	**4**	9th	**4**	8th	**5**	20/5 =4	4
Chance of heart attack	NCEP public use	3rd	**10**	-	**0**	3rd	**10**	3rd	**10**	3rd	**10**	40/5= 8	8
	My Optum Health	7th	**6**	7th	**6**	7th	**6**	7th	**6**	7th	**6**	30/5 = 6	6
	Allina Hospitals and Clinics	1	**0**	2nd	**11**	1	**0**	-	**0**	-	**0**	11/5= 2.2	2
Heart attack risk	NCEP public use	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5=12	12
	My Optum Health	5th	**8**	4th	**9**	5th	**8**	2nd	**11**	2nd	**11**	47/5=9.4	9
	American Heart Association	7th	**6**	-	**0**	-	**0**	7th	**6**	-	**0**	12/5=2.4	2
Heart disease risk	London School of Hygiene and Tropical Medicine	2nd	**11**	2nd	**11**	2nd	**11**	6th	**11**	6th	**11**	55/5=11	11
	American Heart Association	4th	**9**	4th	**9**	4th	**9**	3rd	**10**	3rd	**10**	47/5=9.4	9
	Medical college of Winconsin	7th	**6**	7th	**6**	-	**0**	7th	**6**	7th	**6**	24/5=4.8	5
	University of Maryland Health Center	9th	**4**	9th	**4**	9th	**4**	9th	**4**	9th	**4**	20/5=4	4
Heart Disease Risk Assessment	NCEP public use	1st	**12**	1st	**12**	1st	**12**	2nd	**11**	2nd	**11**	58/5=11.6	12
	American Heart Association	3rd	**10**	-	**0**	-	**0**	10th	**3**	10th	**3**	16/5=3.2	3

	Siteman Cancer Center (Washington University) Homepage	5th	**8**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	48/5=9.6	10
	CardioSmart (American College of Cardiology)	-	**0**	-	**0**	9th	**4**	-	**0**	-	**0**	4/5=0.8	1
Heart disease risk calculator	Mayo Clinic	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	55/5 =11	11
	Patient UK	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5 =10	10
	The University of Edinburgh (calculator info page)	5th	**8**	5th	**8**	5th	**8**	5th	**8**	5th	**8**	40/5 =8	8
	QRisk 2	6th	**7**	6th	**7**	6th	**7**	6th	**7**	6th	**7**	35/5 =7	7
	London School of Hygiene and Tropical Medicine	7th	**6**	7th	**6**	7th	**6**	7th	**6**	7th	**6**	30/5 =6	6
	NCEP public use	8th	**5**	8th	**5**	8th	**5**	9th	**4**	9th	**4**	23/5 =4.6	5
	My Optum Health	9th	**4**	9th	**4**	9th	**4**	8th	**5**	8th	**5**	22/5 =4.4	4
	University of Maryland Health Center	10th	**3**	10th	**3**	10th	**3**	10th	**3**	10th	**3**	15/5 =3	3
Heart Disease Risk Management	American Heart Association	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	3rd	**10**	50/5=10	10
Heart risk	American Heart Association	3rd	**10**	5th	**8**	-	**0**	10th	**3**	-	**0**	21/5=4.2	4
	NCEP professional use	7th	**6**	9th	**4**	4th	**9**	8th	**5**	4th	**9**	33/5=6.6	7
	University of Maryland Health Center	-	**0**	-	**0**	-	**0**	7th	**6**	-	**0**	6/5=1.2	1
Heart risk calculator	Patient UK	1st	**12**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	60/5 = 12	12

	The University of Edinburgh (calculator info page)	4th	9	4th	9	4th	9	4th	9	4th	9	45/5 =9	9
	QRisk 2	5th	8	5th	8	5th	8	5th	8	5th	8	40/5 =8	8
	London School of Hygiene and Tropical Medicine	7th	6	6th	7	6th	7	6th	7	6th	7	34/5 =6.8	7
	American Heart Association	9th	4	9th	4	9th	4	9th	4	9th	4	20/5 = 4	4
	NCEP professional use	10th	3	10th	3	10th	3	-	0	-	0	9/5 =1.8	2
Heart Risk Score	London School of Hygiene and Tropical Medicine	2nd	11	2nd	11	6th	7	2nd	11	2nd	11	51/5= 10.2	10
	NCEP professional use	3rd	10	3rd	10	2nd	11	4th	9	4th	9	49/5 =9.8	10
	Patient UK	6th	7	6th	7	9th	4	6th	7	7th	6	31/5 = 6.2	6
	Md + Calc	7th	6	7th	6	5th	8	6th	7	7th	6	33/5= 6.6	7
	American Heart Association	8th	5	9th	4	8th	5	9th	4	9th	4	22/5 =4.4	4
	Reynolds risk score	10th	3	10th	3	-	0	-	0	-	0	6/5=1.2	1
	The University of Edinburgh (calculator info page)	-	0	-	0	10th	1	-	0	-	0	1/5= 0.2	0
How can I find out my risk of heart disease	Healthwise Yahoo health	6th	7	7th	6	6th	7	7th	6	6th	7	33/5=6.6	7
	My Optum Health	9th	4	-	0	-	0	-	0	-	0	4/5=0.8	1
My risk of heart attack	NCEP public use	3rd	10	3rd	10	3rd	10	2nd	11	3rd	10	51/5= 10.2	10
	Healthwise Yahoo health	4th	9	5th	8	4th	9	3rd	10	5th	8	44/5= 8.8	9

	American Heart Association	6th	7	-	0	-	0	6th	7	-	0	14/5= 2.8	3
	My Optum Health	8th	5	8th	5	7th	6	8th	5	8th	5	26/5= 5.2	5
My risk of heart disease	NCEP public use	3rd	10	3rd	10	3rd	10	3rd	10	5th	8	48/5=9.6	10
	My Optum Health	5th	8	6th	7	5th	8	6th	7	6th	7	37/5=7.4	7
	American Heart Association	8th	5	-	0	-	0	8th	5	-	0	10/5=2	2
	Healthwise Yahoo health	6th	7	7th	6	6th	7	7th	6	7th	6	32/5=6.4	6
Risk cardiac	NCEP professional use	5th	8	5th	8	5th	8	4th	9	4th	9	42/5=8.4	8
	CVHealth (university of Edinburgh)	7th	6	7th	6	7th	6	7th	6	7th	6	30/5=6	6
Risk Heart	American Heart Association	5th	8	9th	4	9th	4	2nd	11	-	0	27/5=5.4	5
	NCEP professional use	8th	5	7th	6	7th	6	6th	7	6th	7	31/5=6.2	6
Risk Heart attack	American Heart Association	2nd	11	5th	8	6th	7	6th	7	6th	7	40/5=8	8
	NCEP public use	8th	5	7th	6	8th	5	8th	5	8th	5	26/5=5.2	5
	My Optum Health	9th	4	8th	5	9th	4	9th	4	9th	4	21/5=4.2	4
Risk of heart disease	London School of Hygiene and Tropical Medicine	3rd	10	3rd	10	3rd	10	10th	3	6th	7	40/5=8	8
Risks leading to heart disease	London School of Hygiene and Tropical Medicine	6th	7	-	0	-	0	-	0	-	0	7/5=1.4	1

Risk tool heart condition	American Heart Association	1st	**12**	2nd	**11**	5th	**8**	5th	**8**	5th	**8**	47/5=9.4	9
	Mayo Clinic	2nd	**11**	1st	**12**	1st	**12**	1st	**12**	1st	**12**	59/5=11.8	12
	Siteman Cancer Center (Washington University) Homepage	3rd	**10**	3rd	**10**	2nd	**11**	2nd	**11**	2nd	**11**	53/5=10.6	11
	NCEP public use	5th	**8**	5th	**8**	3rd	**10**	3rd	**10**	3rd	**10**	46/5=9.2	9
	Disease risk index (Harvard school of public health)	7th	**6**	7th	**6**	6th	**7**	6th	**7**	7th	**6**	32/5=6.4	6
	CardioSmart (American College of Cardiology)	9th	**4**	10th	**3**	9th	**4**	9th	**4**	-	**0**	15/5=3	3
	Open Clinical (link to NCEP professional use)	10th	**3**	-	**0**	10th	**3**	10th	**3**	-	**0**	9/5=1.8	2
	Healthwise MSN	11th	**2**	-	**0**	-	**0**	-	**0**	-	**0**	2/5=0.4	0
	Health Risk Assessors EBSCO	-	**0**	9th	**4**	-	**0**	-	**0**	-	**0**	4/5=0.8	1
Questionnaire risk factors heart disease	Siteman Cancer Center (risk calculator page)	8th	**5**	8th	**5**	8th	**5**	8th	**5**	8th	**5**	25/5 =5	5
What is my risk of heart attack?	NCEP public use	1st	**12**	1st	**12**	1st	**12**	1st	**12**	3rd	**10**	58/5 = 11.6	12
	Healthwise Yahoo health	2nd	**11**	2nd	**11**	2nd	**11**	2nd	**11**	6th	**7**	51/5 =10.2	10
	My Optum Health	5th	**8**	5th	**8**	4th	**9**	3rd	**10**	5th	**8**	43/5 = 8.6	9
	American Heart Association	6th	**7**	10th	**3**	9th	**4**	7th	**6**	7th	**6**	26/5 =5.2	5
What is my risk of heart disease?	NCEP public use	3rd	**10**	3rd	**10**	3rd	**10**	2nd	**11**	3rd	**10**	51/5 =10.2	10
	Healthwise Yahoo health	4th	**9**	5th	**8**	4th	**9**	3rd	**10**	5th	**8**	44/5 = 8.8	9
	American Heart Association	6th	**7**	-	**0**	-	**0**	6th	**7**	-	**0**	14/5 = 2.8	3

	My Optum Health	8th	5	8th	5	7th	6	8th	5	8th	5	26/5 =5.2	5
Work out my risk of heart disease	NCEP public use	1st	12	1st	12	1st	12	1st	12	3rd	10	58/5= 11.6	12
	My Optum Health	2nd	11	2nd	11	2nd	11	2nd	11	4th	9	53/5= 10.6	11
	American Heart Association	3rd	10	-	0	3rd	10	3rd	10	5th	8	38/5 =7.6	8
	Reynolds risk score	-	0	4th	7	4th	7	4th	7	8th	3	24/5 =4.8	5
	Siteman Cancer Center (Washington University) Homepage	-	0	10th	3	-	0	-	0	-	0	3/5 =0.6	1

Appendix 10. Mean rankings for all web-based cardiovascular risk prediction tools retrieved by the tailored cardiovascular risk prediction tools search terms.

	Rank												
Search term	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Assess heart attack.	-	-	-	AHA	Healthwise MSN	-	-	-	-	-	-	-	-
Assess heart disease.	-	-	AHA	-	-	-	-	-	-	Healthwise MSN	-	-	-
Assess heart risk.	AHA	NCEP prof	LSHTM	-	-	-	-		Healthwise MSN	-	-	-	-
Calculate heart attack.	-	e-Tools Age	NCEP public My Optum Health	-	Reynolds risk score	-	-	Prevent disease. com	-	AHA	-	-	-
Calculate heart disease.	NCEP public	Reynolds risk score	-	e-Tools Age My Optum Health	-	-	-	-	-	-	LSHTM	-	-
Calculate heart risk.	LSHTM	NCEP prof	NCEP public	-	-	My Optum Health	-	-	University of Edinburgh (calculator info page) AHA	-	-	-	-

Search term	12	11	10	9	8	7	6	5	4	3	2	1	0
Heart attack assessment.	-	NCEP public AHA	-	-	NCEP prof	-	-	Health wise MSN	-	-	Cardio Smart	-	-
Heart disease assessment.	-	-	-	-	NCEP public AHA	-	Siteman Cancer Center Homepage NCEP prof	-	-	Cardio Smart	-	-	-
Heart risk assessment.	-	Patient UK	-	-	-	Heart Institute of the Cascades	NCEP prof AHA	-	-	Assign	-	Ethos Heart Aware	-
Heart attack calculator.	NCEP public	My Optum Health	-	Everyday Health	Med India	AHA	-	QRisk 2	Mayo Clinic	-	-	-	-
Heart disease calculator.	-	My Optum Health	Patient UK	LSHTM	-	University of Edinburgh (calculator info page)	Ethrisk NCEP public	QRisk 2	-	-	Mayo Clinic AHA	-	-
Heart risk calculator.	Patient UK	-	-	University of Edinburgh (calculator info page)	QRisk 2	LSHTM	-	-	-	AHA	NCEP prof	-	-

Search term	12	11	10	9	8	7	6	5	4	3	2	1	0
Heart attack prediction.	-	-	-	-	NCEP prof	-	-	-	-	-	-	-	-
Heart attack tool.	NCEP public	-	-	Healthwise Yahoo health NCEP prof	Mayo Clinic	AHA	-	Health wise MSN	-	-	-	Cleveland Clinic	-
Heart attack risk tool.	NCEP public	NCEP prof	-	AHA Healthwise AOL	Healthwise Yahoo health	-	-	Mayo Clinic	My heartrisk. net	Cleveland Clinic	-	Prolipid	-
Heart disease tool.	Mayo Clinic	NCEP public	-	-	-	Weight loss advisory. com	Health wise Yahoo health	Open Clinical	-	-	AHA	-	-
Heart risk tool.	NCEP prof	NCEP public	AHA	-	Mayo Clinic	-	-	-	-	Healthwise MSN	-	Open Clinical	-

Appendix 11. Mean rankings for all web-based cardiovascular risk prediction tools retrieved by the general layman search terms.

	Rank												
Search term	**12**	**11**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Am I at risk of heart disease?	-	-	-	-	-	-	-	-	-	-	AHA	My Optum Health	-
Calculate heart disease.	NCEP public	Reynolds risk score	-	e-Tools Age My Optum Health	-	-	-	-	-	-	-	LSHTM	-
Calculate my risk of heart disease.	NCEP public	Siteman Cancer Center Homepage	AHA	Revolution Health	-	My Optum Health	-	Heart Healthy Women Org	-	-	-	-	-
Cardiac disease risk.	-	-	-	-	-	LSHTM	-	-	-	University of Maryland Health Center	-	-	Medical college of Winconsin
Cardiac risk score.	Md + Calc	-	NCEP prof	LSHTM	-	AHA	-	-	-	-	-	-	-
Cardiovascular risk calculator.	University of Edinburgh (calculator info page)	University of Edinburgh (calculator page)	Patient UK	-	QRisk 2	UCL Hospital	GP training.net	-	LSHTM	The Filey Surgery	-	-	-
Cardiovascular risk score.	-	-	-	Patient UK LSHTM	-	-	Assign	NCEP prof	NCEP public	-	-	-	-

Search term	12	11	10	9	8	7	6	5	4	3	2	1	0
Chance of heart attack.	-	-	-	-	NCEP public	-	My Optum Health	-	-	-	Allina	-	-
Heart attack risk.	NCEP public	-	-	My Optum Health	-	-	-	-	-	-	AHA	-	-
Heart disease risk.	-	LSHTM	-	AHA	-	-	-	Medical college of Winconsin	University of Maryland Health Center	-	-	-	-
Heart disease risk assessment.	NCEP public	-	Siteman Cancer Center Homepage	-	-	-	-	-	-	AHA	-	Cardio Smart	-
Heart disease risk calculator.	-	Mayo Clinic	Patient UK	-	University of Edinburgh (calculator info page)	QRisk 2	LSHTM	NCEP public	My Optum Health	University of Maryland Health Center	-	-	-
Heart disease risk management.	-	-	AHA	-	-	-	-	-	-	-	-	-	-
Heart risk.	-	-	-	-	-	NCEP prof	-	-	AHA	-	-	University of Maryland Health Center	-

Search term	12	11	10	9	8	7	6	5	4	3	2	1	0
Heart risk calculator.	Patient UK	-	-	The University of Edinburgh (calculator info page)	QRisk 2	LSHTM	-	-	AHA	-	NCEP prof	-	-
Heart risk score.	-	-	NCEP prof LSHTM	-	-	Md + Calc	Patient UK	-	AHA	-	-	Reynolds risk score	The University of Edinburgh (calculator info page)
How can I find out my risk of heart disease?	-	-	-	-	-	Healthwise Yahoo health	-	NHS Choices	-	-	-	My Optum Health	-
My risk of heart attack.	-	-	NCEP public	Healthwise Yahoo health	-	-	-	My Optum Health	-	AHA	-	-	-
My risk of heart disease.	-	-	NCEP public	-	-	My Optum Health	Healthwise Yahoo health	-	-	-	AHA	-	
Risk cardiac.	-	-	-	-	NCEP prof	-	CVHealth	-	-	-	-	-	
Risk heart.	-	-	-	-	-	-	NCEP prof	AHA	-	-	-	-	

Search term	12	11	10	9	8	7	6	5	4	3	2	1	0
Risk heart attack.	-	-	-	-	AHA	-	-	NCEP public	My Optum Health	-	-	-	
Risk of heart disease.	-	-	-	-	LSHTM	-	-	-	-	-	-	-	
Risks leading to heart disease.	-	-	-	-	-	-	-	-	-	-	-	LSHTM	
Risk tool heart condition.	Mayo clinic	Siteman Cancer Center Homepage	-	AHA NCEP public	-	-	Disease risk index (Harvard)	-	-	Cardio Smart	Open Clinical	Health Risk Assessors EBSCO	Healthwise MSN
Questionnaire risk factors heart disease.	-	-	-	-	-	-	-	Siteman Cancer Center (risk calculator page)	-	-	-	-	-
What is my risk of heart attack?	NCEP public	-	Healthwise Yahoo health	My Optum Health	-	-	-	AHA	-	-	-	-	-
What is my risk of heart disease?	-	-	NCEP public	Healthwise Yahoo health	-	-	-	My Optum Health	-	AHA	-	-	-
Work out my risk of heart disease.	NCEP public	My Optum Health	-	-	AHA	-	-	Reynolds risk score	-	-	-	Siteman Cancer Center Homepage	-

Appendix 12. Aggregated mean ranking scores for web-based cardiovascular risk prediction tools retrieved by the search tailored to cardiovascular risk prediction tools.

	Risk prediction tool	Webpage retrieved	Aggregated rankings	Total ranking score
1st	NCEP public	http://hp2010.nhlbihin.net/atpiii/calculator.asp	10, 12, 10, 11, 8, 12, 6, 12, 12, 11, 11	115
2nd	AHA	http://www.americanheart.org/presenter.jhtml?identifier=3003499	9, 12, 10, 4, 3, 11, 8, 6, 7, 2, 3, 7, 2, 10	94
3rd	NCEP prof	http://hp2010.nhlbihin.net/atpiii/calculator.asp?usertype=prof (homepage) http://www.openclinical.org/app_nhlbiCHDrisk.htm (open clinical page)	11, 11, 8, 6, 6, 2, 8, 9, 11, 12 5, 1	90
4th	Healthwise	http://www.aolhealth.com/health-concern/interactive-tool-are-you-at-risk-for-a-heart-attack http://health.msn.com/health-topics/cholesterol/articlepage.aspx?cp-documentid=100105399 http://health.yahoo.com/heart-causes/interactive-tool-are-you-at-risk-for-a-heart-attack/healthwise--te7950.html	9 8, 3, 4, 5, 5, 3 9, 8, 6	60
5th	My Optum Health	http://www.myoptumhealth.com/portal/ManageMyHealth/Heart+Attack	10, 9, 7, 11, 11	48
6th	LSHTM	http://riskscore.lshtm.ac.uk/	10, 2, 12, 9, 7	40
7th	Mayo Clinic	http://www.mayoclinic.com/health/heart-disease-risk/hb00047	4, 2, 8, 12, 5, 8	39
8th	Patient UK	http://www.patient.co.uk/doctor/Primary-Cardiovascular-Risk-Calculator.htm	11, 12, 10	33
Joint 9th	e-Tools Age	http://www.etoolsage.com/Calculator%5CHeart_Attack_Risk_Calculator.asp?toolsort=1500	11, 9	20
	University of Edinburgh	http://cvrisk.mvm.ed.ac.uk/calculator.htm (calculator info page)	4, 7, 9	

10th	Reynolds risk score	http://www.reynoldsriskscore.org/	8, 11	19
11th	QRisk 2	http://www.qrisk.org/	5, 5, 8	18
12th	Everyday Health	http://www.everydayhealth.com/publicsite/ha_calculator.aspx	9	9
13th	Med India	http://www.medindia.net/patients/calculators/cardiacrisk.asp	8	8
Joint 14th	Heart Institute of the Cascades	http://www.yourheart.org/Your_Heart_Risk_Assessment/	7	
	Weight loss advisory.com	http://www.weightlossadvisory.com/heart_disease_tool.htm	7	7
Joint 15th	Ethrisk	http://www.epi.bris.ac.uk/CVDethrisk/CHD_CVD_form.html	6	
	Siteman Cancer Center	http://www.yourdiseaserisk.wustl.edu/ (homepage)	6	6
Joint 16th	Cardio Smart	http://www.cardiosmart.org/CardioSmart/Default.aspx?id=298	2, 3	5
	Prevent disease.com	http://preventdisease.com/healthtools/heart_attack_risk.html	5	
Joint 17th	Cleveland Clinic	http://my.clevelandclinic.org/heart/prevention/framingham.aspx	1, 3	4
	Myheartrisk.net	http://myheartrisk.net/	4	
18th	Assign	http://assign-score.com/	3	3
Joint 19th	Ethos Heart Aware	https://www.healthawareservices.com/nahrs/index.htm?hospID=108&moduleName=heartAware	1	1
	Prolipid	http://www.prolipid.com/tips-and-tools/heart-attack-risk-calculator.html	1	

Appendix 13. Aggregated mean ranking scores for web-based cardiovascular risk prediction tools retrieved by the general layman search terms.

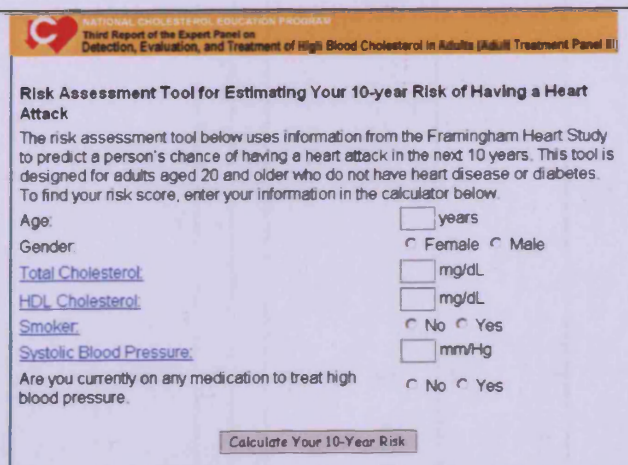
	Risk prediction tool	Webpage retrieved	Aggregated rankings	Total ranking score
1st	NCEP public	http://hp2010.nhlbihin.net/atpiii/calculator.asp	12, 12, 4, 8, 12, 12, 5, 10, 10, 5, 9, 12, 10, 12	133
2nd	AHA	http://www.americanheart.org/presenter.jhtml?identifier=3003499	2, 10, 7, 2, 9, 3, 10, 4, 4, 4, 3, 2, 5, 8, 9, 5, 3, 8	98
3rd	LSHTM	http://riskscore.lshtm.ac.uk/	1, 7, 9, 4, 9, 11, 6, 7, 10, 8, 1	73
4th	My Optum Health	http://www.myoptumhealth.com/portal/ManageMyHealth/Heart+Attack	9, 1, 7, 6, 9, 4, 1, 5, 4, 9, 5, 11	71
5th	NCEP prof	http://hp2010.nhlbihin.net/atpiii/calculator.asp?usertype=prof (homepage) http://www.openclinical.org/app_nhlbiCHDrisk.htm (open clinical page)	10, 5, 7, 2, 10, 8, 6, 2	50
6th	Patient UK	http://www.patient.co.uk/doctor/Primary-Cardiovascular-Risk-Calculator.htm	10, 9, 10, 12, 6	47
7th	Healthwise	http://health.yahoo.com/heart-causes/interactive-tool-are-you-at-risk-for-a-heart-attack/healthwise--te7950.html	7, 9, 6, 10, 9	41
8th	University of Edinburgh	http://cvrisk.mvm.ed.ac.uk/calculator.htm (calculator info page) http://cvrisk.mvm.ed.ac.uk/calculator/calc.asp (calculator page)	12, 8, 9, 0 11	40
9th	Siteman Cancer Center	http://www.yourdiseaserisk.wustl.edu/ (home page) http://www.yourdiseaserisk.wustl.edu/hccpquiz.pl?lang=english&func=home&quiz=heart (calculator page)	11, 10, 11, 1 5	38
Joint 10th	Mayo Clinic	http://www.mayoclinic.com/health/heart-disease-risk/hb00047	11, 12	23
	QRisk 2	http://www.qrisk.org/	8, 7, 8	

11th	Md + Calc	http://www.mdcalc.com/framingham-cardiac-risk-score	12, 7	19
12th	Reynolds risk score	http://www.reynoldsriskscore.org/	11, 1, 5	17
13th	University of Maryland Health Center	http://www.healthcalculators.org/calculators/heart_disease_risk.asp	3, 4, 3, 1	11
Joint 14th	Revolution Health	http://www.revolutionhealth.com/calculators/heart-attack-risk	9	9
	e-Tools Age	http://www.etoolsage.com/Calculator%5CHeart_Attack_Risk_Calculator.asp?toolsort=1500	9	
15th	UCL Hospital	http://www.mycvrisk.co.uk/	7	7
Joint 16th	Disease risk index (Harvard)	http://www.diseaseriskindex.harvard.edu/update/	6	6
	Assign	http://assign-score.com/	6	
	GP training.net	http://www.gp-training.net/doctors/utilities/fram/fram.htm	6	
	CVHealth (University of Edinburgh)	http://www.cvhealth.ed.ac.uk/	6	
Joint 17th	Heart Healthy Women Org	http://www.hearthealthywomen.org/index.php?view=article&id=382&Itemid=1&option=com_content	5	5
	Medical college of Winconsin	http://www.mcw.edu/display/router.asp?docid=3131	0, 5	
18th	Cardio Smart	http://www.cardiosmart.org/CardioSmart/Default.aspx?id=298	1, 3	4
19th	The Filey Surgery	http://www.fileysurgery.com/coronary_risk_calculator.htm	3	3
20th	Allina Hospitals and Clinics	http://www.allina.com/ahs/healthwellness.nsf/page/heart_assess	2	2

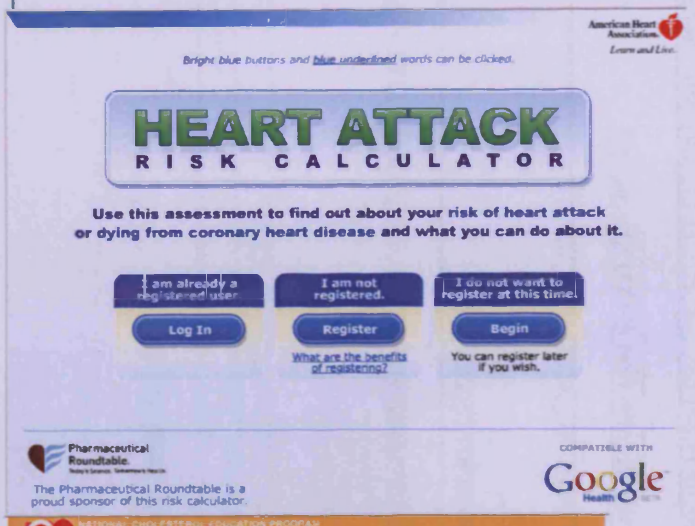
21st	Health Risk Assessors EBSCO	http://calculators.epnet.com/?docid=healthcalculators/chd/precalcdoc&token=59ffc286-2897-478f-9f5f-f40d3249a5a9&DeliveryContext=coe&CollectionIID=347&frame=ai1	1	1

Appendix 14. Homepages of top 10 ranked web-based cardiovascular risk calculators included in Critical Appraisal.

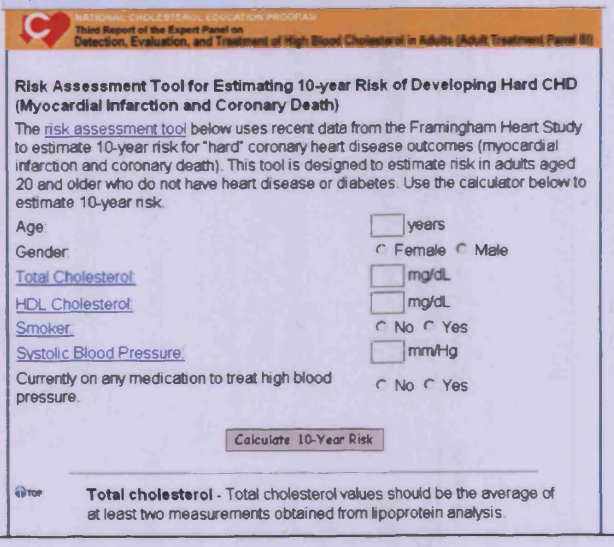
NCEP (public) - Risk assessment tool for estimating your 10 year risk of having a heart attack.



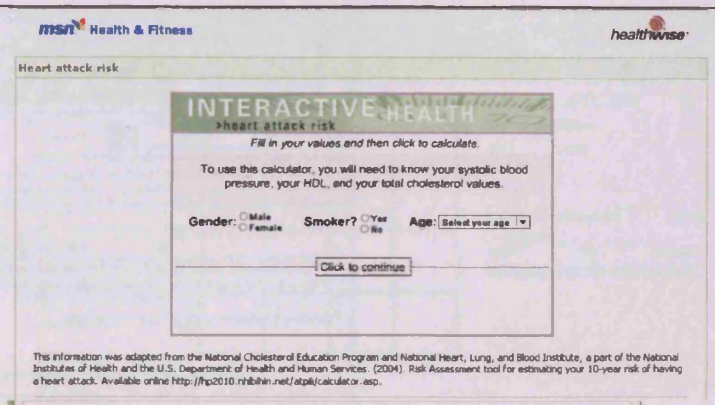
American Heart Association – Heart attack, coronary heart disease, metabolic syndrome risk assessment.



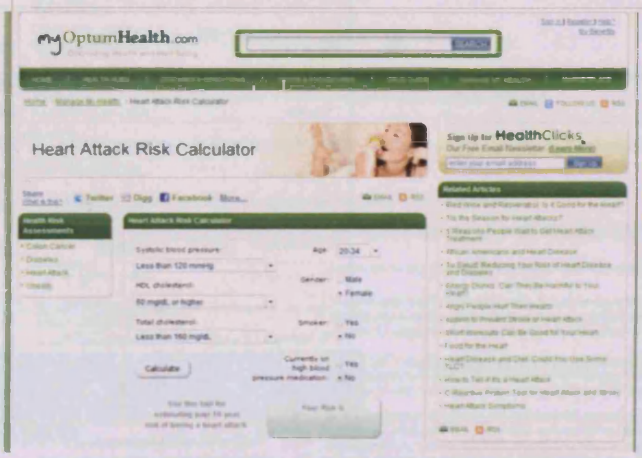
NCEP (prof) - Risk assessment tool for estimating 10 year risk of developing Hard coronary heart disease (myocardial infarction and coronary death).



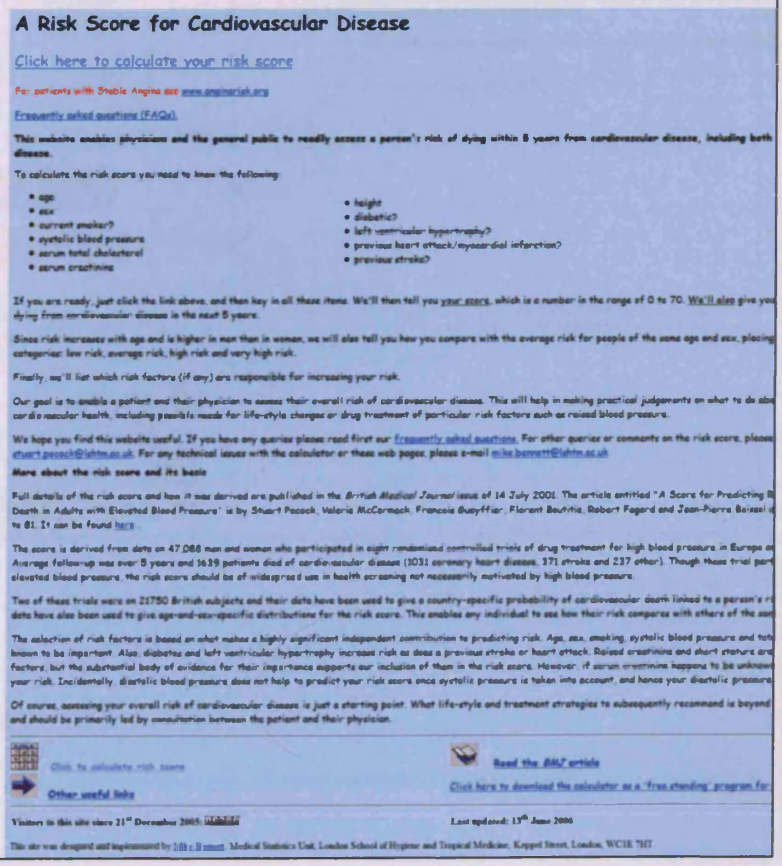
Healthwise – Interactive Health, heart attack risk.



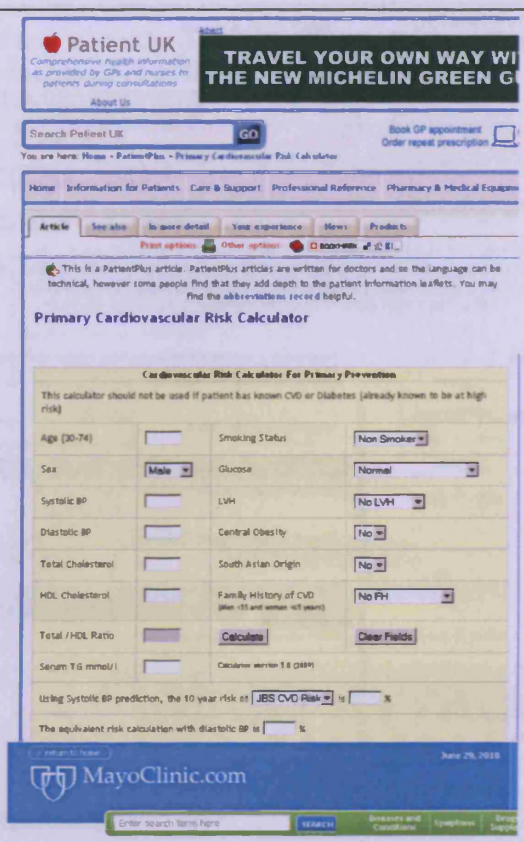
My Optum Health – Heart attack risk calculator.



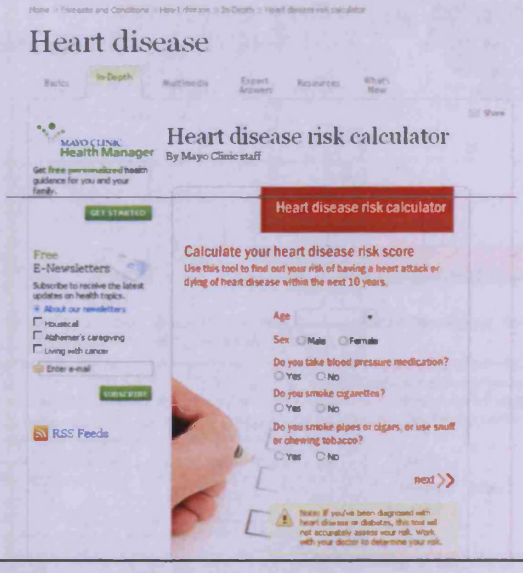
London School of Health and Tropical Medicine – A risk score for cardiovascular disease.



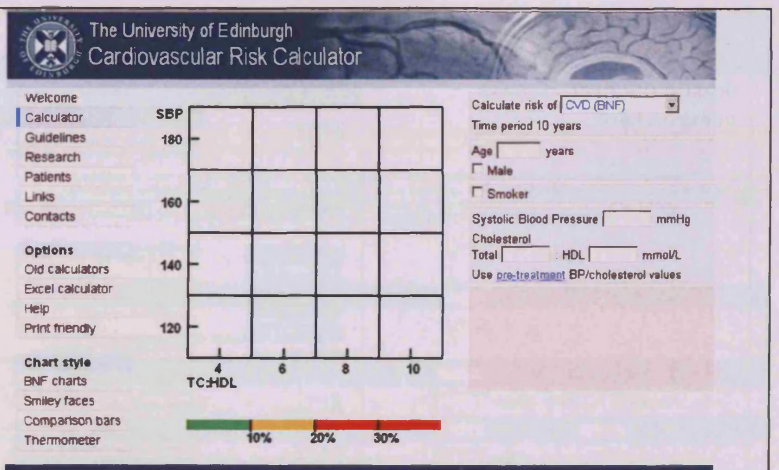
Patient UK – primary cardiovascular using algorithm.



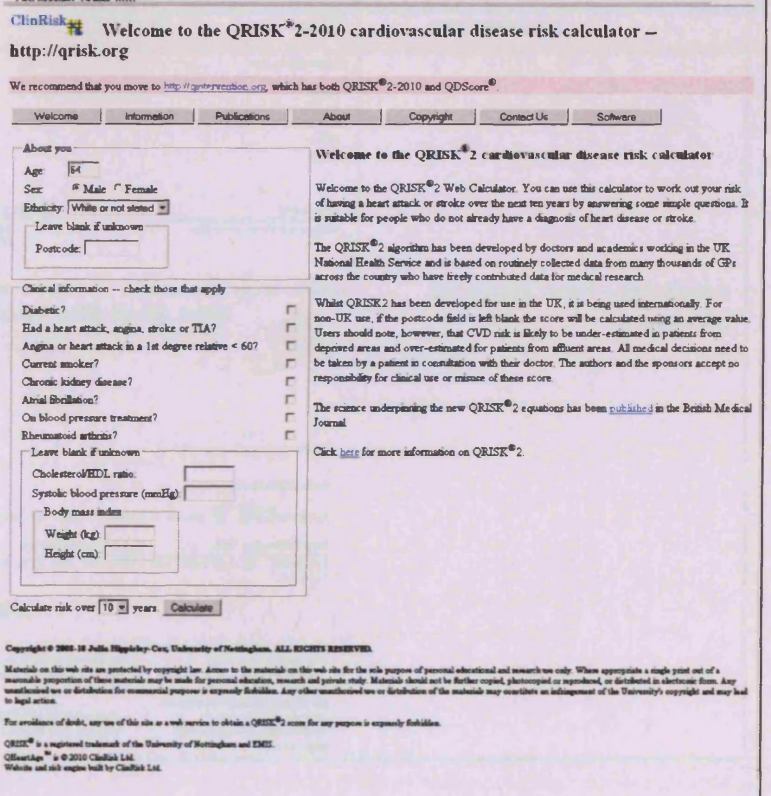
Mayo clinic – Heart disease risk calculator.



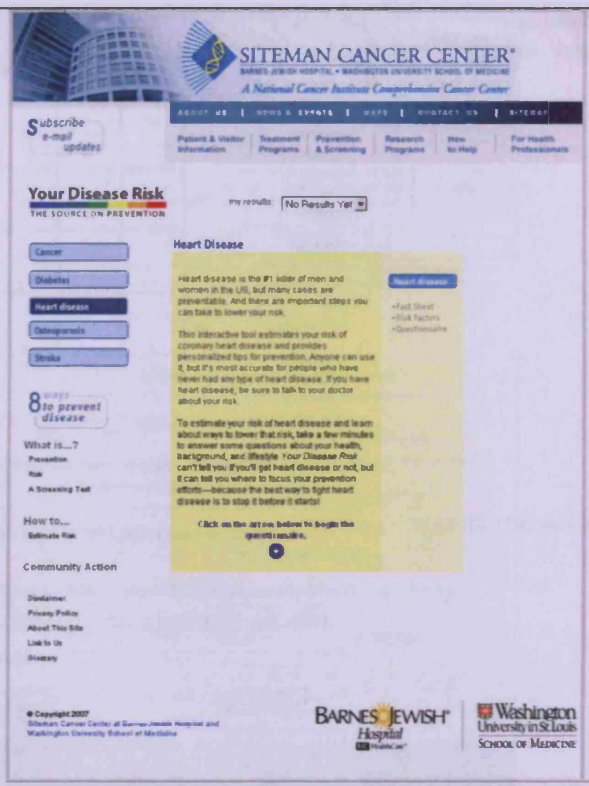
University of Edinburgh – Cardiovascular risk calculator.



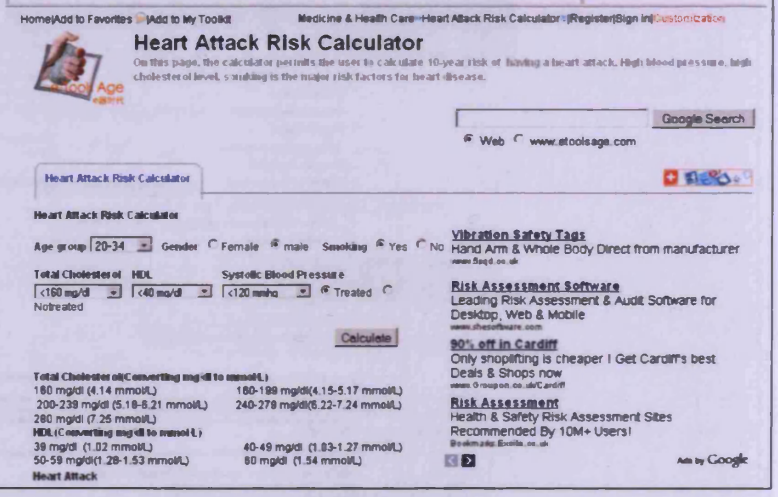
QRisk 2 – Cardiovascular disease risk calculator.



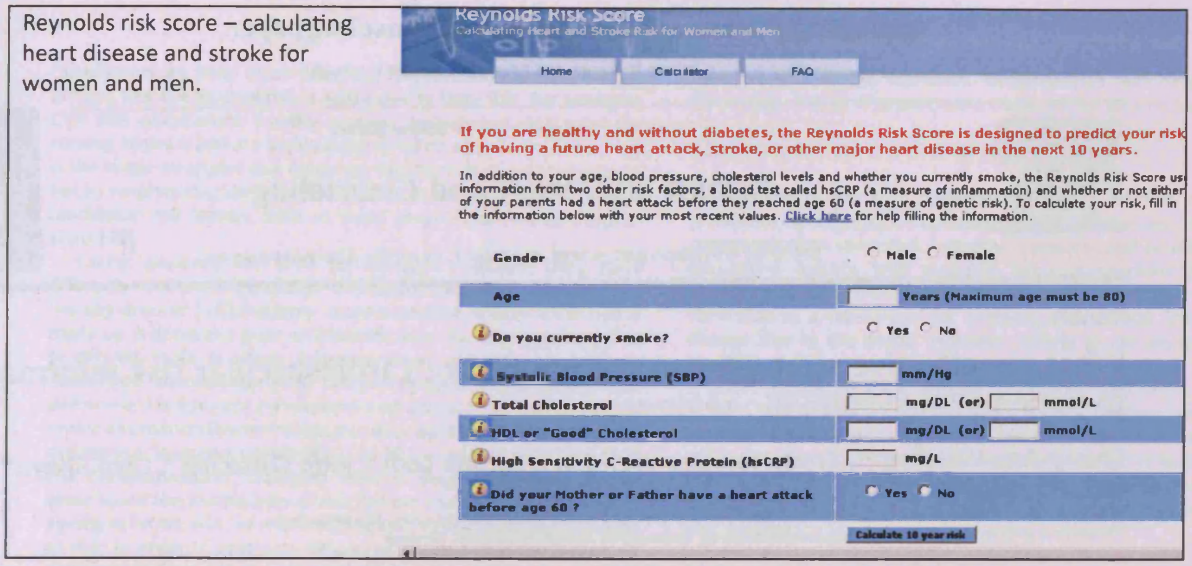
Siteman Cancer Center - Your disease risk heart disease questionnaire.



e-tools Age – Heart attack risk calculator.



Reynolds risk score – calculating heart disease and stroke for women and men.



Appendix 15. Patient Education and Counseling paper.

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Review

What are effective strategies to communicate cardiovascular risk information to patients? A systematic review

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ABSTRACT

Objective: To compare different interventions used to communicate cardiovascular risk and assess their impact on patient related outcomes.
Methods: A systematic search of six electronic data sources from January 1980 to November 2008. Data was extracted from the included studies and a narrative synthesis of the results was conducted.
Results: Fifteen studies were included. Only four studies assessed individuals' actual cardiovascular risk; the rest were analogue studies using hypothetical risk profiles. Heterogeneity in study design and outcomes was found. The results from individual studies suggest that presenting patients with their cardiovascular risk in percentages or frequencies, using graphical representation and short timeframes, is best for achieving risk reduction through behaviour change. However, this summary is tentative and needs further exploration.
Conclusion: Better quality trials are needed that compare different risk presentation formats, before conclusions can be drawn as to the most effective ways to communicate cardiovascular risk to patients.
Practice implications: Instead of directing attention to the accuracy of cardiovascular risk prediction, more should be paid to the effective presentation of risk, to help patients reduce risk by lifestyle change or active treatment.

1. Introduction

Although it is possible to quantitatively predict the risk of heart disease with increasing precision, such as Framingham, SCORE and QRISK2 [1–3], much less is known about how to make use of the risk prediction and how to portray and communicate the risk, in ways which motivate people to reduce their risk by modifiable factors. This paper reports a systematic review of studies which have compared different ways of communicating cardiovascular risk to patients.

There are various ways statistical risk information can be communicated to patients. Numerical expressions include percentages, natural frequencies and numbers needed to treat [4,5]. Graphical representations can also be used. These include bar graphs and pictograms or icon arrays [6]. The effects of risk presentation on patients' have been described previously [7–10]. For example, understanding, perceptions and behaviour are sensitive to the way the risk information is formatted and framed [11–14]. There is a call for this risk information to be presented in a simple and balanced way. Also, there is an emerging consensus that it is important to communicate risk appropriately and effectively, as poor representation of statistical information may result in sub-optimal choices and treatment [4,5,11]. We are not aware of any literature reviews that have focused on the effect of presentation formats for communicating cardiovascular risk to patients.

The communication of cardiovascular risk is particularly complex for a number of reasons. Firstly, there are multiple factors, such as age, cholesterol levels and smoking status that contribute to cardiovascular disease (CVD); with at least 80% of CVD, stroke and type 2 diabetes attributable to the existence of modifiable risk factors such as a poor diet, lack of physical activity and tobacco use [15].

Secondly, extended time horizons need to be considered. Heart disease is an insidious process and reducing its risk is work that has to be carried out over many decades, including multiple changes to lifestyle [16]. The optimum time to reduce risk is when aged in the early 20 s and certainly in the 30 s [17]. However, most risk

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calculations are done much later and the methods almost always assume that the issue of risk is addressed in later life. For example, CVD risk calculations usually present anticipated risk over the coming 10 years and are highly dependent on age as a variable. Age is the single strongest risk factor for future cardiovascular events, but by emphasising the impact of ageing in risk prediction models, modifiable risk factors, such as blood pressure are underemphasised [18].

Lastly, patients find CVD an abstract concept, they have difficulty interpreting personal candidacy for it and consider it a 'sneaky disease' [19]. Patients' understanding of how CVD risk is made up is generally poor and insufficient; the risk presented in prediction tools is often misunderstood, which can lead to unrealistic perceptions [20]. Misperceptions occur when the perceived risk does not correspond with actual risk; this can be an under-estimation (incorrect optimism or optimistic bias) or over-estimation (incorrect pessimism) [21,22]. In aggregate, then, CVD risk communication strategies need to help individuals better understand the multiplicity of risk factors and the contribution of ageing to future risk; as well as being able to promote perceptions of risk, in order to motivate behaviour change and for informed decisions to be made regarding cardiovascular health. A previous systematic review [23] on the effects of presenting coronary risk information has recently been conducted. It concluded that coronary risk information can improve accuracy of risk perceptions and increase intention to initiate prevention strategies. However, it did not focus on the differing forms that risk information can take.

The aim of this review was to compare the effectiveness of different interventions used to communicate cardiovascular risk and assess the impact of the formats used in these interventions, on patient related outcomes such as understanding, affect, intention to modify behaviour and reduction in actual risk.

2. Methods

2.1. Data sources and search strategy

Systematic searches of six electronic databases: ASSIA, EMBASE, MEDLINE, CINAHL, PsycINFO and Science Citation Index Expanded were conducted from January 1980 up to November 2008. Comprehensive search strategies (aiming for high recall, low precision) were adapted from Cochrane Heart Filter mesh terms. The search strategy included subject heading and keyword searching. Terms (such as cardiovascular disease; heart disease; risk communication; risk assessment) were combined. Searches were adapted to each of the databases used (available on request). Citations of retrieved papers were hand searched to identify further relevant studies.

2.2. Study inclusion and selection

Studies were eligible for inclusion if they: (1) were published in peer-reviewed journals written in English; (2) involved adult population (over 18 years old) (3) were of any quantitative design, such as randomised controlled trials (RCT) or observational; (4) compared risk communication interventions (of any format) for individualised cardiovascular risk assessment in primary or secondary care, against other interventions, with a control or usual care. Non peer-reviewed, unpublished or non-English language papers, qualitative designs, and those solely reporting the preferences patients had for risk presentation formats were excluded.

CAW conducted a title and abstract screen to select relevant studies, the selection was validated by GE and TvdW, who each checked half of the abstracts. Disagreement was resolved by discussion. Full text papers were obtained for included studies.

2.3. Data extraction and analysis plan

Data extraction was undertaken using a 64-item template (available on request), comprising population characteristics, risk communication strategies, outcome measures and results. Methodological quality was assessed using a checklist for both randomised and non-randomised studies [24]. This has been identified as a useful tool for assessing risk of bias [25]. It was chosen due to the broad inclusion criteria in the design of the studies.

CAW extracted data, and as validation, two other authors (TvdW and SL) each extracted data from a random half of the studies. Meta-analysis was not feasible due to the heterogeneity in study outcomes and therefore a narrative synthesis of findings was conducted. Studies were categorised into those that assessed individuals' *actual* risk and *analogue* studies that used hypothetical risk profiles.

3. Results

3.1. Included studies

Fig. 1 summarises the study selection and extraction process. 56 full papers were retrieved for further assessment and 29 were excluded. Of the 27 studies included for detailed data extraction, four were subsequently excluded because they only varied the *degree of risk* rather than the presentation or communication of risk formats [26–29]. Another five were excluded because the risk communication elements were embedded in a decision aid that had other components, and therefore, the outcomes could not be attributed to the risk communication strategy alone [30–34]. Lastly, three were excluded because they were not comparative studies of risk formats or did not report their comparison group [35–37]. No additional studies were found in the hand searching of the included studies' citations. In summary, fifteen studies were included. Only four studies assessed individual's actual risk, as the majority ($n = 11$) were analogue studies asking individuals to imagine a hypothetical risk profile. Table 1 provides a detailed description of each study in terms of design, sample, risk communication intervention, outcomes and main findings.

3.2. Quality of studies

Methodological quality of studies was assessed using the Downs and Black checklist [24]. Two studies were determined to be of good quality [38,39]. The other studies were deemed to be of medium quality [40–52].

Of the four studies where individuals' actual risk was calculated [38–41], two were RCTs [38,39] and two were observational [40,41]. The RCTs were of good quality: both were adequately powered and compared groups to identify possible confounders. In one trial the outcome assessor was blinded to the randomisation groups [38]. However, in the other trial, contamination of the control group may have occurred due to the randomisation at a patient and not physician level [39]. The two observational studies achieved lower quality scores.

Eleven analogue studies asked individuals to imagine a hypothetical risk profile. They were predominantly observational studies with a factorial design. Six studies randomised groups [43,47,48,50–52]; six attempted to identify principal confounders by comparing groups [42,45,47,50–52] and two blinded participants to the manipulations [47,49]. However, six studies did not report power calculations for sample sizes [42–45,48,49]; one was

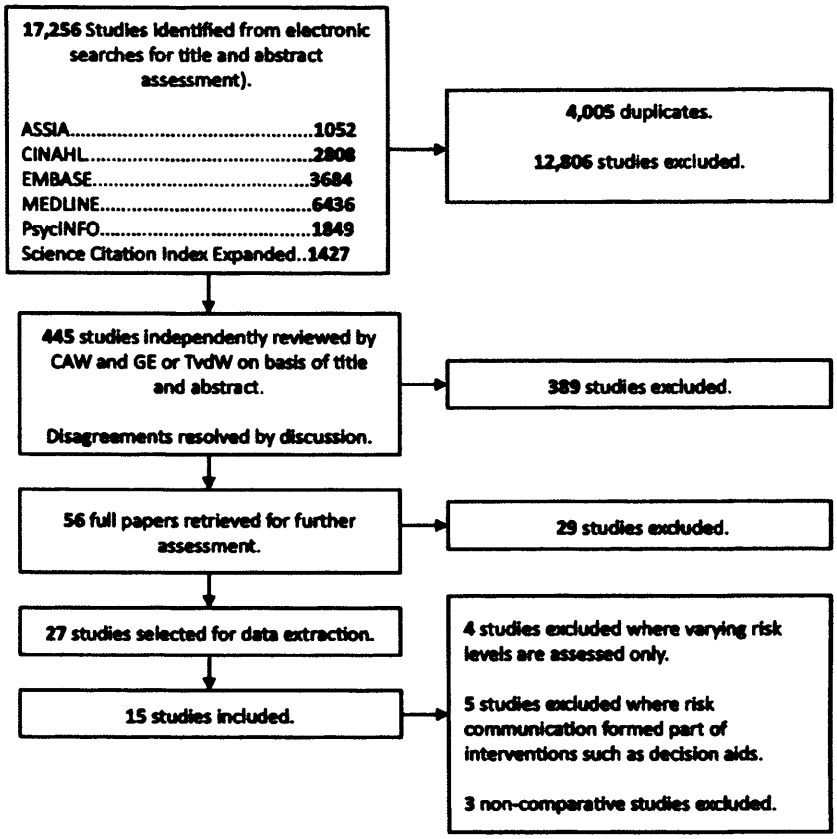

Fig. 1. Study selection and extraction process flowchart.

underpowered [52] and one reported concerns about the reliability of the findings because participants failed to follow questionnaire instructions [50]. There was variation of included studies in terms of risk presentation formats, type of cardiovascular risk, timeframe and outcomes measured (see Table 2).

3.3. Summary of findings

3.3.1. Numerical formats

One study assessing patients' actual risk [41] and seven analogue studies [42,43,45,46,49,51,52] compared a number of different numerical risk presentation formats with each other. Additionally, one actual risk study used a combination of two numerical formats in an intervention and compared it with usual care [39], and one analogue study compared a numerical format with risk categories [47].

Two analogue studies were concerned with whether perceptions of risk and emotional responses were sensitive to numerical risk presentation [42,43]. Fair and colleagues [42] examined the effect of two formats (percentages and frequencies) on responses to messages regarding the risk of coronary heart disease (CHD). Risk perceptions, emotions and behavioural intentions were sensitive to the format used. Frequencies led to higher perceived risk (OR = 2.471 (95% CI; 1.692–3.609), $p < 0.001$), more worry ($p < 0.001$), more disturbance ($p < 0.001$), and increased intention to make lifestyle changes ($p < 0.05$), than did percentages. Conversely, French et al. [43] used vignettes that presented risk of having a cardiac event in either percentage or frequency formats, and found no differing effect on risk perception, emotion or understanding.

One study assessing actual risk [41] and five analogue studies [45,46,49,51,52] were mainly concerned with presenting treatment effectiveness in differing numerical formats. These studies evaluated how different formats lead to differing acceptance rates of medication. Straus [41] compared formats for presenting the ratio of the benefits and costs of taking warfarin medication, and measured patients' intention to take warfarin. The highest percentage of patients (76.4%, $n = 13$) chose to warfarin when they were presented with the likelihood of being helped or harmed ratio. Conversely, the absolute risk reduction versus absolute risk increase ratio had the lowest percentage of patients choosing to take warfarin (17.6%, $n = 3$). It is not reported whether differences were significant and no confidence intervals are given. This study had a small sample ($n = 17$) and needs to be interpreted with caution.

In a cross-sectional study by Goodyear-smith [45], respondents with existing CVD were presented with descriptions of the benefit of a hypothetical medication to reduce the risk of a future heart attack. The same information was expressed in different formats. Their willingness to accept the medication was measured. The presentation of negatively framed 5-year absolute risk (expressed as percentages) encouraged acceptance the most, with 89% ($n = 89$) consenting to take medication when this format was presented. The numbers needed to treat (NNT) format encouraged acceptance of treatment the least compared to the other formats (67%, $n = 67$). This finding was also seen in a similar study by Hux and Naylor

Table 1
Design characteristics and principal results of included studies by type of risk assessment.

Author, year, country	Sample, context	Design, aim, methodological quality score	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Actual risk assessment in patients						
Asimakopoulou et al, 2008, UK [40]	95 patients with Type 2 diabetes and without existing cardiovascular disease (CVD), Diabetic Clinics and General Practitioner Surgeries.	Observational–factorial design, To examine the impact of communicating risk of coronary heart disease (CHD) and stroke, using 3 timeframes, on patients' perception, understanding of risk of CHD/stroke and their subsequent recall/memory for these risks, 13.	Absolute 1, 5 or 10-year risk of developing CHD/stroke as a result of having diabetes, using the UKPDS Risk Engine v2.0.	Numerical and graphical presentation: percentage of risk in given timeframe (1, 5, 10 years). Bar charts, with 10-slice pie chart and pictogram of 100 smiley faces used as supplements.	Risk perception, understanding and memory.	The 10-year timeframe produced consistently higher perceived, understood and recalled CHD risk estimates compared with both 1-year (mean difference = 14.52, $p < 0.001$) and 5-year groups (mean difference = 10.34, $p < 0.01$). This was also seen for stroke risk. The 10-year time frame produced consistently inflated understood and recalled risk estimates compared with both the 1-year (mean difference = 9.22, $p < 0.001$) and 5-year (mean difference = 6.27, $p < 0.05$) groups. Originally inflated risk perceptions of CHD were successfully corrected with the help of the graphical tools ($F_{1,92} = 73.01$; $p < 0.001$), as was inflated stroke risk ($F_{1,91} = 119.05$; $p < 0.001$), but 10-year risk group was the most resistant to correction for both CHD and stroke, as they were the only group who recalled much higher risk at 6 week follow-up than they understood at the consultation ($F_{4,176} = 4.73$; $p < 0.001$).
Charlson et al., 2008, USA [38]	660 patients undergoing coronary artery catheterization, Hospital.	Randomised controlled trial, To test whether an innovative approach of framing risk, based on 'net present value' economic theory (what patients can gain now), would be more effective in behavioural intervention than the standard 'future value approach' in reducing cardiovascular morbidity and mortality following angioplasty, 22.	Relative potential to improve current health status and quality of life, when modifying risk factors in the intervention group; and value of preventing future health problems in the control group.	Numerical presentation: Net present value approach (biologic age reduction one could achieve, if each risk factor was changed). Future risk approach, (risk reduction framed as the value of preventing future health problems).	Freedom from death, myocardial infarction (MI) stroke, angina or severe asymptomatic ischemia at 2 years, discrete stage of change and behaviour specific self-efficacy.	No significant differences were found between groups for the rates of death, stroke, MI, class II–IV angina or severe ischemia between the net present value group and future value group (p = non significant); or stage of change and self-efficacy (p = non significant). Over the 2-year follow-up, patients in both groups reached action on 1.5 risk factors.
Grover et al., 2007, Canada [39]	3053 men and women aged 30–70 years with diabetes or CVD; or men (aged 45–70) and women (aged 55–70) without CVD who had a 10-year coronary risk of at least 10% based on Framingham equations, Primary care.	Randomised controlled trial, To determine whether showing physicians and patient's the patient's calculated coronary risk can improve the effectiveness of treating dyslipidemia in a primary care setting, 22	Absolute and comparative 8-year cardiovascular risk, evidenced by increased cardiovascular age in intervention group; usual care in the control group.	Numerical and graphical presentation: Percentages and cardiovascular age. Comparative risk graphically summarised by population risk tertiles, so patient could see his/her absolute risk compared with that of peers. Vertical bar graphs showing risk change after each lipid profile was taken.	Changes in blood lipid levels and non-lipid risk factors, percentage of patients reaching lipid targets and global 10-year risk.	Over the 12-month follow-up the intervention (i.e. coronary risk profile) led to greater cholesterol reductions (OR = 1.26 (95% CI; 1.07–1.48, p value not reported). After adjustment for baseline difference between groups, the intervention group was more likely to reach the recommended lipid targets (OR = 1.26 (95% CI; 1.04–1.53, p value not reported). There was a significant interaction effect between the risk profile and cardiovascular age, in that the higher a patient's risk (evidenced by increased cardiovascular age) the greater the impact associated with the risk profile (OR = 1.69 (95% CI; 1.21–2.36; $p < 0.05$).
Straus, 2002, UK and Canada [41]	17 patients admitted for nonvalvular atrial fibrillation, Hospital	Observational–pre–post design, To test a patient-centred measure of the likelihood of being helped or harmed by an intervention, 13.	Ratios of being helped or harmed by warfarin medication (e.g. decreased risk of stroke and increased risk of haemorrhage).	Numerical presentation: • Absolute risk reduction/absolute risk increase (ARR/ARI). • Relative risk reduction/relative risk increase (RRR/RRI). • Number needed to treat/numbers needed to harm (NNT/NNH). • Likelihood of being helped or harmed) (LHH).	Patients' choice to take medication.	LLH had the highest percentage of patients choosing warfarin (76.4%, $n = 13$). 70.4% ($n = 12$) accepted treatment when presented with the ARR/ARI format, 47.1% ($n = 8$) accepted treatment when presented with NNT/NNH. ARR/ARI had the lowest percentage of patients choosing warfarin (17.6%, $n = 3$). Whether differences were significant was not reported.

Analogue studies						
Fair et al., 2008, UK [42]	740 respondents from general population who had not previously suffered from a medically diagnosed heart condition (heart attack or angina). Location not stated.	Quasi-experimental–factorial design. To test the hypothesis that responses to CHD risk estimates are heightened by use of ratio formats, peer group risk information, and long timeframes, 16.	Absolute and comparative 10 or 30 risk of CHD, based on risk tables published by the Framingham Heart Study.	Numerical presentation: Natural frequencies and percentages, either with or without comparative/peer group risk.	Risk perception, emotional response to risk information and intention to make lifestyle changes.	No main effect of timeframe on risk perception was observed. A significantly higher proportion of respondents perceived their risk to be higher when risk was presented in frequency formats (OR = 2.471 (95% CI; 1.692–3.609), $p < 0.001$), or if those risks were supplemented with peer group risk information (OR = 1.578 (95% CI; 1.144- 2.177), $p < 0.01$). Respondents presented with risks in the form of a frequencies reported feeling more worried ($p < 0.001$) and disturbed ($p < 0.001$) than those presented with percentages. Respondents who saw both personal and peer group risk information said they felt more worried ($p < 0.01$) and disturbed ($p < 0.01$) and less reassured ($p < 0.05$) than those who were presented with risk over a 10-year period. There was a significant interaction between age group and numerical expression of risk; when risk was expressed as a frequency, younger age groups (30–49 years) felt more worried ($p < 0.01$) and more disturbed ($p < 0.05$) than the older groups (50–70 years). There was also a significant interaction between age group and peer group risk, in which the younger age groups felt more worried ($p < 0.001$), more disturbed ($p < 0.05$) and less reassured ($p < 0.05$). Presentation of frequencies also increased intention to make lifestyle changes ($p < 0.05$). Peer group risk information failed to have an impact on intention to change (p = non significant). There was a significant interaction between peer group risk and age group on intention to change lifestyle. The 30–39 year old age group had a higher stated intention to change their lifestyle than the older age groups (when presented with peer group risk as well as personal risk ($p < 0.05$).
French et al., 2004, UK [43]	970 adults aged 40–60 with no history of heart disease. Location not stated.	Observational–factorial design. To examine the emotional and cognitive impact of personal and social comparison information about health risk and to examine the effect of presenting this risk information using different probability formats, and the presence or absence of format-congruent visual representations, 13.	Absolute and comparative 10-year risk of having a cardiac event (heart attack, angina, heart failure).	Numerical and graphical presentation: Vignettes describing the risk of having a cardiac event, with four factors manipulated: format (percentage or natural frequency); format-congruent visual representation, e.g. bar chart for percentages, pictogram for natural frequencies (presence or absence); level of social comparison risk (favourable or unfavourable) and level of personal risk (low or high).	Ratings of disturbance/worry, ratings of reassurance, likelihood of having a cardiac event, comparison of own risk compared to others and confidence in understanding of information given.	There were no main effects of frequency versus percentage format (p = non significant). Respondents who received a visual presentation gave lower ratings of being disturbed/worried ($M = 9.37$) than those who did not received a visual representation ($M = 10.98$) ($F(1,313 = 8.74$; $p < 0.01$). This main effect was not found for the ratings of being reassured. Favourable social comparison information led to significantly less disturbance/worry, more reassurance and lower personal susceptibility ratings than unfavourable information ($p < 0.05$). Unfavourable social comparison information had no discernible impact, relative to not providing any social comparison information. No difference in the comparison of own risk compared to others, between those who received unfavourable, favourable or no social comparison information. Personal risk had more of an impact on reassurance ($\eta^2 = 0.08$) than social comparison risk ($\eta^2 = 0.06$). This was also seen for disturbance/worry ($\eta^2 = 0.09$ vs. $\eta^2 = 0.05$) and perceived risk ($\eta^2 = 0.07$ vs. $\eta^2 = 0.03$).
Frileux et al., 2004, France [44]	150 respondents from a convenience sample without established heart disease. Location not stated.	Observational–factorial design. To explore the impact of the preventive medical message on intention to change behaviour; to explore the impact of the severity of the threatened disease manifestation, its likelihood, the time frame of the risk, the effectiveness of a preventive behaviour, and the nature of this behaviour on people's intention to engage in action to prevent the disease. 10	5, 10, 15, 20-year risk of coronary artery disease (CAD) presented as 2 severities: angina pectoris or heart attack.	Numerical presentation: percentages. Four different components of a message about preventing CAD were manipulated: severity (angina pectoris and heart attack); probability occurrence (5, 10, 15, 20%); time horizon (5, 10, 15, 20 years); level of controllability (entirely under your control or not much you can do to reduce it).	Intention to adopt a specific behaviour.	All 4 main factors had a significant effect on the intention to adopt a preventive behaviour. Greater severity (heart attack) produced greater intentions than lower severity (angina pectoris) ($p < 0.001$). The higher the probability the higher the estimated level of intention (effect stronger at low probabilities than at higher probabilities) ($p < 0.00001$). The shorter the time horizon the higher the intention ($F_{3,414} = 229.33$; $p < 0.001$). The lower the controllability, the lower the estimated level of intention to change behaviour. ($p < 0.00001$). Respondents intended to change behaviour even when told this would be of little use. There was an interaction between age and timeframe, where intention to adopt a preventive behaviour was greater for older participants (aged between 60 and 80 years) when shorter timeframes were used, and for younger participants (aged between 20 and 30 years)

Table 1 (*Continued*)

Author, year, country	Sample, context	Design, aim, methodological quality score	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Goodyear-Smith et al., 2008, New Zealand [45]	100 patients with existing heart disease (MI, angina or both), taking statins and who had experience with taking medications and making decisions regarding medications, Family Practice.	Quasi-experimental, explorative study, To determine which methods of expressing a preventive medication's benefit encourage patients with known cardiovascular disease to decide to take the medication 13.	5-Year risk of a heart attack with and without medication (16% with and 23% without medication).	Numerical and graphical presentation: • Relative and absolute risk (positive and negative framing) – percentages. • Detailed and simplified natural frequencies. • NNT. • Odds ratios. • Vertical bar graphs–natural frequencies of those who have and do not have a heart attack with and without medication.	Acceptance of treatment.	81% were willing to take medication regardless of the way the benefit of medication was expressed. Absolute risk (negative framing) encouraged acceptance of treatment the most, with 89% of respondents accepting treatment. NNT least encouraged acceptance of treatment, with 67% of respondents accepting treatment. Natural frequency bar graph produced a higher acceptance rate (86%) compared to its numerical equivalent (75%), it is not reported whether this was significant (p = not reported).
Hux and Naylor, 1995, USA [46]	100 outpatients of family practice, hypertension and cardiology centres, Private setting.	Quasi-experimental–cross-sectional design, To assess how three different formats of the same data affected the willingness to take what were implied to be different lipid-lowering drugs, 12.	Data on effectiveness of a drug to prevent myocardial infarction and heart disease.	Numerical presentation: • RRR and ARR percentages. • Positively and negatively framed NNT – number of people treated for 5 years to prevent one myocardial infarction. • Average gain on disease-free years – number of extra weeks free of heart disease. • Stratified gain in disease-free survival – percentages, e.g. *5% had an extra 2 to 6 years free from heart disease.*	Acceptance of treatment.	Relative risk reduction format had highest proportion accepting treatment (88%, n = 88). NNT had the lowest acceptance rate (31%, n = 31). Average gain in disease-free years had a 40% (n = 40) acceptance rate and stratified gain in disease-free survival had a 56% (n = 56) acceptance rate. A significantly higher percentage of patients accepted treatment on the basis of RRR (88%) than absolute risk reduction (42%) and NNT (31%) ($p < 0.001$).
Man-Son-Hing et al., 2002, Canada [47]	198 Volunteers aged 60–80 years without atrial fibrillation, Recruitment from outpatient geriatric and medical clinics.	Observational–factorial design, To compare the impact of quantitative vs. qualitative descriptions of probability risk estimates in decision aids on the clinical decision-making process, regarding stroke prevention in atrial fibrillation, 18.	Absolute 2-year probabilities of stroke and major haemorrhage with no antithrombotic therapy. Set at low (3%) or moderate (8%) risk.	Numerical and graphical presentation: natural frequencies and pictogram of 100 faces in the quantitative (numerical) condition; Category phrases describing the risk of stroke and bleeding (e.g. low, moderate, etc.) in the qualitative condition.	Choice of antithrombotic therapy, rank-order of stroke risk and realistic expectations of outcomes.	No significant difference between treatment choices for the low risk arm (p = non significant). In the moderate risk arm, respondents in the qualitative group were more likely to choose therapy at the extremes of effectiveness (warfarin or not therapy) (p = 0.01). Also, more persons in the qualitative group chose the options of aspirin and were 'unsure' than those in the quantitative group. The use of qualitative or quantitative decision aid made no significant difference in respondents' ability to rank-order their stroke risk in a quantitative or qualitative manner (all comparison p values >0.10). The quantitative (numerical) decision aid resulted in a significantly higher percentage of respondents having realistic estimates of the numerical probabilities for all outcomes compared to the qualitative decision aid (all values $p < 0.01$) e.g. when estimating the chance of stroke while taking warfarin, 76 and 32% of the quantitative and qualitative groups gave correct answers, respectively. Linear regression showed that female gender was significantly associated with an increased choice to take warfarin medication ($p < 0.05$).

Mason et al., 2008, USA [48]	683 respondents from a reactive sample of people who were not teachers or researchers, Internet survey completed remotely.	Observational–factorial design, To determine whether people focus primarily on information about their own risk status or on a comparison with others, 12.	Absolute and comparative 10-year risk of having a cardiac event (heart attack, angina, heart failure).	Numerical presentation: Percentages, absolute risk and 4 levels of increasing comparison risk difference.	Negative affect responses to the risk information (disturbed and worried) and seriousness of a cardiac event in a person of the same age and sex.	When maintaining constant relative differences between personal risk and comparison risk, negative affect was higher at high personal risk (20%) than at low personal risk (10%) ($p < 0.01$). Also, respondents responded to the magnitude of the difference between personal and comparison risk, such that, as the difference increased (in which personal risk was higher than comparison risk), so did negative affect, independently of personal risk ($F_{1,530} = 9.10$, $p < 0.01$, $\eta_p^2 = 0.044$). When maintaining constant absolute differences between personal risk and comparison risk, there was no significant main effect of level of personal risk (p = non significant). Affective responses to comparison difference were sensitive to relative difference between personal and comparison risk. Relative differences correlated negatively with personal risk ($F_{3,530} = 8.19$, $p < 0.01$, $\eta_p^2 = 0.044$). It could be argued that at higher levels of personal risk, the role of comparison information becomes less. Judgements of the severity and prevalence of cardiac events was not affected by personal risk and comparison difference whether controlling for relative or absolute differences (p = non significant).
Misselbrook and Armstrong, 2001, UK [49]	274 hypertensive patients and age/sex matched non-hypertensive patients, General Practice.	Quasi-experimental–cross-sectional design, To examine patients' choice about treatment in response to different forms of risk presentation of the benefits of treating mild hypertension, 13.	Benefit of treatment in reducing stroke.	Numerical presentation: • RRR and personal probability of benefit from treatment model – percentages. • NNT. • ARR – natural frequencies.	Acceptance of treatment.	For RRR most patients would accept treatment (92% CI; 89–96, $n = 255$). For absolute risk reduction 75% (95% CI; 70–80, $n = 208$) would accept treatment. For NNT 68% (95% CI; 63–74, $n = 188$) would accept treatment. Personal probability of benefit had least patients accepting treatment (44%, 95% CI; 38–50, $n = 121$) with the narrow majority declining treatment. Also, Hypertensive patients were significantly more willing than non-hypertensive patients to take treatment when presented with relative risk reduction information (Mann–Whitney $U = 6688$, $p < 0.001$).
Scott and Curbow, 2006, USA [50]	395 College/University women, University classrooms.	Observational study–factorial design, To examine the interactive effects of message frames and CVD risk factors on women's knowledge, beliefs, efficacy and behavioural intentions, 15.	No individualised risk estimates, generalised descriptive statements regarding the prevention of heart disease.	4 messages comprising either the probable benefits/gains of engaging in healthy behaviours or the probable costs/losses of not doing so, in either the short-term or long-term future, e.g. • Gain × Present • Gain × Future • Loss × Present • Loss × Future	Susceptibility, self-efficacy to prevent heart disease, perceived efficacy of behavioural interventions and behavioural intent.	There were no main or interactive effects of time orientation on any outcomes (p = non significant). Those who read a gain-framed message showed a significantly greater mean increase in self-efficacy to prevent heart disease compared to those who read a loss-framed message ($F_{1,291} = 8.21$, $p < 0.05$, effect size = 0.02). There was a significant interactive effect of message frame and parental history of high blood pressure for intention to check blood pressure ($F = 5.13$, $p < 0.05$, effect size = 0.01). Intention was significantly increased only in those with a family history exposed to the loss-framed message. Conversely, only the gain-framed message significantly increased intention in those without a family history. No other significant main or interactive effects of message and health history variables on any other outcomes.
Sorensen et al., 2008, Denmark [51]	1519 non-institutionalised Danes over 40 years randomly drawn from a national database at Statistics Denmark, Location not stated.	Observational–cross-sectional design, To explore whether lay people can discriminate between preventive interventions when effectiveness is presented in terms of relative risk reduction, and whether such discrimination is influenced by presentation of baseline risk, 18.	Death of a heart attack within 3 years.	Numerical presentation: percentages and natural frequencies (for baseline risk of heart attack). RRR achieved by a hypothetical drug treatment to prevent heart attacks presented as 10, 20, 30, 40, 50 or 60% in order to test whether baseline risk had an effect on acceptance of treatment. Baseline numeric risk information was either present or not.	Acceptance of treatment and perceived difficulty of understanding the size of the treatment effect.	No significant difference in acceptance rates across respondents who were and were not presented with baseline risk information (p = non significant). 76% of respondents reported that RRR was not difficult to understand. There was no difference in reported understanding of RRR across respondents who were or were not presented with baseline risk information (p = non significant). Respondents who reported no difficulties understanding the concept, were more likely to accept the hypothetical treatment irrespective of RRR-level and whether baseline risk had been presented ($p < 0.05$).

Table 1 (Continued)

Author, year, country	Sample, context	Design, aim, methodological quality score	Type of cardiovascular risk	Variables of the risk communication	Main outcome measure(s)	Main conclusions
Stovring et al., 2008, Denmark [52]	1169 respondents from a representative sample of individuals aged 40–59 with or without experience of CVD. University building.	Observational–pre–post design. To study the concordance of decisions based on one of four single information formats for treatment effectiveness with subsequent decisions based on all four formats combined with a pictorial representation, 17.	Absolute and relative 10-year risk of a fatal heart attack (5% and 15% risk).	Numerical and graphical presentation: • ARR and RRR percentages. • NNT. • Number of months for prolongation of life without heart attack (POL) (e.g. postponement of adverse outcomes). • Smiley face pictograms showing numbers affected with and without treatment and natural frequencies bar graph. information on treatment effectiveness presented in terms of (1) single information format and subsequently (2) picture in combination with data on NNT, RRR and life extension (POL).	Consent to therapy after the initial and final information, concordance of decision and difficulty in understanding.	Respondents initially presented with RRR generally became less likely to consent to treatment after receiving comprehensive information (73% (CI; 67–78) initial concordance rate and 67% (CI; 62–73) final concordance rate). While respondents initially presented with POL became more willing to accept treatment after having been given the fuller picture (56% (CI; 51–62) initial concordance rate and 64% (CI; 62–73) final concordance rate). However, it was not reported whether these differences were significant. ARR gave highest concordance (94%, CI; 91–97) between initial and final decision but was not statistically superior to the other formats (p = non significant). Followed by RRR, POL and NNT but differences were small. Difficulty in understanding did not affect the concordance of decision to accept treatment.

[46], where NNT resulted in only 31% (n = 31) of respondents willing to take the medication. Additionally, the relative risk reduction (RRR) format (expressed as percentages) elicited the highest proportion of respondents accepting treatment (88%, n = 88). When Misselbrook and Armstrong [49] presented the benefits of reducing the risk of stroke, the personal probability of benefit format led to the lowest percentage of respondents accepting treatment (44%, 95% CI; 38–50, n = 121) compared to the other formats. Again, the highest percentage of respondents accepted treatment on the basis of the RRR format (92% CI; 89–96, n = 255).

Stovring et al. [52] examined the concordance of the decision to accept treatment (e.g. whether the decision was upheld), when treatment effectiveness was presented as a single numerical format, and then as a more comprehensive, collective presentation of formats including absolute risk reduction (ARR), RRR and NNT. Decisions tended not to change with presentation of the comprehensive additional information. Furthermore, Sorensen et al. [51] examined acceptance rates of treatment to reduce risk of fatal heart attack. Acceptance did not change when the RRR format was supplemented with baseline risk information (expressed as natural frequencies), which would enable a calculation to determine perspective.

In the study that compared a numerical intervention with usual care, Grover et al. [39] gave patients a copy of their coronary risk profile. This comprised 8-year absolute cardiovascular risk presented as increased cardiovascular age, comparative risk (expressed as percentages) and bar graphs (to demonstrate the changes in patients' lipid levels over time). At 12-month follow-up, patients receiving their risk profile were more likely to reach lipid targets (OR = 1.26 (95% CI; 1.04–1.53, p value not reported) and achieve greater cholesterol reductions (OR = 1.26 (95% CI; 1.07–1.48, p value not reported).

Man-Son-Hing et al. [47] compared two versions of a decision aid that differed in the way they presented risk, using a factorial design. The purpose of the decision aid was to help with choices regarding antithrombotic therapy to prevent stroke; the risk information was presented in either quantitative numerical formats (natural frequencies) with graphical representations (pictograms with smiley faces); or in a more qualitative way (high to low risk categories). When the risk of stroke without antithrombotic therapy was presented as 'moderate' (8%), participants receiving the numerical information were significantly more likely to choose the therapy with the extremes of effectiveness (e.g. warfarin or no therapy) ($p < 0.01$); and those receiving the risk category information were more likely to choose aspirin (middle of the range effectiveness) and be more uncertain about their choice. This difference was not seen when a low (3%) risk of having a stroke with no therapy was presented. Additionally, those receiving the numerical decision aid were significantly more likely to have realistic risk perceptions, by giving correct estimates of the numerical probabilities for the outcomes achievable from therapy, than those who received the alternative risk category version ($p < 0.01$).

To summarise, studies looking at numerical risk presentation formats have found that making patients aware of their risk can encourage risk reduction action to be taken, especially if this risk is high. There is conflicting evidence regarding whether numerical presentation formats can effect patients' perceptions or emotions. However, numerical presentation of risk as opposed to simple risk categories (e.g. high, moderate, low) appears to lead to more accurate risk perceptions. Additionally, treatment decisions are sensitive to the way a treatment's effectiveness is presented. The RRR format appears to 'encourage' treatment the most and the NNT format leads to the least acceptance.

Table 2
Summary of cardiovascular risk manipulation of included studies by type of risk assessment.

Study	Numerical formats					Graphical formats			Risk			
	Percentages	Natural frequencies	Ratios	NNT	Other (state)	Bar graph	Pictogram	Other (state)	Absolute	Comparative	Relative	Risk reduction
Actual risk assessment in patients												
Asimakopoulou et al., 2008 [40]	•	–	–	–	–[a]	•	•	•[a]	•	–	–	–
Charlson et al., 2008 [38]	–	–	–	–	•[b,c]	–	–	–	–	–	•	•
Grover et al., 2007 [39]	•	–	–	–	•[d]	•	–	–	•	•	–	•
Straus 2002 [41]	–	–	•	–	–	–	–	–	–	–	•	•
Analogue studies												
Fair et al., 2008 [42]	•	•	–	–	–	–	–	–	•	•	–	–
French et al., 2004 [43]	•	•	–	–	–	•	•	–	•	•	–	–
Frileux et al., 2004 [44]	•	–	–	–	–	–	–	–	•	–	–	–
Goodyear-Smith et al., 2008 [45]	•	•	•	•	–	•	–	–	•	–	•	•
Hux and Naylor, 1995 [46]	•	–	–	•	•[e,f]	–	–	–	•	–	•	•
Man-son-Hing et al., 2002 [47]	–	•	–	–	•[g]	–	•	–	•	–	–	–
Mason et al., 2008 [48]	•	–	–	–	–	–	–	–	•	•	–	–
Misselbrook and Armstrong, 2001 [49]	•	•	–	•	–	–	–	–	•	–	•	•
Scott and Curbow, 2006 [50]	–	–	–	–	•[h]	–	–	–	–	–	–	–
Sorensen et al., 2008 [51]	•	•	–	–	–	–	–	–	•	–	•	•
Stoving et al., 2008 [52]	•	–	–	•	•[i]	•	•	–	•	–	•	•

Study	Time frame		Outcomes							
	≤10	>10	Risk perception	Emotional response	Understanding	Intention to change behaviour	Change in risk factors, Overall risk	Acceptance of treatment/ Medication choice		Other (state)
Actual risk assessment in patients										
Asimakopoulou et al., 2008 [40]	•	–	•	–	•	–	–	–		–[j]
Charlson et al., 2008 [38]	•	–	–	–	–	–	•	–		•[k,l]
Grover et al., 2007 [39]	•	–	–	–	–	–	•	–		–
Straus 2002 [41]	–	–	–	–	–	–	–	•		–
Analogue studies										
Fair et al., 2008 [42]	•	•	•	•	–	•	–	–		–
French et al., 2004 [43]	•	–	•	•	•	–	–	–		–
Frileux et al., 2004 [44]	•	•	–	–	–	•	–	–		–
Goodyear-Smith et al., 2008 [45]	•	–	–	–	–	–	–	•		–
Hux and Naylor, 1995 [46]	–	–	–	–	–	–	–	•		–
Man-son-Hing et al., 2002 [47]	•	–	–	–	–	–	–	•		•[m,n]
Mason et al., 2008 [48]	•	–	•	•	–	–	–	–		–
Misselbrook and Armstrong, 2001 [49]	–	–	–	–	–	–	–	•		–
Scott and Curbow, 2006 [50]	–	–	•	–	–	•	–	–		•[o,p]
Sorensen et al., 2008 [51]	•	–	–	–	•	–	–	•		–
Stoving et al., 2008 [52]	–	–	–	–	•	–	–	•		–

[a] Pie chart.
[b] Net present value approach (biologic age reduction).
[c] Future value approach.
[d] Cardiovascular age.
[e] Average gain in disease-free years.
[f] Stratified gain in disease-free survival.
[g] Categories.
[h] Descriptive statements.
[i] Stage of change.
[j] Memory/recall.
[k] Self-efficacy.
[l] Outcome expectation.
[m] Rank order of stroke risk.
[n] Outcome expectation.
[o] Self-efficacy.

3.3.2. Graphical formats

Six studies in this review used graphical representations, mainly bar graphs and pictograms. Two used actual risk assessment [39,40] and four were analogue studies [43,45,47,52]. No study compared different graphical formats with each other. Two studies compared a graphical format against its numerical equivalent [43,45]. Four studies used numerical and graphical formats collectively [39,40,47,52]; two of which used more than one graphical representation and reported the effect resulting from a combination of the graphical formats [40,52].

Four studies incorporated both graphical and numerical formats into their interventions. Asimakopoulou et al. [40] presented 1,5 and 10-year absolute risk of developing CHD or stroke to patients with diabetes, using percentages in conjunction with bar graphs, pictograms of smiley faces and pie charts. Patients' perceived risk was grossly inflated compared to their actual risk. The graphical tools helped to correct these inflated risk perceptions of CHD risk ($F_{1,92} = 73.01$; $p < 0.001$), as well as inflated stroke risk ($F_{1,91} = 119.05$; $p < 0.001$). Additionally, Grover et al. [39] presented patients with a risk profile comprising bar graphs to demonstrate the changes in patients' lipid levels over time. This was more successful in reducing cholesterol (OR = 1.26 (95% CI; 1.07–1.48, p value not reported) and meeting lipid targets (OR = 1.26 (95% CI; 1.04–1.53, p value not reported) than usual care.

Man-Son-Hing et al. [47] found that when the risk of a stroke without antithrombotic medication was moderate and presented as a pictogram of natural frequencies, as opposed to risk categories, more realistic risk perceptions resulted ($p < 0.01$) and therapy with extremes of effectiveness (e.g. warfarin or no therapy) was more likely to be chosen. Stovring et al. [52] presented comprehensive information about the effectiveness of a pharmaceutical drug, using a combination of four numerical formats and a pictogram showing numbers affected with and without treatment. Initial decisions to accept treatment made when one numerical format was presented first, did not change after subsequent presentation of the more comprehensive risk information. This finding is contradicted by Goodyear-Smith and colleagues [45] who found that acceptance of medication to reduce the risk of a heart attack increased by 11% (from 75% to 86%) when bar graphs (showing the number of people who do and do not have a heart attack when taking the medication, compared to those who do not taking it) were presented, as opposed to when the same information was expressed only numerically as natural frequencies. However, it is not reported whether this was significant.

Lastly, the effect of the presence or absence of graphical presentation was compared by French et al. [43]. When the risk of having a cardiac event was accompanied with visual representation (e.g. bar graphs for the percentage format, pictograms for the natural frequency format) significantly less disturbance and worry resulted, compared to those who did not receive visual representations ($F_{1,313} = 8.74$; $p < 0.01$). However, greater feelings of reassurance were not reported, which would intuitively be expected, and perceptions and behavioural intentions remained unaffected.

To summarise, studies that have used graphical presentation in their interventions have shown that presenting risk both graphically and numerically can lead to more accurate risk perceptions, to favourable changes in risk factors and can help reduce negative emotions. However, whether treatment decisions are sensitive to numerical or graphical formats used in the presentation of medication effectiveness is not clear.

3.3.3. Presentation of comparative risk

Comparative or peer group risk can be used to demonstrate how an individual's risk compares to that of the average person of the same age and sex. The effects of presenting comparative risk information were examined by four studies. Three were analogue [42,43,48]. Two of these compared the presentation of both personal and comparative risk against presentation of personal risk only [42,43]. One of these also examined the effect of presenting comparative risk higher or lower than personal risk [43]. One study examined the effects of relative differences between personal and comparison risk [48]. Assessment of actual risk was used in one study, which incorporated comparative risk into an intervention comprising numerical and graphical presentations [39].

Of the two studies that compared the presentation of personal and comparative risk against personal risk only, Fair et al. [42] found that risk perceptions and emotions were sensitive to the presence of comparative risk information. When messages about CHD contained information about both personal and comparative risk, respondents perceived their risk to be significantly higher (OR = 1.578 (95% CI; 1.144–2.177), $p < 0.01$), and reported more worry ($p < 0.01$), more disturbance ($p < 0.01$), and less reassurance ($p < 0.01$), than presentation of personal risk information only. However, behaviour intentions did not differ significantly. The other study by French et al. [43] assessed respondents' perceptions and emotions. Personal risk had more of an impact on reassurance ($\eta^2 = 0.08$) than social comparison risk ($\eta^2 = 0.06$). This was also seen for disturbance and worry ($\eta^2 = 0.09$ vs. $\eta^2 = 0.05$) and perceived risk ($\eta^2 = 0.07$ vs. $\eta^2 = 0.03$). This study also distinguished between the presentation of favourable and unfavourable comparative risk information, and compared this against not providing any comparative risk information. Those presented with favourable comparison information (e.g. average or below average risk) reported being significantly more reassured, less disturbed and worried and thought they were less likely to have a cardiac event, than those who received unfavourable information (e.g. above average risk) ($p < 0.05$). However, unfavourable comparison information had no discernible impact on risk perceptions or emotions, relative to not providing any comparison information.

Mason et al. [48] examined whether people attend mainly to information regarding personal risk or comparative risk. They presented hypothetical scenarios about the risk of a cardiac event. Levels of personal and comparison risk varied in these scenarios. As the difference between personal risk and comparison risk increased (in which personal risk was higher than comparison risk), so did worry and disturbance. ($F_{1,530} = 9.10$, $p < 0.01$, $\eta_p^2 = 0.044$). Furthermore, responses to the varying relative differences between personal risk and comparison risk correlated negatively with personal risk ($F_{3,530} = 8.19$, $p < 0.01$, $\eta_p^2 = 0.044$), suggesting that at higher levels of personal risk, the role of comparison information becomes less.

The study by Grover et al. [39] showed how an individual's risk compares to the average person by using the concept of cardiovascular age equivalent. This is calculated using the equivalent risk of a person who has no modifiable risk factors. In cases where an individual has modifiable risk factors, their risk will be higher than a person of the same age and sex without those factors; therefore their risk will be equivalent to someone older. When a risk profile was given to patients that presented comparative 8-year cardiovascular risk as cardiovascular age equivalent and percentages, patients had greater cholesterol reductions (OR = 1.26 (95% CI; 1.07–1.48, p value not reported) and were more likely to reach lipid targets (OR = 1.26 (95% CI; 1.04–1.53, p value not reported) over the 12-month follow-up, than those who did not receive their risk profile. In particular, an interaction effect was found where the higher the patient's risk (evidenced by increased cardiovascular age), the greater the impact of the risk profile (OR = 1.69 (95% CI; 1.21–2.36), $p < 0.05$).

To summarise, using comparative risk together with personal risk effects risk perceptions and emotions, and can reduce risk

factors. However, the impact of comparison risk depends on the level of personal risk; when personal risk is high, negative emotions are heightened and comparative risk is attended to less.

3.3.4. Framing of risk information

One analogue study investigated the impact of risk message framing [50]. Scott and Curbow [50] evaluated framing of messages regarding the probable benefits or costs of engaging in or not engaging in healthy behaviours relating to heart disease. These were presented as 'gain-framed' (e.g. benefits of engaging in healthy behaviours) or 'loss-framed' (e.g. costs of not engaging in healthy behaviours). Gain-framed messages led to a significant increase in self-efficacy to prevent heart disease as opposed to loss-framed messages ($F_{1,291} = 8.21$, $p < 0.05$, effect size = 0.02). Moreover, there was a significant interactive effect of message frame and parental history of high blood pressure for intention to check blood pressure ($F = 5.13$, $p < 0.05$, effect size = 0.01). Intention was significantly increased only in those with a family history exposed to the loss-framed message. Conversely, only the gain-framed message significantly increased intention in those without a family history.

3.3.5. Timeframe manipulations

The timeframe used when presenting cardiovascular risk information was manipulated in one study assessing actual risk [38] and four analogue studies [40,42,44,50]. Specific timeframes were not used in two studies, only present vs. future [38] and short-term vs. long-term [50]. One study examined time horizons less than 10 years [40]. Two studies [42,43] considered the presentation of risk over longer time horizons, greater than 10 years.

Charlson et al. [38] presented information about the reduction of cardiovascular morbidity risk achievable by modifying risk factors, using the 'net present value' approach (biologic age reduction one could achieve either in 3 months or 2 years, e.g. respondents told that changing behaviour would decrease their biological age) or the 'future value' approach (risk reduction framed as the value of preventing future health problems, e.g. respondents told changing behaviour would increase lifespan). However, at 2-year follow-up no differences between the two groups were found in rates of death, stroke, myocardial infarction, angina or severe ischemia, stages of change or self-efficacy. Also, Scott and Curbow [50] framed information about the costs and benefits of engaging in or not engaging in healthy behaviours, in relation to heart disease, in the short or long-term. The timeframe of the messages did not have an effect on behavioural intentions, self-efficacy or perceived susceptibility. It is argued that this may have been due to the young sample used and the future-oriented nature of heart disease.

Asimakopoulou et al. [40] presented the risk of developing CHD or stroke as a result of having diabetes in 1, 5 or 10 years, using percentages with graphical accompaniments. Originally inflated risk perceptions of CHD were successfully corrected with the help of the graphical tools ($F_{1,92} = 73.01$; $p < 0.001$), as was inflated stroke risk ($F_{1,91} = 119.05$; $p < 0.001$). However, those who received risk information in the 10-year timeframe were most resistant to correction and recalled a much higher risk at 6 week follow-up than they understood at the initial consultation ($F_{4,176} = 4.73$; $p < 0.001$), possibly suggesting they did not understand the concept of accrual of risk over time.

Frileux et al. [44] found that when individuals indicated their intention to adopt a specific behaviour for a number of scenarios that varied in the timeframe presented (either short 5 or 10 years, or long 15 or 20 years), shorter timeframes led to greater intention to change behaviour ($F_{1,138} = 29.66$; $p < 0.001$). In fact, the shorter the timeframe, the greater the intention to change behaviour ($F_{3,414} = 229.33$; $p < 0.001$). Furthermore, an interaction between age and timeframe was found, where intention to adopt preventive behaviour was greater for older participants (age between 60 and 80) when shorter timeframes were used, and for younger participants (aged between 20 and 30) when longer timeframes were used. Conversely, Fair et al. [42] found no effect of timeframe manipulation on perceptions, emotion or behavioural intentions, when 10 or 30-year timeframes were used in messages regarding CHD risk.

To summarise, patients remain insensitive to the framing of risk information merely in the short-term or long-term. The presentation of specific timeframes does have an effect; shorter timeframes (less than 10 years) may lead to more accurate risk perceptions and increased intention to change behaviour, than 10-year risk or longer, especially for older patients.

4. Discussion and conclusion

4.1. Discussion

This review demonstrates that compared to the intensive and ongoing investment in the calculation of cardiovascular risk estimates, there is a poverty of research on how to convey these estimates in a meaningful way, so as to motivate people to modify their risk of developing heart disease. We had broad inclusion criteria, yet only found 15 studies, 11 of which were analogue studies and only 4 studies which dealt with the presentation of actual risk to patients. The methodological quality of studies varied, the majority had observational designs and were heterogeneous with respect to the conceptualisation, formats and framing of cardiovascular risk probabilities. Therefore, only a few meaningful subgroups could be formulated (real or hypothesised risk, type of cardiovascular risk manipulation, etc.).

The conclusions we draw from these few studies are tentative and need further exploration. Nevertheless, we summarise the results from individual studies. Making patients aware of their risk can encourage risk reduction action to be taken, especially if this risk is high. Numerical presentation of risk as opposed to simple risk categories leads to more accurate risk perceptions and can influence treatment decisions. Relative risk reduction format 'encourages' acceptance of treatment the most and numbers needed to treat format encourages the least. The presentation of absolute and comparative risk, both graphically and numerically, effects risk perceptions and emotions and can lead to reduction in patient risk factors. However, the impact of comparison risk depends on the level of personal risk; comparative risk is attended to less when personal risk is high. Lastly, shorter timeframes (less than 10 years) lead to more accurate risk perceptions and increased intention to change behaviour, than timeframes longer than 10 years.

A strength of this review is that it comprised a comprehensive systematic literature search that aimed for high recall. Study inclusion and data extraction were agreed and validated by at least two reviewers throughout the reviewing process. Weaknesses include possible selection bias from the exclusion of unpublished literature and non-English language studies; and the fact that data extraction was not independent, but involved a validation procedure (however, consensus between reviewers was very high). Caution needs to be taken when interpreting this review's findings as it incorporated studies that used actual risk assessment and analogue studies. Real patients' differ from participants in hypothetical studies [12]. Additionally, multiple types of CVD risk were included (such as those for primary CHD prevention, secondary prevention, and stroke prevention in Atrial Fibrillation). Therefore, there may be an interaction of format effect by type of CVD risk, in which investigation is beyond the scope of this review.

The principal findings of this review confirm previous research indicating that visual displays have desirable properties that

enhance understanding of risk [6]; cardiovascular age equivalent formats are clear, memorable and considered an 'eye-opener' or 'wake-up call' [53]; natural frequencies are the natural way people think about risk probabilities and are effective in correcting inappropriate risk perceptions [8,22,54]; and the relative risk format is more favourably evaluated than other formats (such as absolute risk or numbers needed to treat) [7,55].

Studies in this review provided inconclusive evidence of the effect of presenting patients with comparative risk information. They demonstrated that individuals attend to risk information based on the magnitude of personal risk and their risk in comparison to others. These appear to be independent and additive, as comparing individual risk with the 'average' may be less important when ones' personal risk is high; possibly because the salience of the personal risk overrides the comparative information in these circumstances [48]. However, the exact nature of the effect on behavioural intentions, perceptions and emotion is arguable. This format is potentially important as it puts individualised risk into context and is a way demonstrating the risk attributable to non-modifiable risk factors, such as age. Previous studies have shown it to influence treatment decisions [56].

Furthermore, the cardiovascular age equivalent format should be an effective motivator in reducing risk [53], because in cases where an individual has multiple risk factors, their 'heart age' will be higher than their biological age. In this review, this format was assessed by one RCT [39]. An effect on the reduction of risk factors was found, especially when cardiovascular age was high; but this was only compared against not providing risk information to patients, not against alternative formats.

The inconsistency found in this review regarding the effect of longer timeframes (such as 15, 20 and 30 years), could be attributed to the fact that individuals are poorly attuned to how risk accumulates over time, are not good at forecasting the future, fail to take account of the timeframes used to represent risk and do not adjust their risk perceptions to account for the longer time spans [10,56–58].

The few studies that measured understanding did so by recall immediately after presentation, self reported confidence or perceived difficulty in understanding [40,43,51,52]. A question has to be asked as to whether these methods really do measure a patient's understanding of their risk, or mere recall of information. If this is the case, is there a more suitable way to measure understanding? Furthermore, only a small number of studies in this review used graphical representations, these being mainly bar graphs and pictograms; and no study compared graphical formats with each other (only graphics used collectively with numeric presentation).

This review highlights the tension between providing patients with neutral and unbiased risk information whilst presenting risk in a way that encourages behaviour change and risk reduction. During analysis, a distinction between two types of studies emerged; studies that seemed to use risk communication to achieve risk reduction by modifying lifestyle or taking medication, and those that did not. Two studies assessing real patients' risk, communicated risk in order to explicitly 'persuade' and reduce risk. They measured changes in risk factors or overall reduction of risk [38,39]. Three analogue studies had a persuasive motive as well, as they measured intention to change behaviour [42,44,50]. Seven studies (six analogue [45–47,49,51,52] and one real [41]) also persuaded to a lesser extent, and measured the acceptance of treatment to reduce cardiovascular risk. This raises debate as to how legitimate it is to persuade people to make decisions regarding their health, such as changing their behaviour or taking medication. In contrast, three studies (one real [40] and two analogue [43,48]) were concerned only with the emotional and cognitive aspects of the risk communication, such as what people thought about the risk presentation not how they acted upon it. The difference in outcomes measured by risk communication studies has been highlighted previously [59].

5. Conclusion

This review demonstrates a lack of well-designed studies in cardiovascular risk communication. This has been due to a combination of diverse methodological quality and contradictory results. It is likely that the heterogeneity of study characteristics, such as the design, sample and type of cardiovascular risk presented have contributed to this. A wide range of outcomes have been measured and there has been little consistency in risk presentation formats used, therefore, it is difficult to draw firm conclusions. Two different aims were identified in the communication of cardiovascular risk; first, risk communication to influence patient awareness and correct inappropriate risk perception to facilitate the decision to reduce risk; and second, the impact of different risk reduction strategies to facilitate the decision on how to reduce the risk.

5.1. Practice implications

There is a need for more research into the communication of actual risk to real patients. RCTs comparing different risk presentation formats are needed to examine whether peoples' intentions, perceptions and understanding of risk vary by graphical format. Projecting risk over longer time horizons to show increase in risk as the patient ages was attempted in the studies included in this review, but failed to have any desirable impact. It needs to be accepted that patients have difficulty in forecasting their future risk, and more meaningful projections should be used instead of presenting risk in an abstract 10-year horizon. This could be in the form of more salient outcomes and forecasts of loss in the future, such as not being able to achieve important milestones, birth of grandchildren or similar.

Determining how best to present cardiovascular risk information to patients strongly depends on the intended aims of the communication. Is the purpose to raise awareness and improve understanding, or to persuade those at risk to adopt new behaviours to reduce risk? Being clear about the communication aims would help clarify research in this complex area.

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Appendix 16. Search strategies for electronic databases.

Medline search strategy

Database: MEDLINE (1996- February Week 3 2008)

Search Strategy:

1. * Cardiovascular Diseases/
2. * Heart diseases/
3. * Coronary Disease/
4. Coronary heart disease$ .mp
5. **N/ 1-4**
6. * Risk/
7. * Risk factors/
8. relative risk .mp
9. absolute risk .mp
10. risk adj assess$ .mp
11. risk adj predict$ .mp
12. risk adj estimat$ .mp
13. risk adj perception .mp
14. risk adj analys$ .mp
15. risk adj calculat$ .mp
16. risk adj apprais$ .mp
17. risk adj approximat$ .mp
18. risk adj evaluation .mp
19. risk adj format .mp
20. risk adj score .mp
21. risk adj information .mp
22. risk adj display .mp
23. risk adj presentation .mp
24. risk adj Communication .mp
25. **N/ 6- 24**
26. **5 and 25**
27. **Limit to English language and human studies**

Embase search strategy

Database: EMBASE (1996- 2008 Week 09)

Search Strategy:

1. * Cardiovascular Disease/
2. * Heart Disease/
3. * HEART INFARCTION PREVENTION/
4. **N/ 1-3**
5. * Risk Assessment/
6. * RISK FACTOR/
7. relative risk .mp
8. absolute risk .mp
9. risk adj assess$ .mp
10. risk adj predict$ .mp
11. risk adj estimat$ .mp
12. risk adj perception .mp
13. risk adj analys$ .mp
14. risk adj calculat$ .mp
15. risk adj apprais$ .mp
16. risk adj approximat$ .mp
17. risk adj evaluation .mp
18. risk adj format .mp
19. risk adj score .mp
20. risk adj information .mp
21. risk adj display .mp
22. risk adj presentation .mp
23. risk adj Communication .mp
24. **N/ 5-23**
25. **4 and 24**
26. * CARDIOVASCULAR RISK/
27. * CORONARY RISK/
28. **26 or 27**
29. presentation .mp
30. communication .mp
31. **29 or 30**
32. **28 and 31**
33. **25 or 32**
34. **Limit to English language and human studies**

CINAHL search strategy

Database: Cinahl (1982–February Week 3 2008)

Search Strategy:

1. *CARDIOVASCULAR DISEASES/
2. *Coronary Disease/
3. *Heart Diseases/
4. Coronary heart disease$ .mp
5. **/N 1-4**
6. *RISK FACTORS/
7. *RELATIVE RISK/
8. *RISK ASSESSMENT/
9. absolute risk .mp
10. risk adj assess$ .mp
11. risk adj predict$ .mp
12. risk adj estimat$ .mp
13. risk adj perception .mp
14. risk adj analys$ .mp
15. risk adj calculat$ .mp
16. risk adj apprais$ .mp
17. risk adj approximat$ .mp
18. risk adj evaluation .mp
19. risk adj format .mp
20. risk adj score .mp
21. risk adj information .mp
22. risk adj display .mp
23. risk adj presentation .mp
24. risk adj Communication .mp
25. **N/ 6-24**
26. **5 and 25**
27. *CARDIOVASCULAR RISK FACTORS/
28. Presentation .mp
29. Communication .mp
30. **28 or 29**
31. **27 and 30**
32. **26 or 31**
33. **Limit to English Language**

PsycINFO search strategy

Database: PsycINFO (February Week 4 2008)

Search Strategy:

1. Exp Heart Disorders/
2. Exp Cardiovascular Disorders/
3. Exp Heart/
4. Cardiovascular disease$ .mp
5. Coronary heart disease$ .mp
6. Coronary disease$ .mp
7. Heart disease$ .mp
8. **/N 1-7**
9. Exp Risk Factors/
10. Exp Risk Assessment/
11. Exp Risk Perception/
12. relative risk .mp
13. absolute risk .mp
14. risk adj assess$ .mp
15. risk adj predict$ .mp
16. risk adj estimat$ .mp
17. risk adj perception .mp
18. risk adj analys$ .mp
19. risk adj calculat$ .mp
20. risk adj apprais$ .mp
21. risk adj approximat$ .mp
22. risk adj evaluation .mp
23. risk adj format .mp
24. risk adj score .mp
25. risk adj information .mp
26. risk adj display .mp
27. risk adj presentation .mp
28. risk adj Communication .mp
29. **N/ 9 -28**
30. **8 and 29**
31. **Limit to English language and human studies**

ASSIA search strategy

AND OR Combine	Search History
#23	**Search Query #23** ((**risk communication**) or (**risk presentation**) or (**risk display**) or (**risk information**) or (**risk score**) or (**risk format**) or (**risk evaluation**) or (**risk approximat***) or (**risk apprais***) or (**risk calculat***) or (**risk analys***) or (**risk perception**) or (**risk estimat***) or (**risk predict***) or (**risk factors**) or (**risk assessment**) or (**risk**)) and ((**coronary heart disease**) or (**heart disease**) or (**cardiovascular disease**)) (Copy Query) 1023 results found in Multiple Databases + 1509 results found in COS Scholar Universe: Social Science 2 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to Current Limited to: Published Works Only; English Only
#22	**Search Query #22** (**risk communication**) or (**risk presentation**) or (**risk display**) or (**risk information**) or (**risk score**) or (**risk format**) or (**risk evaluation**) or (**risk approximat***) or (**risk apprais***) or (**risk calculat***) or (**risk analys***) or (**risk perception**) or (**risk estimat***) or (**risk predict***) or (**risk factors**) or (**risk assessment**) or (**risk**) (Copy Query) 28051 results found in Multiple Databases + 15359 results found in COS Scholar Universe: Social Science 420 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to Current Limited to: Published Works Only; English Only
#21	**Search Query #21 risk communication** (Copy Query) 91 results found in Multiple Databases + 3648 results found in COS Scholar Universe: Social Science 1 result found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
#20	**Search Query #20 risk presentation** (Copy Query) 2 results found in Multiple Databases + 5425 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
#19	**Search Query #19 risk display** (Copy Query) 1 result found in Multiple Databases + 1262 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
#18	**Search Query #18 risk information** (Copy Query) 69 results found in Multiple Databases + 10042 results found in COS Scholar Universe: Social Science

	2 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #17	**Search Query #17 risk score** (Copy Query) 40 results found in Multiple Databases + 3030 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #16	**Search Query #16 risk format** (Copy Query) 1 result found in Multiple Databases + 1493 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #15	**Search Query #15 risk evaluation** (Copy Query) 13 results found in Multiple Databases + 6376 results found in COS Scholar Universe: Social Science 1 result found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #14	**Search Query #14 risk approximat*** (Copy Query) 1 result found in Multiple Databases + 3167 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #13	**Search Query #13 risk apprais*** (Copy Query) 72 results found in Multiple Databases + 1294 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #12	**Search Query #12 risk calculat*** (Copy Query) 9 results found in Multiple Databases + 2285 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #11	**Search Query #11 risk analys*** (Copy Query) 40 results found in Multiple Databases + 11868 results found in COS Scholar Universe: Social Science 1 result found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only

☐ #10	**Search Query #10 risk perception** (Copy Query) 459 results found in Multiple Databases + 4480 results found in COS Scholar Universe: Social Science 1 result found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #9	**Search Query #9 risk estimat*** (Copy Query) 77 results found in Multiple Databases + 5784 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #8	**Search Query #8 risk predict*** (Copy Query) 72 results found in Multiple Databases + 7378 results found in COS Scholar Universe: Social Science 0 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #7	**Search Query #7 risk factors** (Copy Query) 6926 results found in Multiple Databases + 9162 results found in COS Scholar Universe: Social Science 19 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #6	**Search Query #6 risk assessment** (Copy Query) 1645 results found in Multiple Databases + 6963 results found in COS Scholar Universe: Social Science 96 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #5	**Search Query #5 risk** (Copy Query) 28051 results found in Multiple Databases + 15359 results found in COS Scholar Universe: Social Science 420 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #4	**Search Query #4 (coronary heart disease)** or **(heart disease)** or **(cardiovascular disease)** (Copy Query) 2108 results found in Multiple Databases + 2101 results found in COS Scholar Universe: Social Science 17 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to Current Limited to: Published Works Only; English Only
☐ #3	**Search Query #3 coronary heart disease** (Copy Query) 801 results found in Multiple Databases + 489 results found in COS Scholar Universe: Social Science

	4 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #2	**Search Query #2 heart disease** (Copy Query) 1524 results found in Multiple Databases + 1636 results found in COS Scholar Universe: Social Science 14 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only
☐ #1	**Search Query #1 cardiovascular disease** (Copy Query) 700 results found in Multiple Databases + 1181 results found in COS Scholar Universe: Social Science 3 results found in Web Resources Related to the Social Sciences/Humanities Date Range: Earliest to 2008 Limited to: Published Works Only; English Only

Science Citation Index Expanded search strategy

Search History

Save History / Create Alert | Open Saved History

Set	Results	
# 9	1,288	#8 AND #3 Databases=SCI-EXPANDED Timespan=All Years
# 8	16,540	#7 OR #6 OR #5 OR #4 Databases=SCI-EXPANDED Timespan=All Years
# 7	9,409	TS=risk presentation AND Language=(English) Databases=SCI-EXPANDED Timespan=All Years
# 6	4,590	TS= risk communication AND Language=(English) Databases=SCI-EXPANDED Timespan=All Years
# 5	2,054	TS=risk display AND Language=(English) Databases=SCI-EXPANDED Timespan=All Years
# 4	764	TS=risk format AND Language=(English) Databases=SCI-EXPANDED Timespan=All Years
# 3	>100,000	#2 OR #1 Databases=SCI-EXPANDED Timespan=All Years
# 2	>100,000	TS=heart disease AND Language=(English) Databases=SCI-EXPANDED Timespan=All Years
# 1	77,591	TS=cardiovascular disease AND Language=(English) Databases=SCI-EXPANDED Timespan=All Years

Appendix 17. Data Extraction Template used in Systematic Review.

Study ID:

Section 1:

1.1 Author(s)	
1.2 Title	
1.3 Year	
1.4 Source	

Methods

Section 2: Details of study

2:1 Aim of intervention	
2:2 Time when study took place (not year of publication)	
2:3 Study design	
2:4 Methods of recruitment of participants	
2:5 Inclusion/exclusion criteria for participation in study	
2:6 Informed consent obtained?	Yes/No/Unclear
2:7 Ethical approval	Yes/No/Unclear
2:8 Funding and source	
2:9 Incentive?	Yes/No/Unclear

Section 3 Assessment of study quality

3:1 Randomisation	Yes/No/Unclear
3:2 Method of generating randomisation schedule for RCTs	
3:3 Method of concealment of allocation	
3:4 Blinding • Participants • Providers • Outcome assessor(s)	 Yes/No/Unclear Yes/No/Unclear Yes/No/Unclear
3:5 Baseline comparability of intervention and control groups	Yes/No/Unclear
3:6 Statistical methods and their appropriateness (if relevant)	
3:7 Power calculation	Yes/No/Unclear
3:8 Patient involvement • In design of study and/or intervention • In delivery of intervention • In evaluation of intervention • In interpretation of study findings	 Yes/No/Unclear Yes/No/Unclear Yes/No/Unclear Yes/No/Unclear
3:9 Advantages of study	
3:10 Limitations of study	

Section 4: Participants

4:1 Description	
4:2 Geographic location	
4:3 Setting	
Number	
4:4 Eligible	
4:5 Excluded	
4:6 Refused to take part	
4:7 Randomised to intervention	
4:8 Randomised to control	
4:9 Excluded post randomisation	
4:10 Withdrawn	
4:11 Lost to follow-up	
4:12 Died	
4:13 Included in analysis	
4:14 Included for each outcome	
4:15 Age: range, mean	
4:16 Gender	
4:17 Ethnicity	
4:18 Health status/problem/diagnosis	
4:19 Other health problem(s)	
4:20 Stage of problem/illness	
4:21 CVD related treatment received/receiving	
4:22 Other social/demographic details	

Section 5: Information on the nature of the CVS risk and formats used in the study

	Intervention A	Intervention B	control
5:1 Characteristics of intervention *(e.g. what the risk communication is embedded in/ general format of intervention)*			
5:2 Type of CVD risk presented *(e.g. CHD event / CVD death)*			
5:3 Mode of risk portrayal used *(e.g. percentages/odds ratio/ natural frequencies)*			
5:4 Format of risk presentation *(Specify)*			
• Narrative/verbal *(e.g. categories)*			
• Numerical			
• Graphical *(e.g. bar graph, pictogram, pie chart)*			
• Metaphorical			
5:5 Mode of delivery *(e.g. table/ score sheet/ calculator)*			
5:6 Medium *(e.g. Paper/computer/face to face consultation)*			
5:7 Interactive?			

Section 6: Outcomes

6:1 Principal outcome measures	
6:2 Secondary outcome measures	
6:3 Validated measurement tools for each outcome	
6:4 Methods of assessing outcome measures	
6:5 Methods of follow-up for non-respondents	
Timing of outcome assessment	
• 6:6 Frequency	
• 6:7 Length of follow-up	
6:8 Adverse events	

Section 7: Results

8. Study's conclusion	

Section 9: Miscellaneous

9:1 Changes in trial protocol	Yes/No/Unclear
9:2 Was study translated from a language other than English?	Yes/No/Unclear
9:3 Was the study a duplicate publication?	Yes/No/Unclear
9:4 Contact with author	Yes/No

Section 10: Notes:

Appendix 18. Downs and Black Checklist for measuring study quality.

	Reporting	*Yes*	*No*
1	***Is the hypothesis/aim/objective of the study clearly described?***	*1*	*0*
2	***Are the main outcomes to be measured clearly described in the Introduction or Methods section?*** If the main outcomes are first mentioned in the Results section, the question should be answered no.	*1*	*0*
3	***Are the characteristics of the patients included in the study clearly described?*** In cohort studies and trials, inclusion and/or exclusion criteria should be given. In case-control studies, a case-definition and the source for controls should be given.	*1*	*0*
4	***Are the interventions of interest clearly described?*** Treatments and placebo (where relevant) that are to be compared should be clearly described.	*1*	*0*
		Yes	*Partially*
5	***Are the distributions of principal confounders in each group of subjects to be compared clearly described?*** A list of principal confounders is provided.	*2*	*1*
		Yes	*No*
6	***Are the main findings of the study clearly described?*** Simple outcome data (including denominators and numerators) should be reported for all major findings so that the reader can check the major analyses and conclusions. (This question does not cover statistical tests which are considered below).	*1*	*0*
7	***Does the study provide estimates of the random variability in the data for the main outcomes?*** In non normally distributed data the inter-quartile range of results should be reported. In normally distributed data the standard error, standard deviation or confidence intervals should be reported. If the distribution of the data is not described, it must be assumed that the estimates used were appropriate and the question should be answered yes.	*1*	*0*
8	***Have all important adverse events that may be a consequence of the intervention been reported?*** This should be answered yes if the study demonstrates that there was a comprehensive attempt to measure adverse events. (A list of possible adverse events is provided).	*1*	*0*

9	***Have the characteristics of patients lost to follow-up been described?***	***1***	***0***
	This should be answered yes where there were no losses to follow-up or where losses to follow-up were so small that findings would be unaffected by their inclusion. This should be answered no where a study does not report the number of patients lost to follow-up.		
10	***Have actual probability values been reported(e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?***	***1***	***0***

External validity

All the following criteria attempt to address the representativeness of the findings of the study and whether they may be generalised to the population from which the study subjects were derived.

		Yes	***No***	***Unable to determine***
11	***Were the subjects asked to participate in the study representative of the entire population from which they were recruited?***	**1**	**0**	**0**
	The study must identify the source population for patients and describe how the patients were selected. Patients would be representative if they comprised the entire source population, an unselected sample of consecutive patients, or a random sample. Random sampling is only feasible where a list of all members of the relevant population exists. Where a study does not report the proportion of the source population from which the patients are derived, the question should be answered as unable to determine.			
12	***Were those subjects who were prepared to participate representative of the entire population from which they were recruited?***	**1**	**0**	**0**
	The proportion of those asked who agreed should be stated. Validation that the sample was representative would include demonstrating that the distribution of the main confounding factors was the same in the study sample and the source population.			
13	***Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?***	**1**	**0**	**0**
	For the question to be answered yes the study should demonstrate that the intervention was representative of that in use in the source population. The question should be answered no if, for example, the intervention was undertaken in a specialist centre unrepresentative of the hospitals most of the source population would attend.			

Internal validity - bias

14	***Was an attempt made to blind study subjects to the intervention they have received?***	**1**	**0**	**0**
	For studies where the patients would have no way of knowing which intervention they received, this should be answered yes.			

15	***Was an attempt made to blind those measuring the main outcomes of the intervention?***	1	0	0
16	***If any of the results of the study were based on "data dredging", was this made clear?***	1	0	0
	Any analyses that had not been planned at the outset of the study should be clearly indicated. If no retrospective unplanned subgroup analyses were reported, then answer yes.			
17	***In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case-control studies, is the time period between the intervention and outcome the same for cases and controls?***	1	0	0
	Where follow-up was the same for all study patients the answer should yes. If different lengths of follow-up were adjusted for by, for example, survival analysis the answer should be yes. Studies where differences in follow-up are ignored should be answered no.			
18	***Were the statistical tests used to assess the main outcomes appropriate?***	1	0	0
	The statistical techniques used must be appropriate to the data. For example nonparametric methods should be used for small sample sizes. Where little statistical analysis has been undertaken but where there is no evidence of bias, the question should be answered yes. If the distribution of the data (normal or not) is not described it must be assumed that the estimates used were appropriate and the question should be answered yes.			
19	***Was compliance with the intervention/s reliable?***	1	0	0
	Where there was non compliance with the allocated treatment or where there was contamination of one group, the question should be answered no. For studies where the effect of any misclassification was likely to bias any association to the null, the question should be answered yes.			
20	***Were the main outcome measures used accurate (valid and reliable)?***	1	0	0
	For studies where the outcome measures are clearly described, the question should be answered yes. For studies which refer to other work or that demonstrates the outcome measures are accurate, the question should be answered as yes.			
	Internal validity - confounding (selection bias)			
21	***Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?***	1		0
	For example, patients for all comparison groups should be selected from the same hospital. The question should be answered unable to determine for cohort and case control studies where there is no information concerning the source of patients included in the study.			

22	***Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited over the same period of time?*** For a study which does not specify the time period over which patients were recruited, the question should be answered as unable to determine.	**1**	**0**	**0**
23	***Were study subjects randomised to intervention groups?*** Studies which state that subjects were randomised should be answered yes except where method of randomisation would not ensure random allocation. For example alternate allocation would score no because it is predictable.	**1**	**0**	**0**
24	***Was the randomised intervention assignment concealed from both patients and health care staff until recruitment was complete and irrevocable?*** All non-randomised studies should be answered no. If assignment was concealed from patients but not from staff, it should be answered no.	**1**	**0**	**0**
25	***Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?*** This question should be answered no for trials if: the main conclusions of the study were based on analyses of treatment rather than intention to treat; the distribution of known confounders in the different treatment groups was not described; or the distribution of known confounders differed between the treatment groups but was not taken into account in the analyses. In nonrandomised studies if the effect of the main confounders was not investigated or confounding was demonstrated but no adjustment was made in the final analyses the question should be answered as no.	**1**	**0**	**0**
26	***Were losses of patients to follow-up taken into account?*** If the numbers of patients lost to follow-up are not reported, the question should be answered as unable to determine. If the proportion lost to follow-up was too small to affect the main findings, the question should be answered yes.	**1**	**0**	**0**
	Power			
27	***Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%?*** Sample sizes have been calculated to detect a difference of x% and y%.	**Size of *smallest* intervention group** A. <n1 = **0** B. n1–n2 = **1** C. n3–n4 = **2** D. n5–n6 = **3** E. n7–n8 = **4** F. n8+ = **5**		

Taken from: Downs S, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health 1998; 52 pp.377–84

Appendix 19. Scores of included studies on the Downs and Black Checklist for measuring study quality.

Checklist no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	TOTAL
Actual risk assessment in patients																												
Asimakopoulou et al 2008	Y 1	Y 1	Y 1	Y 1	P 1	Y 1	N 0	N 0	N 0	N 0	N 0	N 0		U 0	U 0	Y 1	U 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	U 0	N 0	**13**
Charlson et al 2008	Y 1	Y 1	Y 1	Y 1	Y 2	Y 1	Y 1	Y 1	Y 1	N 0	Y 1	N 0		N 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	U 0	Y 1	B 1	**22**
Grover 2007	Y 1	Y 1	Y 1	Y 1	Y 2	Y 1	Y 1	Y 1	Y 1	N 0	Y 1	Y 1		N 0	N 0	Y 1	Y 1	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	N 0	Y 1	Y 1	B 1	**22**
Straus 2002	Y 1	Y 1	Y 1	Y 1	N 0	Y 1	Y 1	N 0	N 0	N 0	N 0	N 0		N 0	U 0	Y 1	U 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	U 0	N 0	**13**
Analogue studies																												
Fair et al 2008	Y 1	Y 1	Y 1	Y 1	P 1	Y 1	Y 1	N 0	N 0	Y 1	Y 1	Y 1		N 0	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	N 0	N 0	A 0	**16**
French et al 2004	Y 1	Y 1	Y 1	Y 1	N 0	Y 1	Y 1	N 0	N 0	N 0	N 0	N 0		N 0	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	N 0	A 0	**13**
Frileux et al 2004	Y 1	Y 1	N 0	Y 1	N 0	Y 1	N 0	Y 0	N 0	N 0	N 0	N 0		N 0	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	N 0	N 0	A 0	**10**
Man-son-Hing et al 2002	Y 1	Y 1	Y 1	Y 1	Y 2	Y 1	Y 1	N 0	N 0	Y 1	U 0	U 0		Y 1	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	U 0	U 0	B 1	**18**
Mason et al 2008	Y 1	Y 1	N 0	Y 1	N 0	Y 1	N 0	N 0	N 0	Y 1	N 0	N 0		N 0	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	U 0	U 0	U 0	A 0	**12**
Scott and Curbow 2006	Y 1	Y 1	N 0	Y 1	P 1	Y 1	Y 1	Y 1	N 0	Y 1	N 0	N 0		N 0	N 0	Y 1	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	N 0	N 0	N 0	B 1	**15**
Goodyear-Smith et al 2008	Y 1	Y 1	Y 1	Y 1	P 1	Y 1	N 0	N 0	N 0	N 0	Y 1	N 0		N 0	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	N 0	N 0	A 0	**13**

Hux and Naylor 1995	Y 1	Y 1	N 0	Y 1	N 0	Y 1	N 0	N 0	N 0	N 0	N 0	N 0		N 0	N 0	Y 1	U 0	Y 1	Y 1	Y 1	Y 1	U 0	N 0	N 0	Y 1	U 0	B 1	**12**
Misselbrook and Armstrong 2001	Y 1	Y 1	Y 1	N 0	N 0	Y 1	Y 1	N 0	N 0	N 0	Y 1	N 0		Y 1	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	N 0	N 0	A 0	**13**
Sorensen et al 2008	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	Y 1	Y 1	Y 1		N 0	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	N 0	B 1	**18**
Stovring et al 2008	Y 1	Y 1	Y 1	Y 1	P 1	Y 1	Y 1	N 0	N 0	Y 1	Y 1	Y 1		N 0	N 0	Y 1	N 0	Y 1	Y 1	Y 1	Y 1	Y 1	Y 1	N 0	N 0	U 0	A 0	**17**

Appendix 20. BMC Health Informatics and Medical Decision Making paper.

Waldron *et al. BMC Medical Informatics and Decision Making* 2010, **10**:41
http://www.biomedcentral.com/1472-6947/10/41

BMC
Medical Informatics & Decision Making

STUDY PROTOCOL Open Access

The effect of different cardiovascular risk presentation formats on intentions, understanding and emotional affect: a randomised controlled trial using a web-based risk formatter (protocol)

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Abstract

Background: The future risk of heart disease can be predicted with increasing precision. However, more research is needed into how this risk is conveyed and presented. The aim of this study is to compare the effects of presenting cardiovascular risk in different formats on individuals' intention to change behaviour to reduce risk, understanding of risk information and emotional affect.

Methods/design: A randomised controlled trial comprising four arms, with a between subjects design will be performed. There will be two intervention groups and two control groups. The first control comprises a pre-intervention questionnaire and presents risk in a bar graph format. The second control presents risk in a bar graph format without pre-intervention questionnaire. These two control groups are to account for the potential Hawthorne effect of thinking about cardiovascular risk before viewing actual risk. The two intervention groups comprise presenting risk in either a pictogram or metonym format (image depicting seriousness of having a myocardial infarction). 800 individuals' aged between 45 and 64 years, who have not been previously diagnosed with heart disease and have access to a computer with internet, will be given a link to a website comprising a risk calculator and electronic questionnaires. 10-year risk of having a coronary heart disease event will be assessed and presented in one of the three formats. A post-intervention questionnaire will be completed after viewing the risk format. Main outcome measures are (i) intention to change behaviour, (ii) understanding of risk information, (iii) emotional affect and (iv) worry about future heart disease. Secondary outcomes are the sub-components of the theory of planned behaviour: attitudes, perceived behavioural control and subjective norms.

Discussion: Having reviewed the literature, we are not aware of any other studies which have used the assessment of actual risk, in a trial to compare different graphical cardiovascular risk presentation formats. This trial will provide data about which graphical cardiovascular risk presentation format is most effective in encouraging behaviour change to reduce cardiovascular risk.

Trial registration: Current Controlled Trials ISRCTN91319318

Background

The risk of heart disease can be predicted with increasing with precision, with the development of algorithms such as Framingham, SCORE and QRISK2 [1-3]. Less is known about how to portray and communicate cardiovascular risk in ways that motivate people to modify their lifestyle to reduce this risk. However, recent research on the effects of presenting coronary risk information found that the presentation of global coronary heart disease (CHD) risk estimates can improve the accuracy of risk perceptions and increase intention to initiate prevention strategies [4]. A systematic review on the effects of different interventions used to communicate cardiovascular risk [5], found that studies comparing interventions for cardiovascular risk presentation

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have been heterogeneous in design, and that many have been of low methodological quality. Very few studies assessed patients' actual risk. The majority were analogue studies where individuals were asked to imagine a hypothetical risk. There was no consistency in which presentation formats were used (percentages and natural frequencies were the most commonly assessed), and only a small number of studies used graphical representations (mainly bar graphs and pictograms). A wide range of outcome measures were assessed, including changes in risk and risk factors, intention to change behaviour and acceptance rates of treatment. The lack of coherent research, and need for methodologically sound trials provides the basis for this proposed trial. The purpose of this trial is to assess cardiovascular risk communication strategies and their impact on preventative behavioural intentions.

At least 80 percent of heart disease, stroke and type 2 diabetes are thought to be attributed to the modifiable risk factors of poor diet, lack of physical activity and tobacco use [6]. Therefore, lifestyle and behaviour change is important in order to reduce the impact of these factors and decrease the incidence rate of heart disease in the population. Informing patients of their future risk is the first step in helping them make decisions about reducing their risk. However, the way this risk information is formatted and framed can influence understanding, perceptions and behaviours [7-10]. Difficulties in communicating cardiovascular risk arise due to the interaction of many variables. Most research has focused on epidemiological precision rather than on how to motivate behaviour change. It has also overlooked the major contribution to risk arising from age (an unmodifiable risk variable) and the difficulty people have in considering risk over long time horizons, such as 10 years spans [11].

Although previous research has compared different graphical risk presentation formats relating to conditions such as diabetes and hereditary breast cancer [12-15]; studies have yet to compare graphical cardiovascular risk presentation formats with each other, especially when assessing and presenting patients' actual risk [5].

There are numerous, commonly used theoretical approaches to health behaviour and behaviour change [16-19]. However, of particular interest is the Theory of Planned Behaviour (TPB) [20]. This theory postulates that behaviour is determined by a small number of factors, namely attitudes, subjective norms and perceived behavioural control. It has empirical support for predicting a wide range of behaviours [21,22]. It predicts intention, which is generally regarded as a strong predictor of behaviour, as people tend to engage in behaviours that they plan to perform [23]. In instances where it is not feasible to measure actual behaviours, intention can be an adequate proxy.

Models are unable to account for every factor that influences behaviour. Most health behaviour theories fail to consider emotion or affect in the form of 'feelings' as opposed to 'affective judgements' [24]. Emotions are important when considering behaviour relating to the reduction of cardiovascular risk, as they have been shown to influence perceptions of risk [25,26] which in turn, can affect health-related behaviour [27]. In our systematic review on cardiovascular risk communication [5], emotional responses to cardiovascular risk were only addressed in analogue studies requiring individuals to imagine a hypothetical risk profile. There is currently little information on the impact of emotions when people are asked to consider their actual cardiovascular risk.

'Worry' is extremely relevant when thinking about one's future risk of heart disease. It has been associated with risk perception and is referred to as cognition 'coloured by affect' [28,29]. Some suggest that worry contains an appraisal of risk elements (such as likelihood and loss) [30] and is not necessarily maladaptive. Specifically, previous research has found that worry positively predicts behavioural intentions [31]. When at high levels, worry can lead to the uptake of screening behaviour [32] and has found to be the strongest predictor of contemplation to quit smoking [33]. However, evidence has also been found for an inverted-U or curvilinear relationship between worry and consequent behaviour [34]. Too much worry can lead to the activation of defensive mechanisms, where incoming information is ignored or distorted [35]. When communicating cardiovascular risk, we do not know how much worry is beneficial and would lead to increasing an individual's motivation to reduce risk versus denial. At what level does worry induce a positive intention to reduce risk, and is there an optimum level before the risk communication process becomes inhibitory?

Patients' understanding of their own cardiovascular risk is generally poor to the point of being non-existent. In addition, there is evidence to show that the data presented in cardiovascular risk prediction tools is often misunderstood [26,36]. This can inhibit people from making informed decisions regarding their health and behaviour. There is as yet no consensus as to which format is most effective in terms of facilitating patient understanding of their risk information [37]; and also, what the most appropriate way to measure understanding actually is. It is argued that current attempts used in the communication of cardiovascular risk, such as recall, self-reported confidence in understanding and perceived difficulty in understanding are not suitable methods; as repetition and personal judgements do not indicate that

individuals' have derived the correct meaning and possess a true understanding [5].

A prerequisite of understanding health related risk information is adequate numeracy and literacy skills. These are poor in many adults, leading to difficulty with simple decimal places and ratio concepts (including fractions, proportions and probabilities) [38]. It has been documented that smokers with lower literacy skills, are less likely to understand their risk of heart disease and stroke [39]. This may be because interpreting risk information involves a hierarchy of skills ranging from calculation, inferences and interpreting tables and charts, which is problematic for those with lower levels of numeracy [40]. Therefore, an important question is: can understanding of risk information be improved? Are there alternative ways of presenting cardiovascular risk to individuals' that are not numerically-based, precise estimates, but more qualitative, gist representations? These are arguably what are most required, as they are used when 'interpreting' the given risk information [41].

One contender for representing gist information is the concept of a metonym. This is a type of metaphor and involves part and whole relations and associations. It is a word for a part of something, used to refer to the whole entity; or the whole is referred to in terms of something associated with it [42]. An example would be representing heart disease by using the concept of a myocardial infarction. Metonyms are important to everyday life as their concepts structure thoughts, attitudes and actions, as well as language [43]. Using a metonym to present future risk of a disease could be a way of improving affective forecasting, as people are not good at predicting the future [44]. It is a striking symbolisation what the disease encompasses, rather than an abstract numerical value. As far as we are aware, there are no existing studies that have used the metonym concept to present risk information.

The concept defined as correlational validity by Ubel [45], can be used to test whether individuals are applying their knowledge and understanding rationally. For example, men and women at high risk of heart disease should be more willing to take statins or blood pressure lowering drugs, than those at moderate or low risk. Therefore, it follows that if high risk individuals understand the risk information presented to them, they should be more likely to have greater intentions to change behaviour to reduce risk and vice versa.

Aims and Objectives

The overall aim of this trial is to compare the effects of different graphical cardiovascular risk presentation formats on individuals' intention to reduce risk, understanding of risk information, emotional affect and worry about future heart disease, using a web-based risk calculator.

The primary objectives of this study are:

- To assess which format leads to the greatest intention to change behaviour.
- To determine which format best facilitates understanding of risk information.
- To analyse which format alters emotional affect.
- To assess which format induces worry about future heart disease the most.
- To examine the correlational validity between intention to change behaviour, understanding of risk and worry about future heart risk. To find out if understanding results in more appropriate intentions regarding cardiovascular risk and what level of worry increases intention to change behaviour.
- To determine whether intention to change behaviour, understanding of risk, and emotional affect are mediated by a person's risk category.

The secondary objectives of this study are:

- To examine the existence of the Hawthorne effect using two control groups.
- To analyse within group changes between pre and post-intervention responses in the group who completed both questionnaires.
- To evaluate the use of the internet-provided risk formatter (process evaluation), including analysis of web-logs.
- To assess the TPB's efficacy to predict intention to change behaviour to reduce future heart risk.

Methods/Design

i) Design

A randomised controlled trial (RCT), with a between-subjects design, will be used to compare the effect of each presentation format on the specified outcomes. There will be four conditions in total, comprising two intervention groups and two control groups. This is to address the possibility of the Hawthorne effect [46] of the four groups and the effect of thinking about cardiovascular risk before viewing actual risk.

ii) Setting

The trial will be conducted remotely from any location with access to a computer and the internet. This places no time or locality constraints on the respondents, as they can participate at their convenience.

iii) Participants

Respondents are eligible for inclusion in the trial if aged between 45 and 64, and have not been previously diagnosed with cardiovascular disease. This is because the risk calculator algorithm is unsuitable for use in a

population of those with existing heart disease due to an underestimation of risk. However, those with hypertension, hypercholesterolemia and diabetes are still eligible. Respondents must also have access to a computer with the internet, have adequate IT skills and be able to read English.

iv) Recruitment

Respondents will be invited to take part in the study using a number of methods. In order of implementation and preference, these methods are: emails to educational institutions, co-operation with large organisations where the workforce has access to a computer; social networking websites (such as *Facebook)* and advertisements in local newspapers. The study will also be advertised on posters and pocket sized cards.

v) Intervention and comparisons

A website comprising a cardiovascular risk formatter and questionnaires has been developed. The purpose of this tool is to enable the different risk presentation formats to be randomly assigned to respondents, creating a platform to measure the outcomes of interest. It uses the Personal Heart Score [47] which assesses 10-year risk of having a coronary heart disease (CHD) event (myocardial infarction, fatal CHD, or cardiac procedure). It uses self-reported, non-laboratory measurements such as age, gender, previous diagnosis of hypertension, hypercholesterolemia or diabetes, smoking status, family history of premature CHD (e.g. a parent who was under the age of 50 when they were told by their GP/Physician that they had a heart attack), level of physical activity (e.g. exercising or playing sport in leisure time) and body mass index. A point scoring system categorises risk into three groups (low risk < 10%; intermediate risk 10-20%; high risk > 20%). It is recognised that other algorithms such as Framingham Risk Score, SCORE or QRISK2 [1-3], provide a more precise risk estimation, especially if they include physiological measurements such as blood pressure. However, it is believed that the Personal Heart Score is most appropriate for the purpose of this study as it provides an estimation of risk level, which can easily be presented in different formats to enable a head-to-head comparison. More importantly, it enables assessment of individuals who have not thought about their cardiovascular risk before and are unaware that they may be at high risk; most of whom are unlikely to have visited a health professional to undergo formal clinical assessment. The website recommends that concerned respondents visit their GP for more formal clinical investigation and before under taking lifestyle changes, links to useful websites such as the British Heart Foundation will also be provided.

Before respondents can proceed, they will be given brief details about the study, asked to indicate their informed consent electronically and will be assessed for eligibility. The computer will then randomise the respondent into one of the four arms, ensuring allocation concealment (see Figure 1). These comprise a bar graph with pre-intervention questionnaire (control group 1), bar graph only (control group 2), pictogram (intervention group 1) or metonym (intervention group 2). Following the risk assessment, all respondents will be given their risk category (low, moderate or high) and the corresponding percentage figure (< 10%, 10-20% or > 20%). The main comparators will be the accompanying graphical risk presentation formats (bar graph, pictogram and metonym).

The bar graph format to be used in the two control groups consists of vertical bar graph depicting percentages. This will be animated (growing upwards) to demonstrate the wide confidence intervals of the risk categories in the Personal Risk Score [47]. A bar graph has been chosen as it is the standard presentation format commonly used in current risk prediction tools. A pictogram of 100 hearts depicting natural frequencies will be used in intervention group 1. Research shows that these formats are better understood by patients, natural frequencies intuitively offer more insight than other formats [9,10] and pictograms help the viewer see the risk in context and facilitate accurate judgements of probability [48,49]. Again, this format will be animated, highlighting each affected heart in turn, to account for the range of numbers affected in the risk category. A metonym format will be used in intervention group 2.

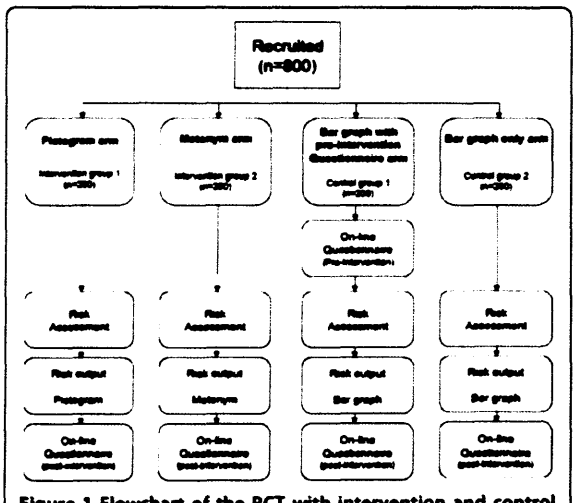

Figure 1 Flowchart of the RCT with intervention and control groups.

This will depict the seriousness of an emergency admission for a myocardial infarction. This has been chosen as heart disease is generally associated with having a myocardial infarction [50]. An image demonstrating healthy longevity will be shown to those in the low risk category; those at moderate risk will be shown an ambulance traveling towards a person's house, and a person being defibrillated will be shown to the high risk category.

To assess changes in emotional affect and worry, all respondents will have these measured at baseline during the risk assessment. Those in the bar graph and pre-intervention questionnaire group (control group 1) will also complete a partially parallel version of the post-intervention questionnaire. This is to address the Hawthorne effect of the four groups, and compare those who are asked to think about their cardiovascular risk and their prior intentions to reduce this, against those who are not. However, to keep the total number of items to a minimum, the focus is on reducing overall cardiovascular risk, instead of specific behaviours that lead to risk reduction. All respondents will view the risk in the format that they have been randomly assigned to and complete the post-intervention questionnaire.

There will be two main comparisons:

1. (a) Bar graph only v. Pictogram
   (b) Bar graph only v. Metonym.

This will enable a head-to-head comparison of the outcomes resulting from the different risk presentation formats.

2. Bar graph and pre-intervention questionnaire v. Bar graph only. Responses from viewing the bar graph and completing the baseline questionnaire will be compared with those from viewing the bar graph only. Additionally, within group changes between baseline and post-intervention questionnaires will be analysed in the group who completed both questionnaires (control group 1).

vi) Outcome Assessment

Outcomes will be assessed by means of a self-complete on-line questionnaire integrated into the web-based formatter. Reliability measures, such as Cronbach's alpha for internal reliability, will be carried out on the questionnaire items at the piloting stage of this trial. Items not meeting the reliability requirements will be eliminated from the final questionnaire. To address possible response bias occurring from fatigue, items measuring the different outcomes and components of the TPB will be mixed up in the questionnaire (as recommended by Ajzen [51]).

The primary outcome measures are:

(i) *Intention to change behaviour*- Items relating to cardiovascular risk reduction were developed using guidance from a manual for constructing questionnaires based on the TPB [52]. This manual was chosen as it has been widely used in previous research that has required TPB questionnaire development [53-55]. It also provides a way of measuring the TPB contrasts directly, reducing the number of items and thus, keeping the cognitive demand of respondents to a minimum. The questionnaire items comprise three risk reducing options of: smoking cessation, exercising more and losing weight. These are the three modifiable risk factors assessed by the Personal Heart Score. The relevance of these risk reducing options will be assessed. Questions relating to smoking will only be asked to those who reported that they are current smokers; adjustment will be made for this during analysis. Responses for intention to lose weight will be assessed for appropriateness (e.g. whether those who do not report this intention actually need to lose weight). Scale items such as *'I intend to exercise more'* with a 7-point Likert response options will be used. An indirect measure of intention to change behaviour will be also assessed, by examining whether individuals take the opportunity to obtain a copy of their risk output to take to their GP.

(ii) Understanding - Items specific to the understanding of cardiovascular risk information have been developed and will be piloted, as no suitable validated scale currently exists. These comprise absolute probability perception e.g. *'What are your chances of having heart disease in the next 10 years?'* with three pre-defined response options (low, moderate, high); subjective understanding of the risk information e.g. '*What should someone in your risk category do to reduce their risk of heart disease*?' with 3 pre-defined response options (do nothing to reduce their risk, try and do a little bit to reduce their risk, do as much as they can to reduce their risk); and confidence in understanding e.g. *'How confident are you that you have understood the risk information given to you?'* with a 7 point Likert Scale to indicate level of confidence in understanding.

(iii) Emotional affect after viewing cardiovascular risk - The Positive and Negative Affect Schedule- Short Form (PANAS-SF) will be used [56]. This is a 10-item truncated version of the PANAS, which has been well validated and cited in over 2,000 scholarly papers [57]. It was felt that the original 20-items would be too time-consuming and cognitively demanding for respondents, possibly leading to high

drop out rates. As this study is interested in respondents' changes of affect after viewing their risk output, a slight adaptation to the wording of the instructions and anchors/pole labels was made to the post-intervention scale, to make it more logical. An example of one item is: *'Thinking about yourself right now at this present moment, to what extent do you feel upset?'* with a 5-point Likert response scale anchored *'not at all'* to *'extremely'*.

(iv) Worry about future heart disease - one item will be used to measure this construct, in order to keep the total time needed to complete the questionnaires to a minimum. No previously developed and validated scale regarding worry about future risk of heart disease currently exists. Therefore, the item was developed using previously validated scales relating to other health conditions, such the Lerman Breast Cancer Worry Scale [58] as a guide. This item is *'After viewing your results, how worried do you feel about developing heart disease in the future?'* with *'very worried'* to *'not at all worried'* anchored on a 7-point Likert response scale.

The following secondary outcomes will also be assessed; these comprise the sub-components of the TPB [20]: attitudes, perceived behavioural control and subjective norms. Items were developed to measure the components directly according to the manual by Francis et al [52]. They will measure the three risk reducing options (smoking cessation, exercising more, losing weight). Again, relevance of the risk reducing options will be assessed, and those not applicable will be omitted from the post-intervention questionnaire.

- *Attitudes* - This comprises evaluative (evaluation using bipolar opposites), instrumental (whether the behaviour achieves something) and experiential (how it feels to perform the behaviour) items. An example is *'For me, stopping smoking would be .....'* with a 7-point Likert scale anchored *'pleasant'* to *'unpleasant'*.
- *Perceived Behavioural Control* - Items relate to either self-efficacy or the controllability of the behaviour. An example of a controllability item is *'Whether I lose weight or not is entirely up to me'* with a 7-point Likert scale to indicate the extent to which the respondent agrees with the statement. An example of a self-efficacy item is *'I am confident that I can exercise more'* with 'very *confident*' to *'not at all confident'* anchored on a 7-point Likert scale.
- *Subjective Norms* - These relate to the perceptions of significant others' preferences about whether one should or should not engage in a specific behaviour. An example is *'I feel under social pressure to lose weight'* with a 7-point Likert scale to indicate the extent to which the respondent agrees with the statement.

Other data collection comprises:

- *Respondents characteristics* (risk category, gender, age, family history of heart disease, diagnosis of hypertension, hypercholesterolemia, diabetes, smoking status, physical activity status, height and weight for BMI calculation and whether the respondent requests an electronic copy of their risk output for their GP).
- *Web logs* examining how long respondents take to complete the study and how long they spend on each page.

vii) Sample size calculation

For simplicity, the sample size calculation is based on a comparison of means, though the analysis will recognise the ordinal nature of the data. It is hard to speculate on the difference between the groups and so the sample size is based on comparing 2 groups on the primary outcome measure which is intention to change behaviour; this will give a group size which will be used for all the groups. Recruitment will continue until 800 respondents (200 in each group) have completed the trial. The likely uptake rate is unknown and a number of the suggested recruitment methods may be needed. Based on a study that used a similar Likert Scale scoring system for a different risk context [59], the scores on intention to change behaviour within a group should have an SD of about 1.5. The total sample size in each group of 200 would then be sufficient to detect a difference of 0.5 point between two groups, with 90% power and significance value of $\alpha = 0.05$.

viii) Analysis

The results will stored on a SQL database and fed back to the researcher via the server that hosts the website. The data will be stored on the shared drive which will be password protected and only accessible to the researcher. Data will be retrieved, coded and inputted into computer software. Microsoft Office Excel 2007 will be used for data manipulation and SPSS version 16 for the main data analyses.

The usual descriptive statistics will be presented to summarise baseline characteristics of the study sample. Continuous variables such as age and level of cardiovascular risk will be summarised using mean and SD and/or median and quartiles. Binary variables such as gender and whether the respondent requests an electronic copy of their risk output for their GP will be summarised by counts and proportions. Summary

statistics will be obtained for the study population as a whole, and for the four randomised groups, without formal testing of statistical significance of any differences between them.

The main analyses of efficacy will relate to the primary outcome measures: intention to change behaviour, understanding of risk information, emotional affect and worry about future heart disease. Summary statistics for the four groups will be presented, as above. The four groups will first be compared on an equal footing using one-way ANOVA. The three selected pairwise contrasts between the specified groups, will then be constructed (e.g. bar graph only v. pictogram; bar graph only v. metonym; and bar graph and preintervention questionnaire v. bar graph only).

Several secondary analyses will be performed. For the bar graph and preintervention questionnaire group (control group 1), paired analyses will be used to assess serial changes in outcome measures between pre- and postintervention questionnaires.

A multiple regression model will be used in a subgroup analysis to look for correlations between risk category on intention to change behaviour, understanding of risk and post worry about future heart disease outcomes, to see if responses are mediated by risk category. It will also be used to assess the correlational validity between intention to change behaviour, worry about future heart disease and understanding of risk information; to determine what level of worry increases intention to change behaviour and whether understanding also results in appropriate intentions. The subcomponents of the TPB (attitudes, perceived behavioural control and subjective norms) will also be examined, to see if they sufficiently predict intention to change behaviour (in order to test the efficacy of the model in predicting cardiovascular-related behaviour change).

The direct and indirect measures of intention to change behaviour will be correlated, to see whether those who report that they intend to change their behaviour actually take the opportunity to print out their risk output to take to their GP. Furthermore, a correlation between accurate understanding of risk information and confidence in understanding will be conducted. Lastly, Independent T-tests will compare baseline and post-intervention emotional affect and worry about future heart disease scores, to determine whether scores generally decrease after viewing a particular risk presentation format, or increase, demonstrating a possible negative impact.

For all analyses, point and interval estimates will be obtained, as well as p-values. In the event of substantial departure from Gaussian distributional form, transformation of scale and/or analogous non-parametric methods will be considered.

Discussion

This protocol provides a detailed description of a RCT designed to compare different graphical cardiovascular risk presentation formats and evaluate their effects on patient-related outcomes. The findings will inform developers of cardiovascular risk prediction tools and risk reduction interventions, providing insight into which format is most effective in encouraging behaviour change to reduce cardiovascular risk.

As far as we are aware, this will be the first RCT to assess different cardiovascular risk graphical presentation formats using actual risk assessment, rather than relying on hypothetical risk scenarios. However, a couple of limitations should be acknowledged. Firstly, a meaningful response rate will not be able to be calculated, but web-logs will give information on response trends (such as those who do not complete the study). Secondly, there is sample bias, as this study uses a self-selecting sample and is restricted to computer literature individuals. Further possible biases will be explored in the event that no difference between the risk presentation formats occurs; this is to avoid under-estimation of their effects.

Lastly, we are only able to provide respondents with a rudimentary estimation of their future 10-year risk of having a CHD event, and present them with a risk category that has wide confidence intervals and a high level of uncertainty. This is due to the use of an algorithm that uses non laboratory, self-reported information [47]; which has been chosen to increase the feasibly of data collection. Nonetheless, this will be an adequate starting point for individuals who have not thought about visiting their GP for a clinical assessment before and may not know that they are at risk.

Acknowledgements

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Authors' contributions

All authors contributed to the development of the research protocol. GE is principal investigator. CAW will be responsible for the management of the trial. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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Appendix 21. Ethical Approval letter.

School of Dentistry
Dean: Professor Elizabeth Treasure
Ysgol Am Deintyddiaeth
Deon: Yr Athro Elizabeth Treasure

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8th April 2009

Miss C A Waldron
Department of Primary Care and Public Health
Cardiff University
Centre for Health Sciences Research
School of Medicine
2nd Floor, Neuadd Meirionnydd
Heath Park
Cardiff.
CF14 4YS

Dear Miss Waldron

Re: Which Format Facilitates Understanding and Intention to Reduce Cardiovascular Risk? A Randomised Controlled Trial.

MDSREC Reference Number: 09/27

This application was considered by the Medical Dental School Research Ethics Committee on Monday 6th April 2009.

Ethical Opinion

On behalf of the committee I am pleased to confirm a favourable ethical opinion for the above research project.

In approving the project, the Committee raised just one point which I have been asked to draw to your attention. This relates to the staged sampling strategy which you propose. It was noted that the groups involved were somewhat differing in their potential educational background, socioeconomic makeup etc and the potential impact of this on the generalisability of your results was queried.

That minor point apart, the Committee was content with the application.

Conditions of Approval

The Medical Dental School Research Ethics Committee requires that any modification to the approved protocol be notified to the Committee.

It should be noted that Ethical Approval is valid for a period of two years from the date it was approved by the Medical Dental School Research Ethics Committee. After this time, if the project has not commenced, you should reapply to the Medical Dental School Research Ethics Committee.

To conform with Cardiff University requirements an annual monitoring form will be issued in due course, with regards to all approved projects.

Documents Considered

Document Type:	Version	Date Received
Application Form	Form signed 25th March 2009	25th March 2009
Purpose and Academic Rationale	Version 1 – 24th March 2009	25th March 2009
Appendix 2 – Appendix 7	Version 1 – 24th March 2009	25th March 2009
Electronic Consent Form	Version 1 – 24th March 2009	25th March 2009
Participant Information Sheet	Version 1 – 24th March 2009	25th March 2009
Story Board	Version 1 – 24th March 2009	25th March 2009

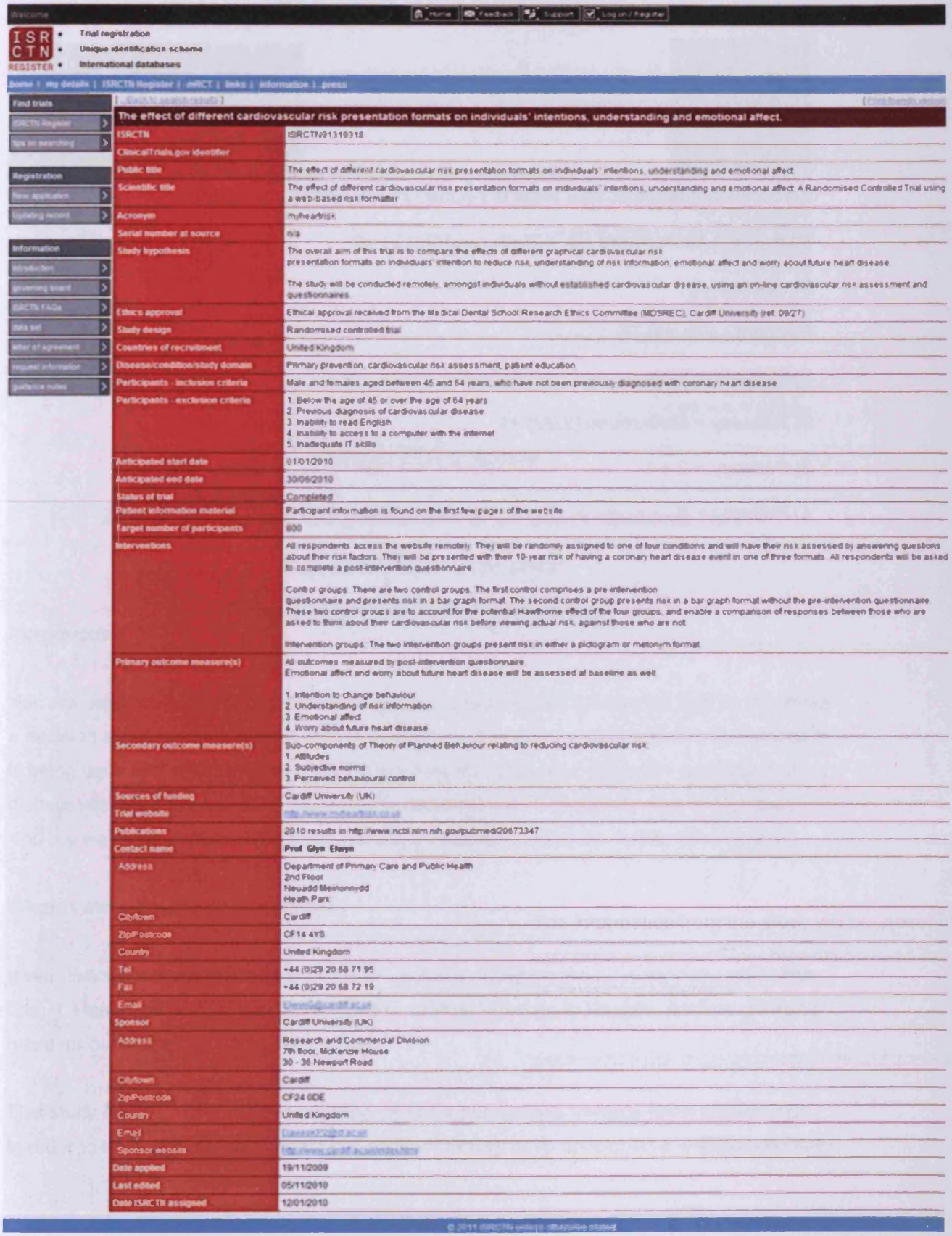
With best wishes for the success of your study.

Yours sincerely

Prof I.G. Chestnutt
Chair
Medical/Dental School Research Ethics Committee

Copy Professor Glyn Elwyn
Department of Primary Care and Public Health

Appendix 22. Screenshot of trial registration in Current Controlled Trials database.



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The effect of different cardiovascular risk presentation formats on individuals' intentions, understanding and emotional affect.

ISRCTN	ISRCTN91319318
ClinicalTrials.gov identifier	
Public title	The effect of different cardiovascular risk presentation formats on individuals' intentions, understanding and emotional affect
Scientific title	The effect of different cardiovascular risk presentation formats on individuals' intentions, understanding and emotional affect: A Randomised Controlled Trial using a web-based risk formatter
Acronym	myheartrisk
Serial number at source	n/a
Study hypothesis	The overall aim of this trial is to compare the effects of different graphical cardiovascular risk presentation formats on individuals' intention to reduce risk, understanding of risk information, emotional affect and worry about future heart disease. The study will be conducted remotely, amongst individuals without established cardiovascular disease, using an on-line cardiovascular risk assessment and questionnaires.
Ethics approval	Ethical approval received from the Medical Dental School Research Ethics Committee (MDSREC), Cardiff University (ref: 09/27)
Study design	Randomised controlled trial
Countries of recruitment	United Kingdom
Disease/condition/study domain	Primary prevention, cardiovascular risk assessment, patient education
Participants - inclusion criteria	Male and females aged between 45 and 64 years, who have not been previously diagnosed with coronary heart disease
Participants - exclusion criteria	1. Below the age of 45 or over the age of 64 years 2. Previous diagnosis of cardiovascular disease 3. Inability to read English 4. Inability to access to a computer with the internet 5. Inadequate IT skills
Anticipated start date	01/01/2010
Anticipated end date	30/06/2010
Status of trial	Completed
Patient information material	Participant information is found on the first few pages of the website
Target number of participants	800
Interventions	All respondents access the website remotely. They will be randomly assigned to one of four conditions and will have their risk assessed by answering questions about their risk factors. They will be presented with their 10-year risk of having a coronary heart disease event in one of three formats. All respondents will be asked to complete a post-intervention questionnaire. Control groups: There are two control groups. The first control comprises a pre-intervention questionnaire and presents risk in a bar graph format. The second control group presents risk in a bar graph format without the pre-intervention questionnaire. These two control groups are to account for the potential Hawthorne effect of the four groups, and enable a comparison of responses between those who are asked to think about their cardiovascular risk before viewing actual risk, against those who are not. Intervention groups: The two intervention groups present risk in either a pictogram or metonym format.
Primary outcome measure(s)	All outcomes measured by post-intervention questionnaire. Emotional affect and worry about future heart disease will be assessed at baseline as well. 1. Intention to change behaviour 2. Understanding of risk information 3. Emotional affect 4. Worry about future heart disease
Secondary outcome measure(s)	Sub-components of Theory of Planned Behaviour relating to reducing cardiovascular risk: 1. Attitudes 2. Subjective norms 3. Perceived behavioural control
Sources of funding	Cardiff University (UK)
Trial website	http://www.myheartrisk.co.uk
Publications	2010 results in http://www.ncbi.nlm.nih.gov/pubmed/20673347
Contact name	**Prof Glyn Elwyn**
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Sponsor	Cardiff University (UK)
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City/town	Cardiff
Zip/Postcode	CF24 0DE
Country	United Kingdom
Email	ClaireS7@cf.ac.uk
Sponsor website	http://www.cardiff.ac.uk/index.html
Date applied	19/11/2009
Last edited	05/11/2010
Date ISRCTN assigned	12/01/2010

Appendix 23. The original algortihm used by the website for randomisation.

The website was made using Adobe flash. There is an inbuilt flash function called Math.random that generates a random number between 0 and 1.

Adobe Flash gets a random value between 0 and 1 by calling the built in flash function Math.random. This value is inputted into the following equation:

Pathway = Math.round (3 x Math.random( )) +1

For example,

Random value = 0.74

1) Pathway = Math.round (3 x 0.74) + 1

2) Pathway = Math.round (2.22) +1

3) Pathway = 2 + 1

4) Pathway = 3

Appendix 24. Participant Information Sheet.

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MyHeartRisk Study

A study into public perceptions of heart disease risk

Participant Information Sheet

Please read this information carefully

Introduction

You are being invited to take part in a research study by Cardiff University. Before you make a decision about whether to take part, it is important for you to understand why the research is being done and what it will involve. Please read the following information carefully and discuss with others if you wish. Take time to decide whether or not you wish to take part. You are welcome to contact us if you have any questions or require further information.

What is the purpose of this study?

Heart disease is the biggest killer in the UK and lots of people are unaware they are at risk from it. Heart disease risk can be reduced by making changes to lifestyle, such as adopting healthier behaviours or taking medication.

This study is being conducted to examine people's perceptions towards heart disease risk. In order to do so, the research team at Cardiff University have developed a web-based heart

disease risk estimator (*www.myheartrisk.co.uk*). This uses a developed prediction tool[1] to assess an individual's future risk of developing heart disease, by using information about their health and lifestyle. There is also an electronic questionnaire which asks people's opinions about their risk.

The overall aim of this study is to provide insight into what people think about their risk when it is presented to them in a certain way. Specifically, we wish to look at issues such as understanding, intentions and emotion. From these results we hope to consider the wider implications for healthcare providers, such as General Practitioners. This study is envisaged to last for 6 months.

Am I eligible?

We are asking around 800 people to participate in the study and have their risk of heart disease calculated. In order to take part you will need to be between 45 and 64 years of age, not have been previously diagnosed with heart disease, not have had a heart attack, other cardiac event (e.g. angina) or had a stroke. You must also have access to the internet, either at home or in another location, and be able to use a computer.

Do I have to take part?

No. Participation is entirely voluntary and it is up to you to decide if you want to take part in this research. You will be free to withdraw from the study, by exiting the web browser at any point and without giving a reason. If you do decide to take part, you will be asked to read the rest of this information page, and indicate your consent by checking the relevant boxes on the consent page.

What will happen to me if I decide to take part?

If you decide to take part in the study you will be asked to spare around 20-30 minutes of your time and navigate through the *myheartrisk* website. You will be asked to answer questions regarding your health and lifestyle, in order for your future risk of heart disease to

[1] Mainous et al. 2007. A Coronary Heart Disease Risk Score Based on Patient-Reported Information. *American Journal of Cardiology* 99, pp.1236-1241.

be calculated. We will also ask you to complete an online questionnaire on your feelings about how your risk has been presented to you.

This study is a randomised trial. We would like to find out more about how people's perceptions differ when their risk is presented in different ways. In order to do this, we need to make comparisons and will put people into groups. Each group will be given a different format for presenting their risk. To ensure the groups are the same to start with, each participant is put into a group by chance (randomly). The results are then compared.

All the data from the study will be stored on computer. Only the research team will access the data. It will be securely protected by using passwords. The same research team that collected the data will perform the analysis of the information.

What do I have to do?

You will be required to navigate through the *myheartrisk* website, input information regarding your health and lifestyle, view your estimated future risk of heart disease and complete a short questionnaire.

Will my taking part in the study be kept confidential?

Yes. All information about your participation in this study will be kept strictly confidential and only made available to the research team. Participation is entirely anonymous and we cannot trace your answers back to you. We do not ask you to provide your contact details, unless you would like us to contact you regarding further information about the study. The results of the questionnaire will be kept securely and then destroyed after an agreed period in keeping with recommended research guidelines.

What are the disadvantages or risks of taking part?

We recognise that viewing your risk of heart disease may be a difficult task. It is possible that the results may be unexpected, make you slightly worried or cause distress. We will, in fact, ask you about any worries that you feel in the questionnaire.
If you do become worried or distressed about your risk of heart disease, we urge you to visit your GP for a formal clinical assessment, especially before undertaking any major changes to your lifestyle and health. We will also provide a link to the *British Heart Foundation* website that provides information about heart disease.

What are the possible benefits of taking part?

You will receive a personalised estimation of your future risk of heart disease.

The results of this study will provide us with a better understanding of the effect of presenting risk information in different ways. We will then be able to inform healthcare professionals and the developers of risk prediction tools, to improve risk communication. The study does not aim to modify treatment or medication.

What will happen if I don't want to carry on with the study?

You can withdraw from the study at any point by closing the web browser.

What if I become concerned?

We recognise that it is possible that personalised risk information may cause you worry or distress. If you wish to discuss any issues raised during the research, we urge you to visit your GP.

If you wish to complain, or have any concerns about any aspect of the way you have been treated during the course of this study, you should contact:
Professor Glyn Elwyn, Department of Primary Care and Public Health, School of Medicine, Cardiff University, Neuadd Meirionnydd, Heath Park, Cardiff, CF14 4XN, (Tel: (0)29 20 68 71 94, ElwynG@cardiff.ac.uk).

What will happen to the results of the research study?

The information from the study will be presented in a report and may also be published in appropriate journals. The information used in the publications will be anonymous; it will not be possible to identify you.

If you would like more information about the study and your participation in it, or would like a copy of the published results once they become available, there is a page on the website where you can leave your contact details. A member of the research team will then get back to you.

Who is organising and funding this research?

The study is organised by Professor Glyn Elwyn of the Department and Primary Care at Cardiff University. It is funded by the School of Medicine at Cardiff University.

Who has reviewed this study?

The study plan has been peer-reviewed by the Medical and Dental School Research Ethics Committee at Cardiff University.

What do I need to do now?

If you do wish to take part in this study, please navigate to the consent page by clicking the 'continue' button at the bottom of this page. You will then be able to start filling out the questionnaire and have your future risk of heart disease estimated.

What if I have other concerns?

If after reading this information sheet you decide not to take part in the study, but feel you would like to discuss any of the issues we have raised, or have other questions about this study, please contact the Principal Investigator, Professor Glyn Elwyn.

Who should I contact for further information?

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Appendix 25. Coding document for on-line questionnaires.

Identification information for each respondent: No missing data		
Variable	**Description**	**Values**
Participant number	ID of respondents	-
Session ID	Unique Session ID to log respondents time on website	-
Date and Time	Date and time respondent entered the website	-
Risk output request	Whether respondents requested to have a copy of their risk output result emailed to them.	0 = No 1= Yes
Condition allocation	The condition respondents were randomised to.	1= Bargraph with pre-intervention questionnaire 2 = Bargraph 3= Pictogram 4 = Metonym

Baseline Questionnaire given to everyone: No missing data		
Variable	**Description**	**Values**
Q 1	Pre PANAS – *To what extent do you feel...* Upset	Scale = 1 (never) to 7 (always)
Q2	Pre PANAS – *To what extent do you feel...* Hostile	Scale = 1 (never) to 7 (always)
Q3	Pre PANAS – *To what extent do you feel...* Alert	Scale = 1 (never) to 7 (always)
Q4	Pre PANAS – *To what extent do you feel...* Ashamed	Scale = 1 (never) to 7 (always)
Q5	Pre PANAS – *To what extent do you feel...* Inspired	Scale = 1 (never) to 7 (always)
Q6	Pre PANAS – *To what extent do you feel...* Nervous	Scale = 1 (never) to 7 (always)
Q7	Pre PANAS – *To what extent do you feel...* Determined	Scale = 1 (never) to 7 (always)
Q8	Pre PANAS – *To what extent do you feel...* Attentive	Scale = 1 (never) to 7 (always)
Q9	Pre PANAS – *To what extent do you feel...* Afraid	Scale = 1 (never) to 7 (always)
Q10	Pre PANAS – *To what extent do you feel...* Active	Scale = 1 (never) to 7 (always)
Total_Pre_Positive_affect	Total scores for positive items from pre PANAS (e.g Q3,Q5,Q7,Q8,Q10)	Total score between 7-49
Total_Pre_Negative_affect	Total scores for Negative items from pre PANAS (e.g Q1,Q2,Q4,Q6,Q9)	Total score between 7-49
Q11	Pre worry – *How worried do you feel about developing heart disease in the future?*	Scale = 1 (not at all worried) to 5 (very worried)

Questions given to those in condition 1 only (Bar graph with pre intervention questionnaire) 9 for missing data – i.e. those who were not randomised to this condition.		
Variable	**Description**	**Values**
Q12	Pre risk perception probability – *I think my risk of heart disease in the next 10* years is..	1 = low 2= moderate 3= High
Q13	Pre intention to reduce heart disease – *I want to reduce my risk of heart disease.*	Scale= 1 (strongly agree) to 7 (strongly disagree)
Q13_reversed	Q13 scores reversed so higher score means greater intention.	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q15	Pre subjective norm – *People who are important to me want me to reduce my risk of heart disease.*	Scale= 1 (strongly agree) to 7 (strongly disagree)
Q15_reversed	Q15 scores reversed so higher score means greater influence of subjective norms.	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q14	Pre Perceived Behavioural Control (controllability) – *The decision to reduce my risk of heart disease is mostly up to me.*	Scale= 1 (strongly agree) to 7 (strongly disagree)
Q14_reversed	Q14 scores reversed so higher score means greater PBC.	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q16	Pre PBC (self-efficacy) – *Reducing my risk of heart disease would be Easy / Difficult.*	Scale = -3 (easy) to +3 (difficult)
Q16_converted_only	Converting Q16 scores from -3 to +3 into 1 to 7	Scale: 1 =-3 (easy) to 7 = +3 (difficult)
Q16_converted_ reversed	Q16 converted scores reversed so higher score means greater PBC.	Scale= 1 (difficult) to 7 (easy)
Mean_pre_PBC_score	Mean total pre PBC score (sum of Q14_reversed,Q16_converted_reversed / 2)	Higher score means greater perceived behavioural control.
Q17	Pre attitudes - *Reducing my risk of heart disease would be Rewarding/Unrewarding.*	Scale = -3 (rewarding) to +3 (unrewarding)
Q17_reversed	Q17 scores reversed so higher score means more positive attitude.	Scale = -3 (unrewarding) to +3 (rewarding)
Q18	Pre attitudes - *Reducing my risk of heart disease would be Undesirable / Desirable.*	Scale = -3 (undesirable) to +3 (desirable)
Q19	Q19 pre attitudes - *Reducing my risk of heart disease would be Worthless / Worthwhile.*	Scale = -3 (worthless) to +3 (worthwhile)
Mean_pre_attidude_ Score	Mean total pre attitude score (sum of Q17_reversed,Q18,Q19 / 3)	Higher score means more positive attitude towards reducing heart disease.

Post intervention questionnaire given to everyone. No missing data		
Variable	**Description**	**Values**
Q20	Post PANAS – *At this present moment to what extent do you feel...* Upset	Scale = 1 (not at all) to 7 (extremely)
Q21	Post PANAS – *At this present moment to what extent do you feel... Hostile*	Scale = 1 (not at all) to 7 (extremely)
Q22	Post PANAS – *At this present moment to what extent do you feel...* Alert	Scale = 1 (not at all) to 7 (extremely)

Q23	Post PANAS – *At this present moment to what extent do you feel...* Ashamed	Scale = 1 (not at all) to 7 (extremely)
Q24	Post PANAS – *At this present moment to what extent do you feel...* Inspired	Scale = 1 (not at all) to 7 (extremely)
Q25	Post PANAS – *At this present moment to what extent do you feel...* Nervous	Scale = 1 (not at all) to 7 (extremely)
Q26	Post PANAS – *At this present moment to what extent do you feel...* Determined	Scale = 1 (not at all) to 7 (extremely)
Q27	Post PANAS – *At this present moment to what extent do you feel...* Attentive	Scale = 1 (not at all) to 7 (extremely)
Q28	Post PANAS – *At this present moment to what extent do you feel...* Afraid	Scale = 1 (not at all) to 7 (extremely)
Q29	Post PANAS – *At this present moment to what extent do you feel...* Active	Scale = 1 (not at all) to 7 (extremely)
Total_post_Positive_affect	Total scores for positive items from post PANAS (e.g Q3,Q5,Q7,Q8,Q10)	Total score between 7-49
Total_post_Negative_affect	Total scores for Negative items from post PANAS (e.g Q1,Q2,Q4,Q6,Q9)	Total score between 7-49
Q30	Post worry – *After viewing your results how worried do you feel about developing heart disease in the future?*	Scale = 1 (not at all worried) to 5 (very worried)
Q31	Understanding - probability perception – *What are your chances of having a coronary heart disease event in the next 10 years?*	1= I am at low risk 2= I am at moderate risk 3 = I am at high risk
Q32	Understanding – confidence – *How confident are you that you have understood the risk information given to you?*	Scale = 1 (not at all confident) to 7 (very confident
Q33	Understanding - subjective understanding – *What should someone in your risk category do to change their risk of heart disease?*	1= Do nothing 2 = Try and do a little 3 = Do as much as they can
Level_of_understanding	Respondent said to have understanding if the appropriate responses are given to Q31 and Q33 according to their risk category.	0 = No understanding – incorrect responses. 1= Partial understanding (Q31 correct but Q33 incorrect). 2= Partial understanding (Q31 incorrect but Q33 correct). 3 = complete understanding – correct responses.
Level_of_understanding_as_scale	Level of understanding turned into a three point scale but recoding 0=0, 1 or 2 = 1, 3=2.	0 = no understanding 1 = partial understanding 2 = complete understanding

Questionnaire about intention to stop smoking – given to current smokers only 9 for missing data (i.e. those who do not smoke)		
Variable	**Description**	**Values**
Q34	Smoking – intention – *To what extent are you prepared to stop smoking?*	Scale =1 (completely unprepared) to 7 (completely prepared).
Q35	Smoking – intention – *How likely are you to stop smoking?*	Scale= 1 (very unlikely) to 7 (very likely).
Q41	Smoking – intention – *I intend to stop smoking.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Mean_smoking_intention _ score	Mean total smoking intention score (sum of Q34,Q35,Q41 / 3)	Higher score means greater intention to stop smoking
Q37	Smoking – attitude – *For me stopping smoking would be... Bad/ Good.*	Scale= -3 (bad) to +3 (good)
Q38	Smoking – attitude – *For me stopping smoking would be... Harmful / Beneficial.*	Scale= -3 (harmful) to +3 (beneficial)
Q39	Smoking – attitude – *For me stopping smoking would be... Unpleasant / Pleasant.*	Scale= -3 (Unpleasant) to +3 (Pleasant)
Mean_smoking_attitude_ score	Mean total smoking attitude score (sum of Q37,Q38,Q39 / 3)	Higher score means more positive attitude towards stopping smoking.
Q40	Smoking – PBC (self-efficacy) – *For me stopping smoking would be... Difficult / Easy.*	Scale= -3 (Difficult) to +3 (Easy)
Q40_converted	Q40 scores converted	Scale: 1 =-3 (Difficult) to 7 = +3 (Easy)
Q45	Smoking - PBC (self-efficacy)- *I am confident that I can stop smoking.*	Scale = 1 (strongly disagree) to 7 (strongly agree)
Q42	Smoking - PBC (controlability) – *Whether I stop smoking or not is entirely up to me.*	Scale = 1 (strongly disagree) to 7 (strongly agree)
Q44	Smoking - PBC (controlability) – *The decision to stop smoking is beyond my control.*	Scale = 1 (strongly disagree) to 7 (strongly agree)
Q44_reversed	Q44 scores reversed so a higher score means greater PBC	
Mean_smoking_PBC_ Score	Mean total smoking PBC score (sum of Q40-converted,Q45,Q42,Q44_reversed / 4)	Higher score means greater PBC over stopping smoking.
Q36	Smoking - subjective norm – *Most people who are important to me think that I... should not stop smoking / should stop smoking.*	Scale= -3 (should not) to +3 (should)
Q36_converted	Converted Q36 scores from -3 to +3 into 1 to 7	Scale: 1 =-3 (should not) to 7 = +3 (should)
Q43	Smoking - subjective norm – *I feel under social pressure to stop smoking.*	Scale = 1 (strongly disagree) to 7 (strongly agree)
Q46	Smoking - subjective norm – *It is expected of me to stop smoking.*	Scale = 1 (strongly disagree) to 7 (strongly agree)
Mean_smoking_subjective _ norm_score	Mean total smoking subjective norm score (sum of Q36_converted,Q43,Q46 / 3)	Higher score means greater influence of subjective norms.

Questionnaire about exercising more - given to everyone No missing data		
Variable	**Description**	**Values**
Q47	Exercise – intention – *To what extent are you prepared to exercise more?*	Scale =1 (completely unprepared) to 7 (completely prepared).
Q48	Exercise – intention – *How likely are you to exercise more?*	Scale= 1 (very unlikely) to 7 (very likely).
Q54	Exercise – intention – *I intend to exercise more.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Mean_exercise_intention_score	Mean total exercise more intention score (sum of Q47,Q48,Q54 / 3)	Higher score means greater intention to exercise more.
Q50	Exercise – attitudes – *For me exercising more would be...* a negative thing to do / a positive thing to do.	Scale= -3 (negative) to +3 (positive)
Q51	Exercise – attitudes - *For me exercising more would be...* Unenjoyable / Enjoyable.	Scale= -3 (unenjoyable) to +3 (enjoyable)
Q53	Exercise – attitudes - *For me exercising more would be...* Useless / Useful.	Scale= -3 (useless) to +3 (useful)
Mean_exercise_attitude_score	Mean total exercise more attitude score (sum of Q50,Q51,Q53 / 3)	Higher score means more positive attitude towards exercising more.
Q52	Exercise - PBC (self-efficacy) - *For me exercising more would be...* Difficult / Easy.	Scale= -3 (Difficult) to +3 (Easy)
Q52_converted	Converted Q52 scores from -3 to +3 into 1 to 7	Scale: 1 =-3 (easy) to 7 = +3 (difficult)
Q58	Exercise - PBC (self-efficacy) – *I am confident that I can exercise more.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q55	Exercise - PBC (controlability)- *Whether I exercise more or not is entirely up to me.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q57	Exercise - PBC (controlability)- *The decision to exercise more is beyond my control.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q57_reversed	Q44 scores reversed so a higher score means greater PBC.	Scale= 1 (strongly agree) to 7 (strongly disagree)
Mean_exercise_PBC_score	Mean total exercise more PBC score (sum of Q52_converted,Q58,Q55, Q57_reversed / 4)	Higher score means greater PBC over exercising more.
Q49	Exercise - subjective norm –*Most people who are important to me think that I... should exercise more/ should not exercise more.*	Scale= -3 (should not) to +3 (should)
Q49_converted	Converted Q49 scores from -3 to +3 into 1 to 7	Scale: 1 =-3 (should not) to 7 = +3 (should)
Q56	Exercise - subjective norm – *I feel under social pressure to exercise more.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q59	Exercise - subjective norm – *It is expected of me to exercise more.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Mean_exercise_subjective_norm_score	Mean total exercise more subjective norm score (sum of Q49_converted,Q56,Q59 / 3)	Higher score means greater influence of subjective norms.

Questionnaire about losing weight - given to everyone No missing data		
Variable	**Description**	**Values**
Q60	Lose weight – intention – *To what extent are you prepared to stop smoking?*	Scale =1 (completely unprepared) to 7 (completely prepared).
Q61	Lose weight– intention – *How likely are you to lose weight?*	Scale= 1 (very unlikely) to 7 (very likely).
Q67	Lose weight– intention – *I intend to lose weight.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Mean_loseweight_ intention_score	Mean total lose weight intention score (sum of Q60,Q61,Q67 / 3)	Higher score means greater intention to lose weight.
Q63	Lose weight – attitudes – *For me losing weight would be...* the wrong thing to do / the right thing to do.	Scale= -3 (wrong thing) to +3 (right thing)
Q64	lose weight – attitudes - *For me losing weight would be...* unsatisfying / Satisfying.	Scale= -3 (Unsatisfying) to +3 (Satisfying)
Q65	Lose weight – attitudes - *For me losing weight would be...* Unhelpful / Helpful.	Scale= -3 (Unhelpful) to +3 (Helpful)
Mean_loseweight_ attitude_ score	Mean total exercise more attitude score (sum of Q63,Q64,Q65 / 3)	Higher score means more positive attitude towards losing weight.
Q66	Lose weight – PBC (self-efficacy)- *For me losing weight would be...* Difficult / Easy.	Scale= -3 (Difficult) to +3 (Easy)
Q66_converted	Converted Q66 scores from -3 to +3 into 1 to 7	Scale: 1 =-3 (Unhelpful) to 7 = +3 (Helpful)
Q71	Lose weight - PBC (self-efficacy) – *I am confident that I can lose weight.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q68	Lose weight - PBC (controlability)- *Whether I lose weight or not is entirely up to me.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q70	Lose weight - PBC (controlability) – *The decision to lose weight is beyond my control.*	Scale = 1 (strongly disagree) to 7 (strongly agree)
Q70_reversed	Q70 scores reversed so a higher score means greater PBC.	Scale= 1 (strongly agree) to 7 (strongly disagree)
Mean_loseweight_PBC _score	Mean total lose weight PBC score (sum of Q66_converted,Q71,Q68, Q70_reversed / 4)	Higher score means greater PBC over losing weight.
Q62	Lose weight - subjective norm – *Most people who are important to me think that I...* Should not lose weight / Should lose weight.	Scale= -3 (should not) to +3 (should
Q62_converted	Converted Q62 scores from -3 to +3 into 1 to 7	Scale: 1 =-3 (should not) to 7 = +3 (should)
Q69	Lose weight - subjective norms – *I feel under social pressure to lose weight.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Q72	Lose weight - subjective norm – *It is expected of me to lose weight.*	Scale= 1 (strongly disagree) to 7 (strongly agree)
Mean_losewieght_ subjective_norm_score	Mean total exercise more subjective norm score (sum of Q62_converted,Q69,Q72 / 3)	Higher score means greater influence of subjective norms.

Questionnaire given to everyone 9 for missing data		
Variable	**Description**	**Values**
Q73_level_of_education	What is your level of education?	1 = Left school before 16 (no formal Qualifications) 2 = Left school at 16 (GCSEs, CSE, O level or equivalent) 3 = Left School at 18 (A levels or equivalent) 4 = College certificate or diploma 5 = University degree or higher 6 = other 7 do not wish to disclose
Q74_recruitment_methods	Where did you find out about this website?	1 = Email invitation at workplace 2 = Found link on the internet 3 = Social networking sites 4 = from personal contacts 5 = poster or card advertisements 6 = Newspaper 7 = Other 8 = undisclosed

Risk Assessment questions. No missing data.		
Variable	**Description**	**Values**
Sex	Are you male or female?	1 = male 2= female
Age	What is your age?	Between 45-64
Age_Categorised	Ages put into categories	1= 45-49 2 = 50-54 3 = 55- 59 4 = 60-64
Family_History	Does your family have a history of heart disease?	0=No 1= Yes
Hypertension	Has your Doctor diagnosed you with high blood pressure?	0=No 1=Yes
Hypercholesterolemia	Has your Doctor diagnosed you with high cholesterol?	0=No 1= Yes
Diabetes	Has your Doctor diagnosed you with diabetes?	
Smoking_status	Do you smoke?	0=Never 1= former 2= current
Exercise_status	Do you exercise or play sport in your leisure time?	0 = seldom / Never 1= sometimes 2 = often / very often
Height	Drag the marker to show your correct height.	cm
Weight	Drag the arrow to show your correct	Kg

	weight.	
BMI	BMI calculated	
BMI_recoded	BMI coded into below 30 or 30 and above	1= under 30 2= 30 and above
Risk_output	Risk output (respondents result)	1= low 2= moderate 3= High
Risk_output_ dichotomised	The risk output results dichotomised into low and moderate/high due to small cells. For subgroup analysis.	1=Low 2= Moderate / High
filter_BMI	Filter to eliminate those who failed to move the arrow to indicate weight and specified they were 3 stone13lbs	Filter on for all analyses.

Appendix 26. Example of risk output results send to respondents on request.

Glyn Elwyn BA MB BCh MSc FRCGP PhD
Research Professor
Department of Primary Care and Public Health
School of Medicine
Cardiff University
Neuadd Meirionnydd
Heath Park CF14 4YS
Visiting Chair Centre for Quality of Care Research
Radboud University Nijmegen Netherlands

elwyng@cardiff.ac.uk
00 44 29 20 68 71 95 tel
00 44 29 20 68 72 19 fax

MyHeartRisk Study

A study into public perceptions of heart disease risk

This page has been produced as you kindly took part in a study by Cardiff University looking into people's perceptions of heart disease risk and requested a copy of the results from your heart disease risk assessment.

The assessment was carried out using a developed prediction tool[1] that calculates an individual's future risk of developing heart disease, by using information about health and lifestyle. This includes age, family history of heart disease, diagnosis of high blood pressure, high cholesterol or diabetes, smoking status, level of physical activity and body mass index.

Please find below, your personalised risk calculated from the information you gave us. This is an estimation of your future risk of heart disease and is not a medical diagnosis.

---

[1] Mainous et al. 2007. A Coronary Heart Disease Risk Score Based on Patient-Reported Information. *American Journal of Cardiology* 99, pp.1236-1241.

Your calculated risk of having a coronary heart disease event in the next 10 years is:

High (over 20%)

A coronary heart disease event is defined as:

Myocardial infarction (heart attack)
Fatal coronary heart disease (death from coronary heart disease)
or cardiac procedure (a medical procedure involving the heart)

For further information about Heart health please visit:

The British Heart Foundation: http://www.bhf.org.uk/

British Heart Foundation main telephone number: 020 7554 0000
Heart Helpline: 0300 330 3311 (open Monday to Friday 9am to 6pm)

For further information about this study please contact:

Cherry-Ann Waldron: **WaldronC@cardiff.ac.uk**
Professor Glyn Elwyn: **ElwynG@cardiff.ac.uk**

We would like to take the opportunity to thank you once again for your participation in this study.

Appendix 27. Press release issued to Local Newspapers.

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

News Centre
News from Cardiff University

Web-based calculator to help predict heart disease

For immediate release:
Friday 12th February, 2009

Internet users can assess their future risk of having heart disease by visiting a new website developed by Cardiff University experts.

myHeartRisk.co.uk is a new website that assesses risk of developing heart disease in the future, by using information about health status and lifestyle. There is also an electronic questionnaire which asks people's opinions about their risk.

Heart disease is the biggest killer in the UK and lots of people do not know they are at risk from it. Heart disease risk can be reduced by making small changes to lifestyle, such as adopting healthier behaviours or taking medication. Therefore, it is important to have an assessment to know if you are at risk.

The website has been developed as part of a research study by Principle Investigator Professor Glyn Elwyn and Cherry-Ann Waldron from Cardiff University's Department of Primary Care and Public Health and supported by Professor Julian Halcox of the Wales Heart Research Institute.

The aim of the research study is to examine perceptions and attitudes towards heart disease, and provide insight into what people think about their risk when it is presented to them in a certain way.

Professor Glyn Elwyn who leads Cardiff University's School of Medicine's Decision Laboratory research group said: "myHeartRisk is a quick and 'easy- to-use' website that provides an estimation to those who may not have thought about their risk of heart disease before."

The study is looking for volunteers to visit the website, who are aged between 45 and 64 years of age, have not been previously diagnosed with heart disease, had a cardiac event (such as a heart attack or angina) or had a stroke.

£1 will be donated to the British Heart Foundation for every person who takes part and completes the study with the University hoping to raise over £1,000.

-Ends-

Notes:
1. Further information or to arrange a media interview, please contact:

Angela Watkins
Tel: 029 206 87190
E-mail: watkinsa6@Cardiff.ac.uk

Cherry-Ann Waldron
029 206 87193
E-mail WaldronC@cardiff.ac.uk

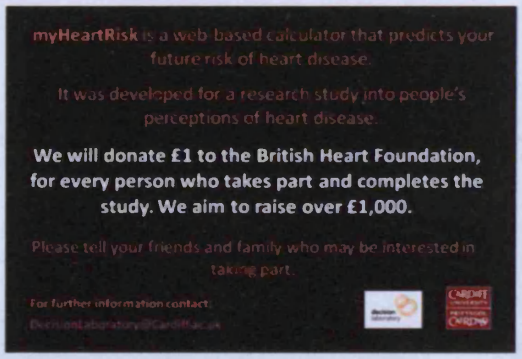
2. Cardiff School of Medicine
Cardiff University's School of Medicine is a significant contributor to healthcare in Wales, a major provider of professional staff for the National Health Service and an international centre of excellence for research delivering substantial health benefits locally and internationally. The school's 800 staff include 500 research and academic staff who teach more than 2,000 students, including 1,110 postgraduate students.

The School is based at the Heath Park Campus, a site it shares the University Hospital of Wales, the third largest university hospital in the UK. The School has an all-Wales role, contributing greatly to promoting, enhancing and protecting the nation's health. A key partner in this role is the National Health Service (NHS) in Wales, with which the School is linked at all levels. This mutual dependency is illustrated by the teaching of medical undergraduates in more than 150 hospitals located in all of Wales' health authorities. The medical curriculum followed at the School enables students to acquire and apply knowledge, skills, judgement and attitudes appropriate to delivering a high standard of professional care.

Around 300 new doctors currently graduate from the School every year and the Welsh Assembly Government has invested substantially in new teaching facilities to increase this number further.

Appendix 28. Healthy on-line magazine blog entitled: What's your Heart Risk?

Appendix 29. A5 sized posters and pocket-sized cards.



Appendix 30. Storyboard of web pages given to web developer.

Homepage

Welcome to 'myheartrisk.co.uk'

A web-based tool that calculates your risk of heart disease

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

A study into public perceptions of heart disease risk

Click to continue...

version 3 - 13/3/09 1

A study into public perceptions of heart disease risk

Participant Information page

Please read this carefully

Introduction
What is the purpose of this study?
Why have I been chosen?
Do I have to take part?
What will happen to me if I decide to take part?
What do I have to do?
Will my taking part in the study be kept confidential?
What are the disadvantages or risks of taking part?
What are the possible benefits of taking part?
What will happen if I don't want to carry on with the study?
What if something goes wrong?
What will happen to the results of the research study?
Who is organising and funding this research?
Who has reviewed this study?
What do I need to do now?
What if I have other concerns?
Who should I contact for further information?

Thank you for taking the time to read this information page.
Please print a copy for future reference.

Click to continue.....

version 3 - 13/3/09 ProgressBar 2

Disclaimer page

Disclaimer

- You will be presented with an estimation of your future risk of heart disease calculated from the information you give us.
- This study uses a published prediction tool that assesses risk using patient self-reported information.
- This estimation is an indication of risk and is not to act as a medical diagnosis.
- We are not able to enter into personal discussions about your cardiovascular risk, you must visit your doctor for this.

ProgressBar

Click to continue.....

version 3 - 13/3/09

3

Consent page

ELECTRONIC CONSENT FORM

A study into public perceptions of heart disease risk

Please check the appropriate boxes

1. I confirm that I have read and understood the information page dated.....for the above study and have been informed of the opportunity to ask questions and how to do this
2. I understand that my participation is voluntary and that I am free to withdraw at any time, by exiting from the web browser, without giving any reason.
3. I have read the disclaimer and understood that this study provides an estimation of my risk of heart disease, and I am to visit my GP if I am interested in having a more formal clinical assessment.
4. I agree to take part in the above study.
5. I **do not** wish to take part in the above study.

ProgressBar

Click to continue.....

version 3 - 13/3/09

4

End page for those not consenting to participate

We are sorry you do not wish to take part in this study....

myheartrisk.co.uk

Many thanks for taking time to visit this website.

Please tell your friends and family who may be interested in taking part in this study.

For further information about the study please contact:

The Research Team at Cardiff University

Cherry-Ann Waldron waldronc@cardiff.ac.uk
Professor Glyn Elwyn Elwyng@cardiff.ac.uk

For further information about heart health please contact:
The British Heart Foundation http://www.bhf.org.uk/

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Eligibility page

ProgressBar

myheartrisk.co.uk

Are you eligible to take part?

Please indicate whether you agree with the below statements, by checking the box that best describes you.

I am between the ages of 45 and 64 years of age.

I have never been previously diagnosed with cardiovascular disease, had a heart attack, other cardiac event, or had a stroke.

Click to continue... ..

version 3 - 13/3/09 6

End page for illegible respondents

myheartrisk.co.uk

Sorry.....

This calculator is unsuitable for you to use as it cannot give you as an accurate estimation as possible.

Many thanks for visiting this website and please tell your friends and family who may be interested in this site and taking part in this study.

For further information about the study please contact:

The Research Team at Cardiff University

Cherry-Ann Waldron waldronc@cardiff.ac.uk
Professor Glyn Elwyn Elwyng@cardiff.ac.uk

For further information about heart health please contact:
The British Heart Foundation http://www.bhf.org.uk/

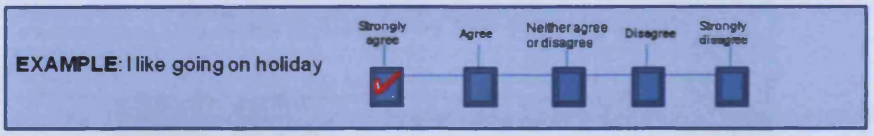
version 3 - 13/3/09 7

Pre intervention questionnaire measuring risk perception – example questions only

myheartrisk.co.uk

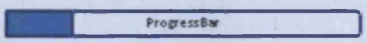
Before we calculate your risk.....

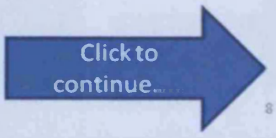
Please read the statements below and check the box on the scale that most applies to you:



Are you worried about developing a heart disease in the future?
Can you indicate on a scale of 1 to 7 how worried you are?'

(with 1 = not at all worried and 7 = extremely worried)





version 3 - 13/3/09 8

Risk profile questions 1

In order for us to calculate your risk profile.....
Please check the box that most applies to you

myheartrisk.co.uk

Are you male or female?

Age
(Move curser over scale to your age and click once)

55

50 60 70

Does your family have a history of heart disease? YES NO

Has your doctor diagnosed you with any of the following?.....

High blood pressure (Hypertension) YES NO

High cholesterol (Hypercholesterolemia) YES NO

Diabetes YES NO

ProgressBar

Click to continue..

version 3 - 13/3/09

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Risk profile questions 2

Just a couple more questions.....

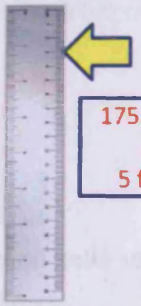
myheartrisk.co.uk

Please check the box that most applies to you

Do you smoke? Never Former Current

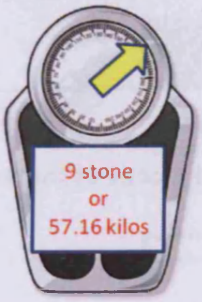
Do you exercise? Often or very often Sometimes Seldom or Never

Drag arrow to show your height and click once.



175.26 cm
or
5 ft 9 "

Drag arrow to show your weight and click once.



9 stone
or
57.16 kilos

Click here for calculation

ProgressBar

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10

myheartrisk.co.uk

Please wait a few moments while your risk is calculated.....

ProgressBar

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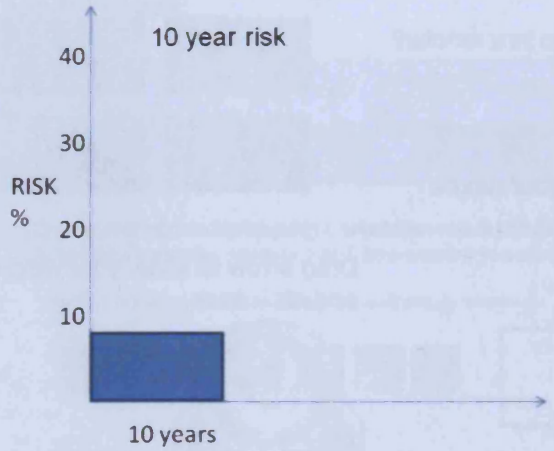
Risk format page (printable page)

myheartrisk.co.uk

Your calculated risk of having a coronary heart disease (CHD) event in the next 10 years is 9%



Click to continue.....

If you would like to print a copy of this to show your doctor click here

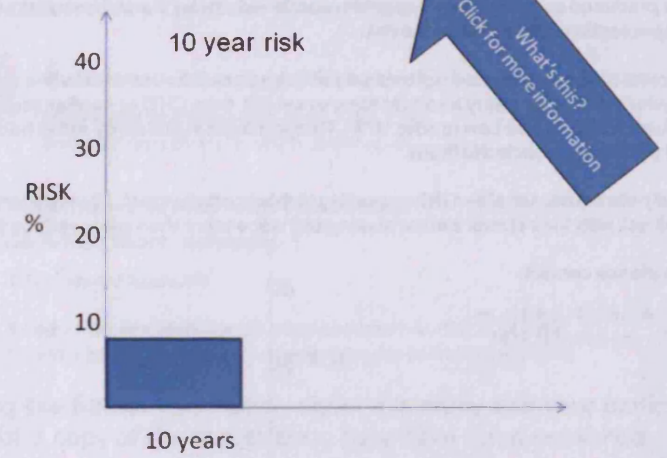
ProgressBar

version 3 - 13/3/09 12

Arrow appears to guide to additional info page

myheartrisk.co.uk

Your calculated risk of having a coronary heart disease (CHD) event in the next 10 years is 9%



Click to continue.....

If you would like to print a copy of this to show your doctor click here

ProgressBar

version 3 - 13/3/09

13

Additional information page

myheartrisk.co.uk

A Coronary Heart Disease event has been defined as:

Myocardial Infarction (heart attack)
Fatal CHD (death from coronary heart disease)
Or Cardiac Procedure (medical procedure involving the heart)

For more information about any of these, please visit the BHF website using the link at the end of this study.

British Heart Foundation

ProgressBar

version 3 - 13/3/09

Click to return

14

Print out page for GP - Details of study and respondents personalised risk estimate

Dear Doctor,

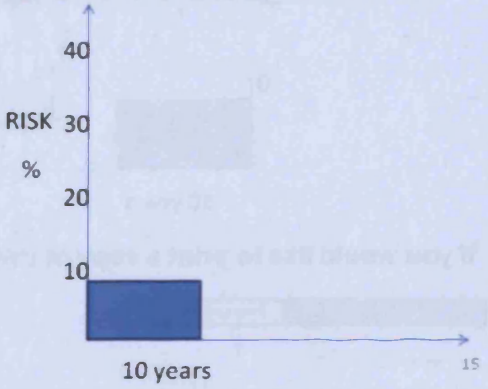
This printout has been produced as your patient has taken part in a study by Cardiff University looking into peoples' attitudes and perceptions of heart disease risk.

A rudimentary assessment of risk was carried out using a published prediction tool that uses self-reported data. It categories 10 year risk of a coronary heart disease event (MI, fatal CHD or cardiac procedure) into high (over 20%), medium (10-20%) and Low (under 10%). Respondents in this study either had their 10 year risk or longer-term (30 year) risk projected to them.

Please find below, your patients personalised risk according to this prediction tool. All respondents were advised to discuss their risk with their doctor before making any necessary changes to reduce their risk.

For further information please contact:

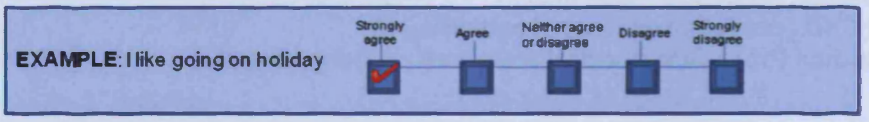
Cherry-Ann Waldron waldronc@cardiff.ac.uk
Professor Glyn Elwyn Elwyng@cardiff.ac.uk



Post intervention questionnaire – example questions only

Now you have seen your risk.....

Please read the statements below and check the box on the scale that most applies to you:



Please indicate your response on the scales

I definitely do not -3 -2 -1 0 +1 +2 +3 I definitely do

.....intend to stop smoking

After viewing your results how worried/disturbed do you feel?

(1= not worried at all, 7= very worried)

1 2 3 4 5 6 7

Progress Bar

Click to continue.....

End of study page

Many thanks for taking part in this study

myheartrisk.co.uk

For further information about the study please contact:

The Research Team at Cardiff University

Cherry-Ann Waldron waldronc@cardiff.ac.uk
Professor Glyn Elwyn Elwyng@cardiff.ac.uk

For further information about heart health please contact:

The British Heart Foundation

http://www.bhf.org.uk/

British Heart Foundation main telephone number: 020 7554 0000
Heart HelpLine: 0300 330 3311 (open Monday to Friday 9am-6pm)

If you would like further information about this study and your participation in it, or would like a copy of the results once they have been published

Please click here:

version 3 - 13/3/09

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For further information

Please enter your contact details

myheartrisk.co.uk

Name: enter

Email: enter

Telephone: enter

Address: Enter

Preferred method of contact: Email:
Telephone:
Letter

Nature of enquiry: More details of study
Details about your participation
Copy of published results
Other: (please specify)

Free text box

Click here to submit.....

version 3 - 13/3/09

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Last page

mybeartisk.co.uk

Thank you

Your details have been submitted.

A member of the research team will contact you shortly.....

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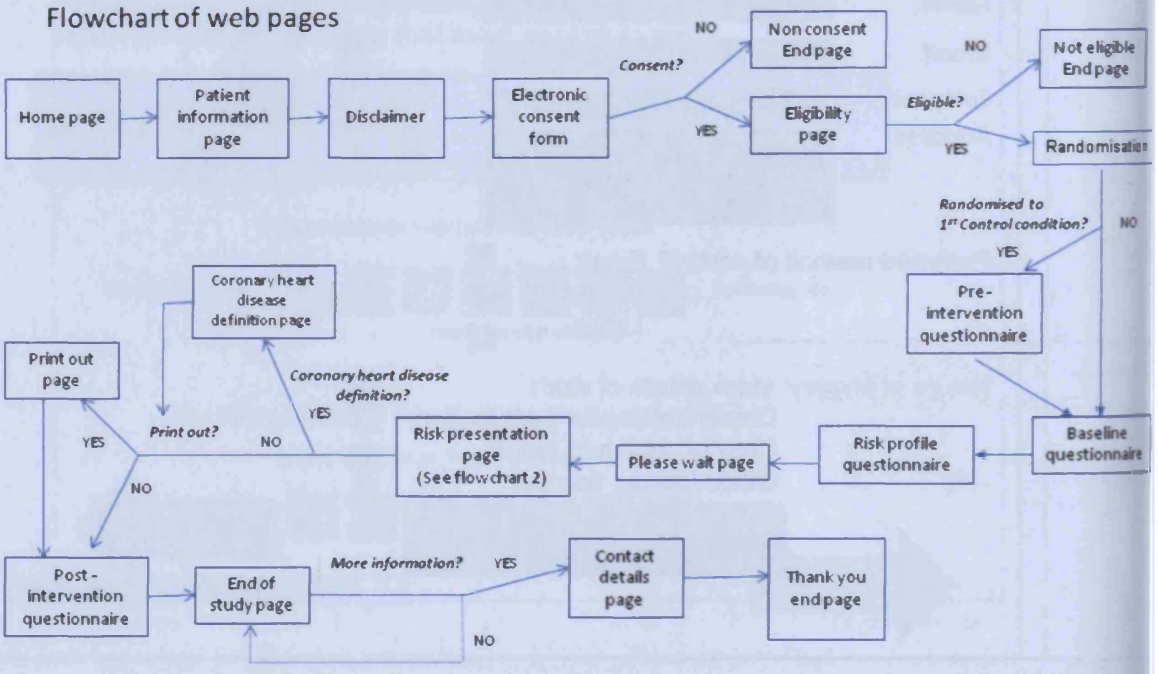
Flowchart of web pages



Appendix 31. Hypothetical risk profiles created for phase 1 of pilot testing.

	Hypothetical risk profiles										
	1	2	3	4	5	6	7	8	9	10	11
Risk factors											
Sex	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Female
Age	62	50	52	56	50	48	52	46	59	47	45
Family History	Yes	No	Yes	No	No	No	No	No	No	No	Yes
High blood pressure	No	Yes	No	Yes	No	No	No	No	Yes	No	Yes
High cholesterol	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes
Diabetes	Yes	Yes	No	No	No	Yes	No	No	No	No	Yes
Smoking status	Current	Former	Never	Current	Former	Current	Never	Current	Never	Former	Current
Exercising status	Sometimes	Seldom/ Never	Often/ very often	Sometimes	Often/ very often	Never	Sometimes	Sometimes	Sometimes	Often/ very often	Never
Height	165cm	5ft 6"	186cm	5ft 2"	170cm	5ft 4"	180cm	185cm	5ft 2"	187cm	5ft 8"
Weight	199kg	13st 10lbs	70kg	8st 7lbs	87 kg	9st 6lbs	80kg	78 kg	11st 9lbs	68kg	10st 6lbs
Risk category	High	High	Moderate	Moderate	Low	Moderate	Low	Low	Moderate	Low	High

Appendix 32. Email circulated to recruit reviewers for phase 1 of pilot testing.

Subject: help with my heart risk website

Dear Decision Lab,

In the meeting on 9th December I was asking for volunteers to pilot test the website for my trial. The web-site is now ready and I am looking for people to try it out.

If you can spare around 10 minutes of your time in the next day or so, please let me know and I will give you sheet with questions and a hypothetical risk profile to input into the website.

Your help will be much appreciated.

Many thanks,

Cherry-Ann

Cherry-Ann Waldron
PhD student
Department of Primary Care and Public Health
Clinical Epidemiology Interdisciplinary Research Group
Cardiff University
2nd Floor, Neuadd Meirionnydd
Heath Park
Cardiff CF14 4YS
T: +44(0)29 2068 7193
E: waldronc@cardiff.ac.uk

Appendix 33. Instruction sheet with one of the hypothetical risk profiles for phase 1 of pilot testing.

Pilot study phase 1.

For the purposes of this pilot study, please imagine you are the person described below.

Please visit www.myheartrisk.co.uk/pilot.html

Work your way through the site, entering the information from the hypothetical risk profile and complete the questionnaires.

As you navigate through the website, please make a note of which risk category you were given, and any problems and glitches etc. that you experienced.

Also, please state which web-browser you use on your computer.

Many thanks for your help.

Hypothetical risk profile 1	
Sex	Male
Age	62
Family History	Yes
High blood pressure	No
High cholesterol	No
Diabetes	Yes
Smoking status	Current
Exercising status	Sometimes
Height	165cm
Weight	199kg

Risk category (e.g. high, moderate, low)	
Web-Brower used (e.g. Firefox version 3.0.15 / Internet Explorer 8)	
Feedback (problems, glitches etc)	

Appendix 34. Responses from reviewers in phase 1 of the pilot testing.

Reviewer	Functionality of website	Layout	Risk presentation formats	Misc.
1	*Can't go back.* *Doctor printout said low when I was high.* *Progress bar not to end on the thank you screen* *Not clear if it is ok to log out of you don't want to leave details.* *End of study page - progress bar doesn't go to the end.*	-	-	-
2	*Difficult to select exact weight.* *Tried to print page that had risk represented as hearts, but took me to next page.* *Tried to print that page an site froze – then switched risk category to low when I got back to page* *Print page didn't work.*	-	-	-
3	*Accidently clicked on the back button on browser during process and took me to homepage – started again.(Don't know whether this is actually a problem or not though).*	*Also, one thing I thought about the arrow to show weight – seemed counterintuitive to decrease rather than increase weight.*	*Don't understand the point of the question marks on the risk graph.*	-

4	*Freezes on male/female/age page (tried twice).* *Also, cannot unclick a section.* *If you're aged 45 you have to move the marker across and back for the page to move. You should start at 40 so people can move marker and not get stuck.* *On the risk page it initially jumped then 2nd click was static.*	*I originally ticked former smoker – all smoking questions 34-41 were about smoking – N/A (also, cannot turn page unless answered questions).* *Family history of heart disease – not known.* *Height in cm – older people use feet and inches.*	*Question marks on bar graph unclear – I think block of colour and number would be better.*	*Q what are the possible benefits of taking part? – participant may expect the 1st time to be ' you will receive a personalised, approximated measurement of your risk of heart disease – future risk of heart disease estimated.* *Who is funding this research? – not BHF? Worth mentioning?* *Further info – should your name + details be provided also?)*
5	-	*Questions 60 to 65 on Likert scale it states negative response items only on either side of the scale.*	*Didn't spot too many glitches, but when it came to the part where it calculated my risk profile I got a row of hearts with question marks. I don't know what that's supposed to mean, but I found this a bit puzzling.*	-
6	*I went to the more info section right at the end and then changed my mind so clicked 'back' and it just went back to the home page so I couldn't go back and print the results.* *Wasn't sure whether the click to continue button would take me through all of the info at the beginning.*		-	*Everything else was clear and worked very well. I liked the progress bar at the bottom.*

	The weighing scales were a little difficult to get the exact weight as they're very sensitive. Could you maybe have an alternative box to enter numbers?	
7	-	*Pre Q – all questions all of the time?* *Q60-65 – 2 x strongly disagree etc (2 negative anchors).*
8	*Dragging the marker for height was tricky – it didn't work until I clicked over it a number of times, then worked ok.* *When I clicked through to entering contact details and changed my mind, the back button doesn't work.* *When I clicked submit when the details were empty, it confirmed details have been submitted – maybe a message could be added saying 'please enter details' before the user is allowed to click 'submit' and progress to next page.* *Maybe because I am using a Mac, each section took two clicks on the mouse rather than 1.*	*I like the layout and design of the site – simple and eye catching.*

9	*I thought it was easy to follow and very professional!*	*There is an issue with qns 60-65, both ends of the scales are labelled the same on these questions.*		*The only other thing is that I was unsure how to interpret 'how do you normally feel/feel now' questions in some cases e.g. upset because of external factors, or just finding self upset? Or alert- in a positive way or because stressed and concerned? I probably would answer these with different interpretations of the meanings pre and post survey.*
10	*Option to print show worry scale results.* *When I clicked on CHD for the definition and I clicked continue, my calculated risk changed from moderate to low.* *Back doesn't work.* *When I filled in the question (sex, age etc) a 2nd time a different result has been given (hearts instead of bar charts).*	*Why do the ticked boxes turn red?* *Colours beige are clickable but not on the last page – blue and underlined everyone recognises as a hyperlink.* *Why change the answer categories in 51,52,53,54 (to right was positive, but now to the left and answers are with -, while it's positive.* *Different font questions 66-72 and again positive thing to do is left now and -3 etc. and different within the same page.*	*It could be me, but I find the heats with ? in them a bit confusing (same with bat chart). The two lines (10 hearts) looks very different, maybe you could explain why there is a difference.* *The red hearts look definite. (maybe a definite statement to go with it?) and pink with ? look like you don't know (maybe a not so definite statement here?)*  ..... 	

			So people can relate to that, because your attention is being drawn to the diagrams/ figures it might be easier to relate to the diagram by using in your explanation.	
11	*On risk page 'coronary heart disease' disappears when highlighted – clicking on this moves up the progress bar and continuing take me to a 'low' risk page.* *Back button on browser doesn't work as expected.*	*All info pages are longer than my screen, even of very little text on them.* *Losing weight Qs have some options for high and low numbers.* *Items 68-69 are offset to the left.*	-	-

Appendix 35. Email circulated to recruit reviewers in phase 2 of pilot testing.

Subject: Help with piloting a web-based trial on cardiovascular risk communication

Dear Clinical Epidemiology IRG members,

I am looking for volunteers to participate in a piloting phase of a web-based trial on cardiovascular risk communication.

The aim of this pilot is to ensure there are no glitches in the website and that everything is user-friendly and easily understood.

I am looking for between 10 and 15 people aged between 45 and 64 (without established heart disease) to navigate through the web-site. This will involve answering questions to assess your future risk of heart disease, viewing the result, and completing a post-intervention questionnaire.

If you have 10 minutes to spare and are able to help, please contact me and I will send you the link to the website. I will be extremely grateful.

Many thanks in advance,

Cherry-Ann

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Appendix 36. Email circulated to those who agreed to participate in phase 2 of pilot testing.

Subject: Many thanks for agreeing to help with piloting a web-based trial on cardiovascular risk communication

Dear Clinical Epidemiology IRG member,

Many thanks for agreeing to take part in the piloting phase of this web-based trial on cardiovascular risk communication.

The website address is www.myheartrisk.co.uk

Please work your way through the website, answering the questions as truthfully as possible (don't worry it is completely anonymous and you cannot be identified!).

Please make a note and let me know of any glitches or problems you encounter, or anything that is confusing and does not make sense.

Your participation is very much appreciated.

Many thanks again,

Cherry-Ann

Cherry-Ann Waldron
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Appendix 37. Phase 2 of pilot testing - Reviewers comments of a positive nature.

Reviewer	General comments about the site	Participant information	Disclaimer, Consent, Eligibility	Baseline affect/worry and Pre-intervention questionnaire	Risk assessment questions	Risk output	Post-interventions questionnaires	End of study and Contact details page
Reviewer 1 n-ex	We found it very easy to follow and the information given was clear.	-	-	-	-	-	-	-
Reviewer 2 n-ex	It's certainly an excellent eye opener for those who need to improve their lifestyle. Well done I'm very impressed.							
Reviewer 3 n-ex	It looked good.	-	-	-	-	-	-	-
Reviewer 4 n-ex								
Reviewer 5 n-ex	The website is easy to follow, bright and inviting!	-	-	-	-	-	-	-
Reviewer 6 n-ex	Very clear and concise. I found the site both user friendly and friendly.							
Reviewer 9 ex	Generally, I was impressed and found it quite easy to navigate etc.	-	-	-	-	No problems answering any of the predictor questions.	-	-
Reviewer 10 ex	Scrolling to see progress bar ok in Opera and chrome in kiosk mode.	The black on white, sans serif typeface is clear for the individual pages.	-	-	-	-	-	-

Reviewer 11 ex	I liked it! Great colour and graphics.	-	-	-	I liked the interactive tools, e.g. the weighing scales.	-	-	-
Reviewer 12 ex	Seems basically fine	-	-	-	-	-	-	-
Reviewer 13 ex	Nice website. Clearly laid out. Links seemed to work.	-	-	-	-	-	-	-
Reviewer 14 ex	Very nice and slick web-site, I actually found it very useful, easy to navigate and couldn't find any glitches, wording was fine also.	-	-	-	-	-	-	-
Reviewer 15 ex	Looks attractive, no significant problems at all.	-	-	-	-	-	-	-
Reviewer 16 ex	It works very nicely and the graphics are great.	-	-	-	I particularly liked the adjustable pointers for age, height and weight.	-	-	-
Reviewer 17 ex	Generally easy to use, clear straightforward etc.	-	-	-	-	-	-	-
Reviewer 18 ex	-	-	-	-	-	The system displayed my risk pictorially as 9 men out of 100 - this looked OK.	-	-

Reviewer 19 ex	Brilliant site. Very easy to navigate and great graphic design. Appealing and convincing. My compliments! I enjoyed the experience and happy to know I'm not about to keel over any time soon.	-	-	-	-	-	-	-
Reviewer 20 ex	I like the idea of the one pound incentive for the Br Heart Foundation.	-	-	-	I liked this dragging options.	The bar chart looks fine.	The TPB questions do not seem to take too much time.	-
Reviewer 21 ex	-	-	-	-	-	-	-	-

Appendix 38. Phase 2 of pilot testing - Reviewers comments of a negative nature.

Reviewer	General comments about the site	Participant information	Disclaimer, Consent, Eligibility	Baseline affect/worry and Pre-intervention questionnaire	Risk assessment questions	Risk output	Post-intervention questionnaires	End of study and Contact details page
Reviewer 1 n-ex Reviewer 2 n-ex	-	-	-	-	The only problem we both encountered was setting our weight on the gauge. We had to leave it as close as, as it was very sensitive to movement.	-	The only bit I wasn't sure of was the section at the end about exercise and weight. I wondered if this had been calculated from the information that I'd given and it was recommended that I exercise more and lose weight.	We both wanted to check 2 boxes on education.
Reviewer 3 n-ex Reviewer 4 n-ex	-	When I was reading through each of the information items from the list at the start, each time I closed a particular item it took me back towards the top of the list, not on the item I had just been on so I could move on to the next one.	-	-	-	-	Questionnaire was a bit repetitive.	-
Reviewer 5 n-ex	No back button, couldn't see if I'd filled in the last question on a page and there was no way to go back and see.	-	-	-	-	-	-	-

Reviewer 6 n-ex	-	The introduction list, I seemed to have to step back and select each item, rather than flick forward through it, each one seemed clear and short, so I would have preferred that.	-	-	Dials with moving needles – could perhaps be bigger.	I wonder whether there should be some comparators to the risk statistic- perhaps the difference from average, or the percentage of improvement if lifestyle is changed. Something to improve the understanding of the message.	I don't think I understood some of the option about fear and exercise fully, so may have flipped through without giving them enough attention, so perhaps reducing their value.	-
Reviewer 7 Ex	-	'What is the purpose of this study' you give the url of the website but it is not the same as the URL that displays in the browser status bar. 'will my taking part be kept confidential' you say '..at an agreed period' rather than '..after an agreed period. 'what do I need to do now?' you instruct to navigate to the electronic consent page, yet the only button available is a 'continue' button. It would be better to say press continue button which will take you to the consent page.	-	-	-	I don't understand the purpose of the two buttons marked 'moderate risk' and 'high risk'	In Qs 51-54 the numbers attributed to each level of difficulty. Etc. seem intuitively to be the wrong way around. I would expect to select -3 for difficult for example rather than +3. Ditto for 66-69. Q60 asks if I am prepared to lose weight. Is it asking me if I am ready to try losing weight or if I am willing to try losing weight, which are not the same thing.	-

Reviewer 8 Ex	At whom is this aimed? The language used appears to be above 9 –year-old/sun reader literacy level.	Scrolling is still a pain. This really needs to retain and indicate where the participant has visited, otherwise they won't know where they have been. A 'next' option would be handy, but there is a lot to wade through. What are the disadvantages or risks of taking part? Typo: 'we recognise that viewing you risk...' What if something goes wrong? – professor Glyn Elwyn, line break	-	-	Do you smoke? – if this question is missed and 'click to continue' clicked, the 'please answer all questions' message is displayed. If smoking is answered and 'click to continue' clicked, the survey goes to the next page, even if the other 3 qs (exercise, height and weight) are missed. I had a very good result, presumably because it thought I was 130cm high and weighed 25kg! I have not checked all combinations on all pages.	Blue link text on the basic calculated display disappears when highlighted.	If question 56 is missed it is highlighted. If it is subsequently filled in but something else is missed, it is still highlighted. Do you intend to have the values for answers showing, especially for qs 51-54, 66-69, etc. (negative scores for positives, positive scores for negatives).	-
Reviewer 9 Ex	-	-	-	I didn't like being asked if I was ashamed or nervous (I assume that was for personality type) it seemed irrelevant and intrusive.	Would have liked to see stones and pounds rather than kilos	-	-	Progress bar still had a way to go once I'd finished.

Reviewer 10 ex	-	Under disadvantages, in line 1 it should be your, not you. In the what if something goes wrong, the formatting of Glyn is a bit odd. In the what will happen to the results, the punctuation is a bit odd in the second paragraph. In what do I need to do now,.. the questionnaire.	-	-	Question about high cholesterol – I don't think that is very clear. How high does it have to be to be counted as high? Does the total have to be 5.5? 6? 7? What about the ratio of low hdl to high? I'm not sure that will get clear answers. And clearly the risk does depend on whether it is 6 or 10?	Explanation of CHD event – don't think MI or cardiac procedure were as helpful to a layperson as it could be.	Wasn't clear why we had to go through the first set of questions again, about being angry, anxious etc. – some explanation might help. It was tempting to just give the same answers as before without thought. Q 69 was hard to answer – forgot to write it down.	-
Reviewer 11 ex	-	-	-	-	-	-	Q 48-51 – isn't entirely clear what you are supposed to read here – it may be that patients might be confused and think the question has been missed off. Also, the scale on Qs 51-54 is confusing given what has gone before, why not just use 1-7 as above?? Same with other questions using this scale. Page with Q60-65 – programme got stuck after complete all qs and I couldn't move on.	-

Reviewer 12 ex	-	-	-	-	-	-	-	-
Reviewer 13 ex	Font sizes differed and the information in largest font did not always seem most important. This seemed a bit of a distraction – maybe better all the same size?	Long list of questions was off-putting. Was I supposed to read them all, or just click on the ones of interest, or ignore and continue? The subjects should have to work through each question to get to the next page- at least the then the content is in front of them if only for a few seconds. If people are sufficiently interested to go on the site, they should be sufficiently interested to read information sheet.	Language is a bit high brow (published prediction tool, self-reported information)	Q16 suddenly has numbers -3,-2,-1,0,1,2,3 rather than previous 1,2,3,4,5,6,7 which was a bit confusing. Also, the minus end was sometimes associated with the most positive response (easy/rewarding).	The line joining 3 boxes for do you smoke and exercise questions suggested a visual analogue scale. Why have it? The boxes alone would be clearer.	-	I don't consider I need to lose weight and so all the losing weight section seemed irrelevant and a bit irritating. Is it not better to exclude this if BMI below 24?	Last page told me I could close the browser, yet progress line was only 90% complete.
Reviewer 14 ex	-	Would be helpful to have some links here. -What do I need to do now – maybe a link to take you straight to the consent screen. -what if you have other concerns – clickable email link to Prof Elwyn, or a link to the Contact details screen -The email on the contact details doesn't work.	Consent – a 'back' button would be helpful in case the person wants to review the participant options again before consenting.	-	Weight adjustable pointer is very sensitive and a bit fiddly.	Would be nice to be able to print off your risk profile at the end, not just request it by email – it would also preserve your anonymity.	Weight reduction – q69. 'difficult is mis-spelt.	-

			We are sorry you do not wish to take part – a 'back' button might be helpful as well in case the person decides to change their mind. A 'quit' button to confirm their decision and take them out of the website. Disclaimer – this mentions a published prediction tool. It would be nice if this were referenced, or if there was a link to it, for anyone who wants further info.					
Reviewer 15 ex	-	List at beginning very long and a bit intimidating – is this necessary- it almost made me turn off.	-	-	Family history – you have risk as being event below 50 – most other assessment make it 60. I was a bit surprised	-	The questions at the end here have no real introduction – so their purpose is not clear – I think a few introductory words 'Now we'd like to check out your views on taking more exercise and losing weight...' or similar.	-

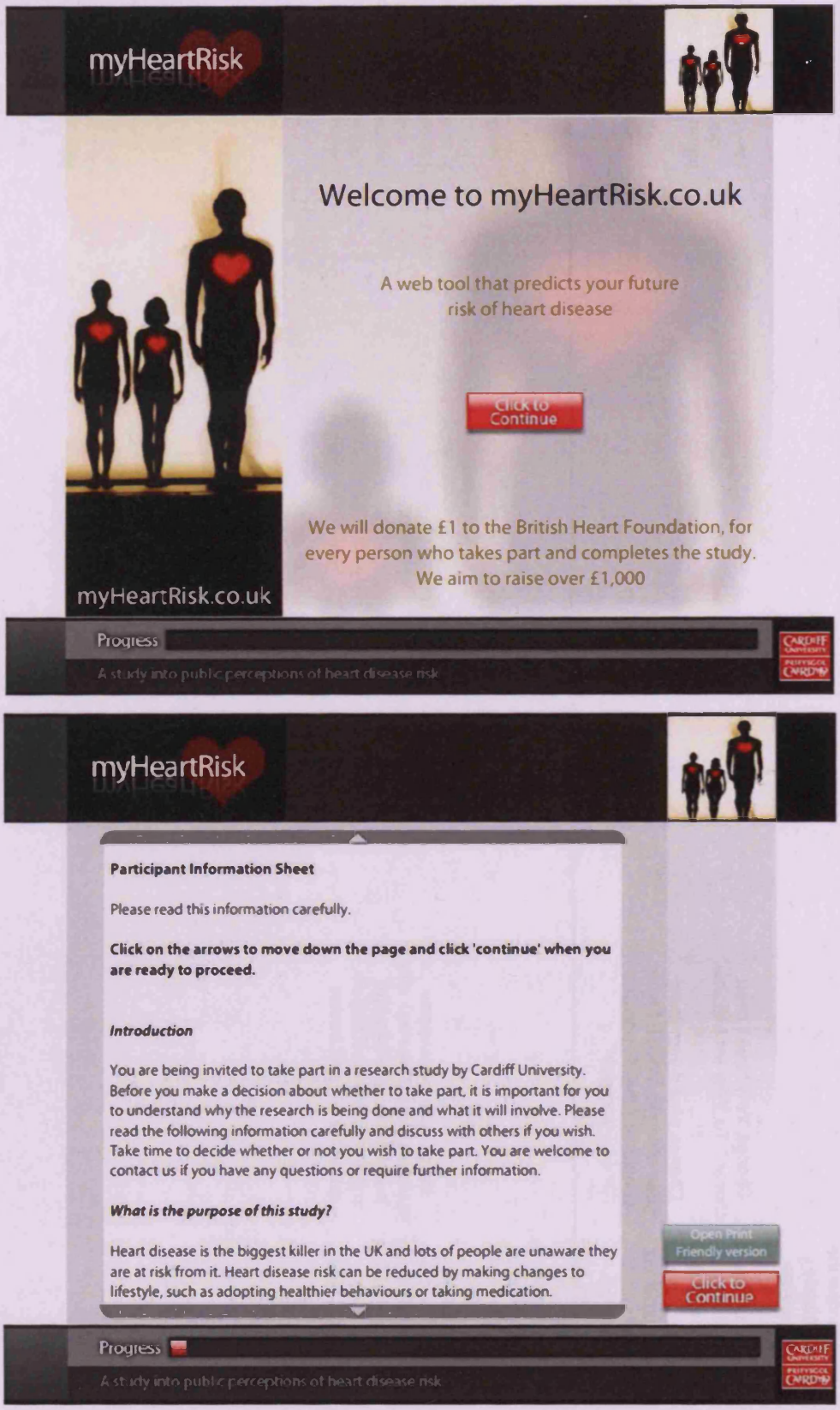
					that although I ticked box for raised cholesterol there was no further details requested here – I came out as low risk but surely if my cholesterol was high this would not be accurate.			
Reviewer 16 ex	The back button on the browser doesn't work with this site - is this deliberate? Desirable? I would have liked to go back, if only to see the pages I missed. Obviously we don't want people to be able to alter what they responded before seeing their risk – but I'm not sure that, after this stage, it is appropriate to prevent them doing so.	'What will happen if I don't want to carry on with the study? You can withdraw from the study at any point by closing the web browser.' Is this really what you want to happen? There are various reasons why a web browser can close without implying intention to withdraw - crashes, navigating away and not being able to get back, being called away and the kids then start using the computer, etc. Better for the system to require deliberate withdrawal , and allow return after interruption - though detect if they never return within a specified time frame and count that as a withdrawal.	-	Page 'Before we calculate your risk': are we asking how worried they feel, or how concerned? I'm concerned re my heart disease risk - but not worried. I realise that this is my most likely pathway of death. I am taking reasonable steps to minimise my risk. I have plenty else of more immediate concern.	-	-	Click to continue after questions 31-33 didn't work, first, but then it jumped to questions 47-54. Maybe I clicked twice, thinking the first click didn't register. Though one isn't allowed to move forward from other pages that require responses - ??? Questions 51-54 are appropriately scored as -3 to +3 for analysis - but this might be off-putting to numerically challenged respondents - why switch from using 1 to 7? Ditto 66-69. Are questions 60-65	-

							appropriate to ask of someone for whom there would be no great advantage to losing weight? I don't like my trousers being tight around my waist, but I don't feel inclined to actively lose weight for health reasons - I don't think you do either. Do the questions I missed seeing ask about smoking cessation intentions, or are such questions only asked to respondents who say they smoke?	
Reviewer 17 ex	Grammatical amendments needed on participant information. see email.	-	Once on the consent page, I don't think I actually saw it labelled as a 'consent page'. Possible to give it that heading?	-	-	-	Q33 – didn't know what to answer here, my indicated risk was very low but of course 'do as much as you can' is the only answer possible even when you're at low risk. Similar for Q60: of course I am prepared to lose weight but how does this fit in with weight not being an issue in some cases? Guess the problem is that I don't quite see what these answers would tell you. Q51: hesitated a long	I would have loved a 'close' button of some kind on the very last page instead of just the advice to close the browser. A psychologica l thing, I guess, I want to know I've rounded off something, completed something. Closing the

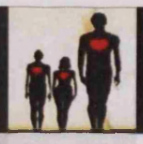
							time here as to how to interpret the sudden switch to the -3,-2,-1,0.1,2,3 answer format..numbers are not my strong point and even now I'm not quite sure if I gave the answers I intended to give.	browser just means I'm moving on to something else and leaving something 'open' behind me. It's all in the mind, I know, but it does make a difference, I think.
Reviewer 18 ex	Should give info about responding time (about 10 mins) at the beginning. There was no escape during the process. Does this mean that you will only generate data on participants who have gone through all pages? Will you not file non- or incomplete responders? I had to zoom	there is a risk that people might be mislead regarding the source of this website, which is Cardiff University and not Br Heart Foundation	-	-	The questions on exercise or play sport; Shouldn't you define what is exercise? Is regular walking or cycling, e.g. to work, exercise?	-	I was confused by the difference in answering scales. It was all 7-point, which is fine. But sometimes the scale was -3, to +3 (e.g. in questions 51-54) instead of 1 to 7. I would opt for the latter format only.	-

	out to view the complete home page.							
Reviewer 19 ex	-	Change 'Why have I been chosen? To 'Why am I eligible' Change what if something goes wrong to 'What If I have concerns/ What if I become worried?'	-	-	-	-	Why don't you change all questions to strongly agree- strongly disagree? Some of the questions do not make sense.	-

Appendix 39. Final version of the website used in the RCT.



myHeartRisk



Disclaimer

You will be presented with an estimation of your future risk of heart disease calculated from the information you give us.

This estimation is an indication of risk and is not a medical diagnosis.

We are not able to enter into personal discussions about your heart disease risk; you must visit your doctor for this.

Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Consent Page

Please read the following statements and check the appropriate box

1. I confirm I have read the information about this study.

2. I understand my participation is voluntary and I am free to withdraw from the study at any time.

3. I have read the disclaimer and understand that this study provides an estimation of my future risk of heart disease, and I am to visit my GP if I am interested in having a more formal clinical assessment.

4. I agree to take part in the study.

- ■ I agree with the above statements
- ■ I disagree with the above statements

Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Are you eligible to take part?

Please read the following statements and check the appropriate box.

1. I am between 45 and 64 years of age.

2. I have never been previously diagnosed with heart disease, had a heart attack, other cardiac event (e.g. angina) or had a stroke.

- ■ I agree with the above statements
- ■ I disagree with the above statements

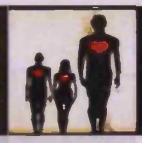
Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD

myHeartRisk



Before we calculate your risk, we would like to find out about how you generally feel.

Please read the following statements/ questions and check the number that best corresponds to you.

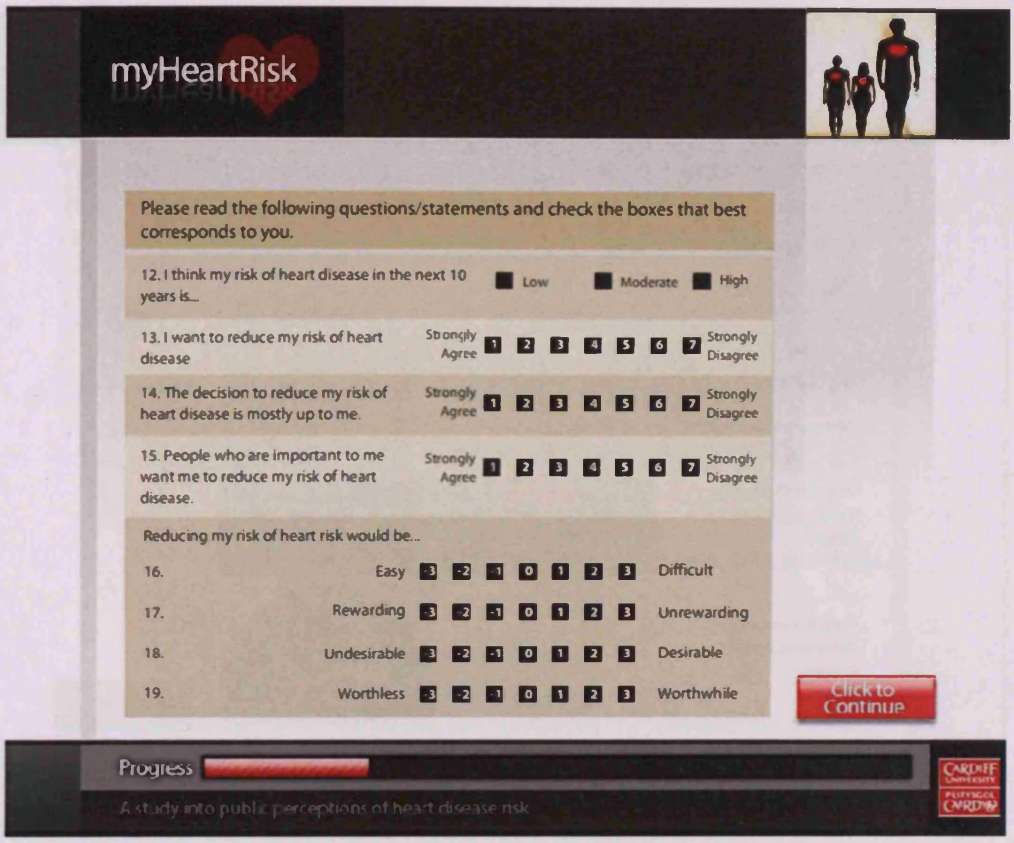
Thinking about yourself and how you normally feel, to what extent do you feel:							
1. Upset	Never	1	2	3	4	5	Always
2. Hostile	Never	1	2	3	4	5	Always
3. Alert	Never	1	2	3	4	5	Always
4. Ashamed	Never	1	2	3	4	5	Always
5. Inspired	Never	1	2	3	4	5	Always
6. Nervous	Never	1	2	3	4	5	Always
7. Determined	Never	1	2	3	4	5	Always
8. Attentive	Never	1	2	3	4	5	Always
9. Afraid	Never	1	2	3	4	5	Always
10. Active	Never	1	2	3	4	5	Always
11. How worried do you feel about developing heart disease in the future?							
	Not at all worried	1	2	3	4	5	Very worried

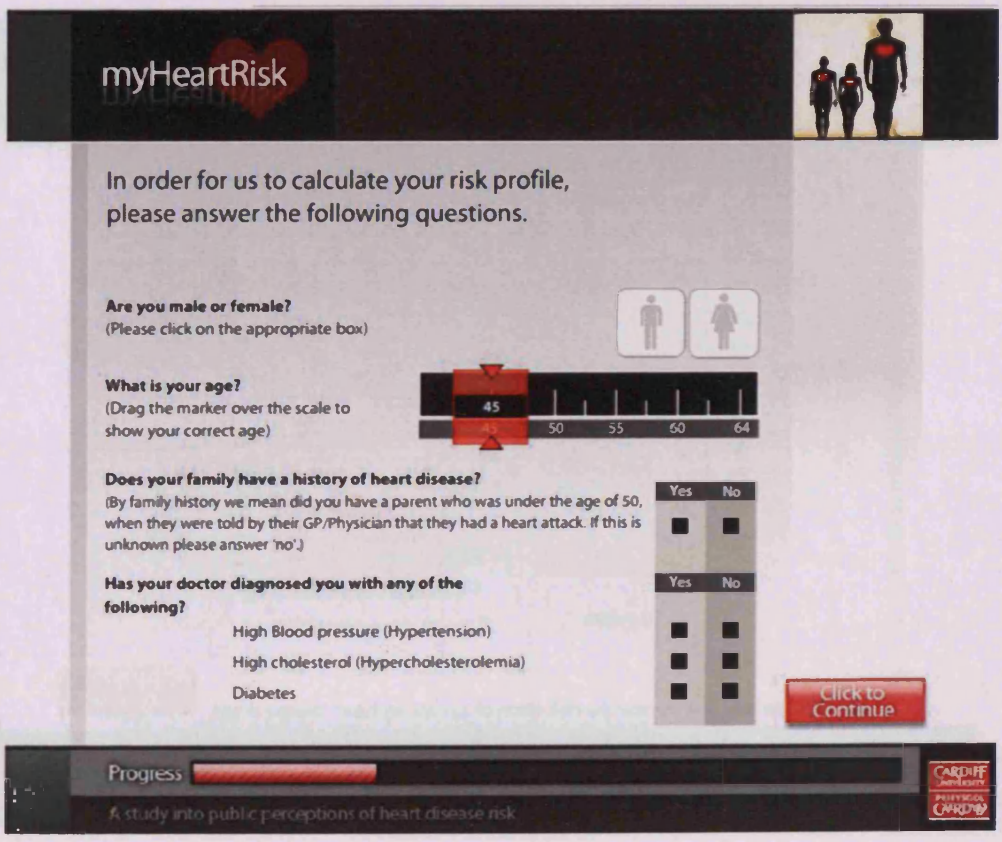
Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY PRIFYSGOL CAERDYDD


myHeartRisk
Please read the following questions/statements and check the boxes that best corresponds to you.
12. I think my risk of heart disease in the next 10 years is...
Low
Moderate
High
13. I want to reduce my risk of heart disease
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
14. The decision to reduce my risk of heart disease is mostly up to me.
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
15. People who are important to me want me to reduce my risk of heart disease.
Strongly Agree 1 2 3 4 5 6 7 Strongly Disagree
Reducing my risk of heart risk would be...
16. Easy -3 -2 -1 0 1 2 3 Difficult
17. Rewarding -3 -2 -1 0 1 2 3 Unrewarding
18. Undesirable -3 -2 -1 0 1 2 3 Desirable
19. Worthless -3 -2 -1 0 1 2 3 Worthwhile
Click to Continue
Progress
A study into public perceptions of heart disease risk


myHeartRisk
In order for us to calculate your risk profile, please answer the following questions.
Are you male or female?
(Please click on the appropriate box)
What is your age?
(Drag the marker over the scale to show your correct age)
45
50
55
60
64
Does your family have a history of heart disease?
(By family history we mean did you have a parent who was under the age of 50, when they were told by their GP/Physician that they had a heart attack. If this is unknown please answer 'no'.)
Yes
No
Has your doctor diagnosed you with any of the following?
Yes
No
High Blood pressure (Hypertension)
High cholesterol (Hypercholesterolemia)
Diabetes
Click to Continue
Progress
A study into public perceptions of heart disease risk

myHeartRisk

Just a couple more questions.....

Please check the box that most applies to you.

Do you smoke?

No, I have never smoked	I have smoked in the past but no longer	Yes, I smoke regularly or I have smoked within the last year
■	■	■

Do you exercise or play sport in your leisure time?

Often or Very Often	Sometimes	Seldom or Never
■	■	■

Drag the marker to show your correct height.

Drag the arrow to show your correct weight.

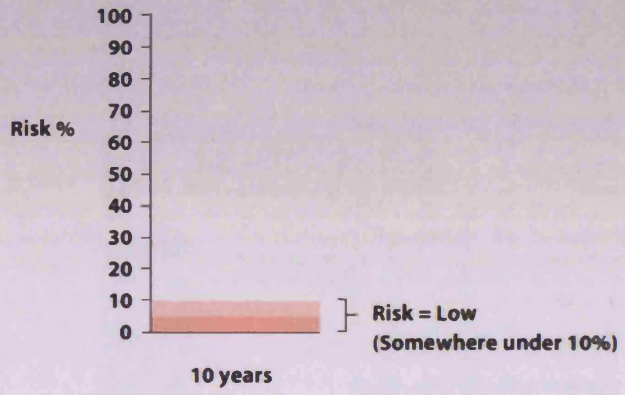
Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Your calculated risk of having a coronary heart disease event in the next 10 years is **Low (under 10%)**

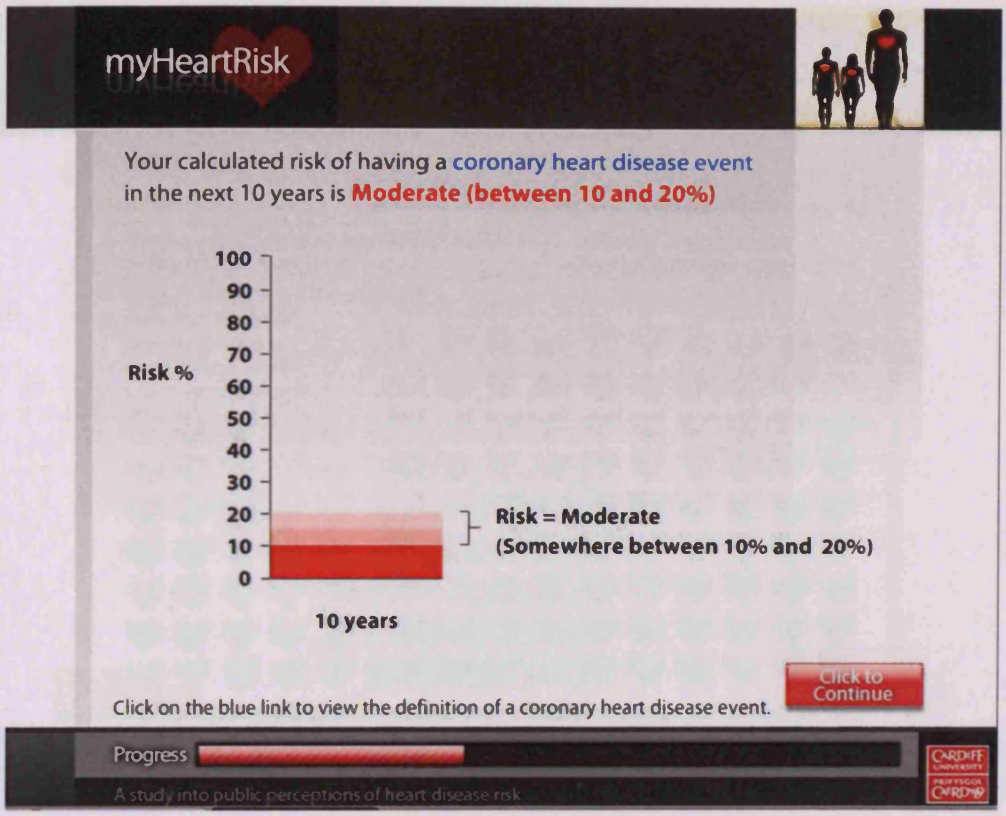


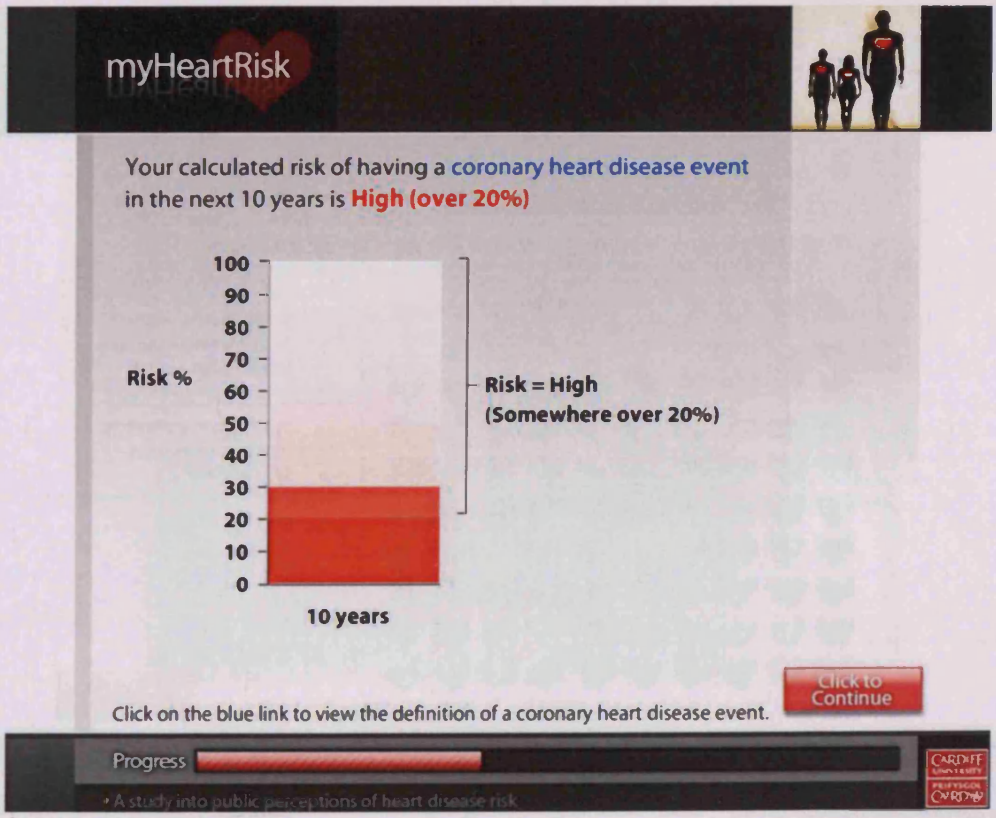
Click on the blue link to view the definition of a coronary heart disease event.

Click to Continue

Progress

A study into public perceptions of heart disease risk

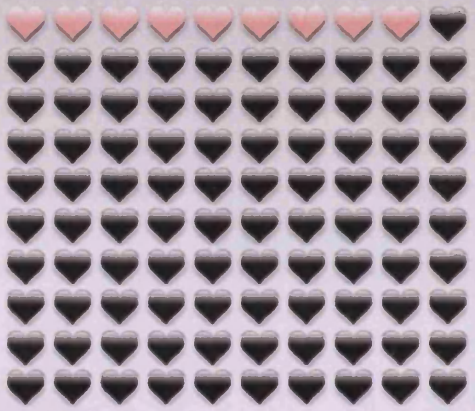

myHeartRisk
Your calculated risk of having a coronary heart disease event in the next 10 years is Moderate (between 10 and 20%)
100
90
80
70
60
50
40
30
20
10
0
Risk %
Risk = Moderate
(Somewhere between 10% and 20%)
10 years
Click on the blue link to view the definition of a coronary heart disease event.
Click to Continue
Progress
A study into public perceptions of heart disease risk


myHeartRisk
Your calculated risk of having a coronary heart disease event in the next 10 years is High (over 20%)
100
90
80
70
60
50
40
30
20
10
0
Risk %
Risk = High
(Somewhere over 20%)
10 years
Click on the blue link to view the definition of a coronary heart disease event.
Click to Continue
Progress
A study into public perceptions of heart disease risk

myHeartRisk

Your calculated risk of having a coronary heart disease event in the next 10 years is **Low (under 10%)**

This means that less than 10 people in every 100 like you will have a coronary heart disease event in the next 10 years.



people like you who may have a coronary heart disease event.

Click on the blue link to view the definition of a coronary heart disease event.

Click to Continue

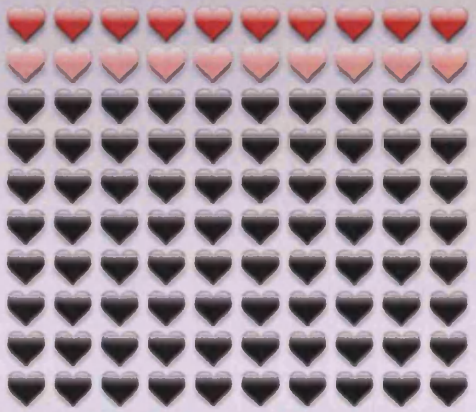
Progress

A study into public perceptions of heart disease risk

myHeartRisk

Your calculated risk of having a coronary heart disease event in the next 10 years is **Moderate (between 10 and 20%)**

This means that somewhere between 10 and 20 people in every 100 like you will have a coronary heart disease event in the next 10 years.



people like you who will definitely have a coronary heart disease event.

people like you who may have a coronary heart disease event.

Click on the blue link to view the definition of a coronary heart disease event.

Click to Continue

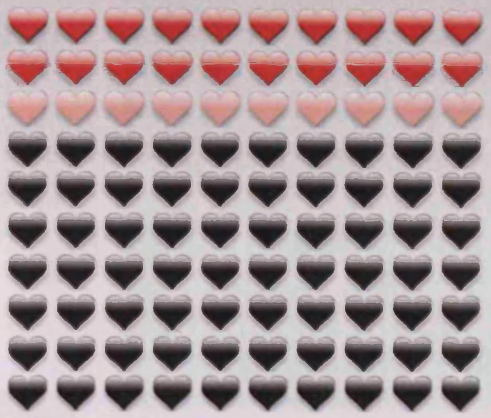
Progress

A study into public perceptions of heart disease risk

myHeartRisk

Your calculated risk of having a coronary heart disease event in the next 10 years is **High (over 20%)**

This means that more than 20 people in every 100 like you will have a coronary heart disease event in the next 10 years.



people like you who will definitely have a coronary heart disease event.

people like you who may have a coronary heart disease event.

Click on the blue link to view the definition of a coronary heart disease event.

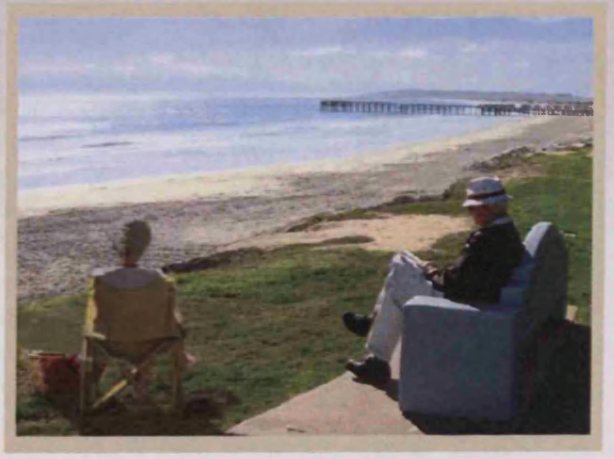
Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Your calculated risk of having a coronary heart disease event in the next 10 years is **Low (under 10%)**



moderate risk

high risk

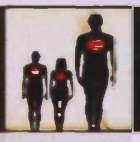
Click on the blue link to view the definition of a coronary heart disease event.

Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk



Your calculated risk of having a coronary heart disease event in the next 10 years is **Moderate (between 10 and 20%)**

low risk

high risk

Click to Continue

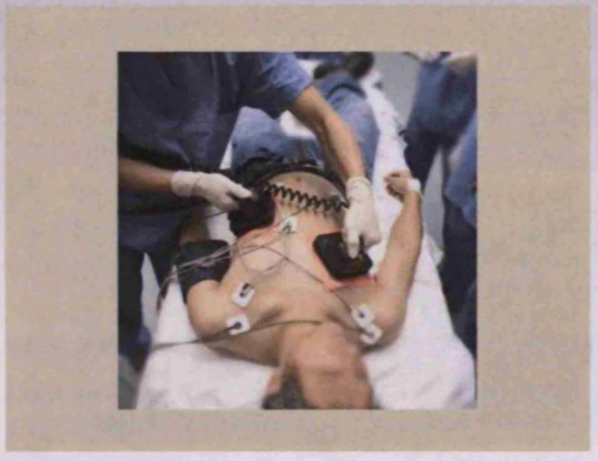
Click on the blue link to view the definition of a coronary heart disease event.

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Your calculated risk of having a coronary heart disease event in the next 10 years is **High (over 20%)**



low risk

moderate risk

Click to Continue

Click on the blue link to view the definition of a coronary heart disease event.

Progress

A study into public perceptions of heart disease risk

myHeartRisk

A Coronary Heart Disease event is defined as:

Myocardial infarction (heart attack)
Fatal CHD (death from coronary heart disease)
or Cardiac Procedure (medical procedure involving the heart)

For more information about any of these, please visit the BHF website using the link at the end of this study.

Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Now you have seen your risk, we would like to see if your feelings have changed.
Please read the following questions/statements and check the number that best corresponds to you.

Thinking about yourself right now at this present moment, to what extent do you feel:

20. Upset	Not at all	1	2	3	4	5	Extremely
21. Hostile	Not at all	1	2	3	4	5	Extremely
22. Alert	Not at all	1	2	3	4	5	Extremely
23. Ashamed	Not at all	1	2	3	4	5	Extremely
24. Inspired	Not at all	1	2	3	4	5	Extremely
25. Nervous	Not at all	1	2	3	4	5	Extremely
26. Determined	Not at all	1	2	3	4	5	Extremely
27. Attentive	Not at all	1	2	3	4	5	Extremely
28. Afraid	Not at all	1	2	3	4	5	Extremely
29. Active	Not at all	1	2	3	4	5	Extremely

30. After viewing your results, how worried do you feel about developing heart disease in the future?	Not at all worried	1	2	3	4	5	Very worried

Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Please read the following questions and check the option that best corresponds to you.

31. What are your chances of having a coronary heart disease event in the next 10 years?

- ■ I am at low risk of having a coronary heart disease event in the next 10 years.
- ■ I am at moderate risk of having a coronary heart disease event in the next 10 years.
- ■ I am at high risk of having a coronary heart disease event in the next 10 years.

32. How confident are you that you have understood the risk information given to you?

Not at all confident ■1 ■2 ■3 ■4 ■5 ■6 ■7 Very confident

33. What should someone in your risk category do to change their risk of heart disease?

- ■ Do nothing to reduce their risk.
- ■ Try and do a little bit to reduce their risk.
- ■ Do as much as they can to reduce their risk.

Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY PHYSICIANS CARDIFF

myHeartRisk

We would now like to ask your views on some of the ways that could help reduce the risk of heart disease.

The following questions and statements are about smoking.
Please check the number that best corresponds to your views on this.

34. To what extent are you prepared to stop smoking?	Completely unprepared	■1 ■2 ■3 ■4 ■5 ■6 ■7	Completely prepared
35. How likely are you to stop smoking?	Very unlikely	■1 ■2 ■3 ■4 ■5 ■6 ■7	Very likely
36. Most people who are important to me think that I....	Should not stop smoking	■-3 ■-2 ■-1 ■0 ■1 ■2 ■3	Should stop smoking
For me, stopping smoking would be...			
37.	Bad	■-3 ■-2 ■-1 ■0 ■1 ■2 ■3	Good
38.	Harmful	■-3 ■-2 ■-1 ■0 ■1 ■2 ■3	Beneficial
39.	Unpleasant	■-3 ■-2 ■-1 ■0 ■1 ■2 ■3	Pleasant
40.	Difficult	■-3 ■-2 ■-1 ■0 ■1 ■2 ■3	Easy

Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY PHYSICIANS CARDIFF

myHeartRisk

The following statements are about smoking.
Please check the number that best corresponds to your views on this.

41. I intend to stop smoking.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
42. Whether I stop smoking or not is entirely up to me.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
43. I feel under social pressure to stop smoking.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
44. The decision to stop smoking is beyond my control.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
45. I am confident that I can stop smoking.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
46. It is expected of me to stop smoking.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree

Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

myHeartRisk

We would now like to ask your views on some of the ways that could reduce your risk of heart disease.

The following questions and statements are about exercising.
Please check the number that best corresponds to your views on this.

47. To what extent are you prepared to exercise more?	Completely unprepared	1	2	3	4	5	6	7	Completely prepared
48. How likely are you to exercise more?	Very unlikely	1	2	3	4	5	6	7	Very Likely

49. Most people who are important to me think that I...	Should not exercise more	-3	-2	-1	0	1	2	3	Should exercise more
For me, exercising more would be...									
50.	A negative thing to do	-3	-2	-1	0	1	2	3	A positive thing to do
51.	Unenjoyable	-3	-2	-1	0	1	2	3	Enjoyable
52.	Difficult	-3	-2	-1	0	1	2	3	Easy
53.	Useless	-3	-2	-1	0	1	2	3	Useful

Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

myHeartRisk

The following questions and statements are about exercising.
Please check the number that best corresponds to your views on this.

54.	I intend to exercise more.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
55.	Whether I exercise more or not is entirely up to me.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
56.	I feel under social pressure to exercise more.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
57.	The decision to exercise more is beyond my control.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
58.	I am confident that I can exercise more.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree
59.	It is expected of me to exercise more.	Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree

Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

We would now like to ask your views on some of the ways that could reduce your risk of heart disease.

The following questions and statements are about losing weight.
Please check the number that best corresponds to your views on this.

60.	To what extent are you prepared to lose weight?	Completely Unprepared	1	2	3	4	5	6	7	Completely Prepared
61.	How likely are you to lose weight?	Very Unlikely	1	2	3	4	5	6	7	Very Likely

62.	Most people who are important to me think that I...	Should not lose weight	-3	-2	-1	0	1	2	3	Should lose weight

For me losing weight would be....

63.		The wrong thing to do	-3	-2	-1	0	1	2	3	The right thing to do
64.		Unsatisfying	-3	-2	-1	0	1	2	3	Satisfying
65.		Unhelpful	-3	-2	-1	0	1	2	3	Helpful
66.		Difficult	-3	-2	-1	0	1	2	3	Easy

Click to Continue

Progress

A study into public perceptions of heart disease risk

myHeartRisk

The following statements are about losing weight.
Please check the number that best corresponds to your views on this.

67.	I intend to lose weight.	Strongly Disagree	1	2	3	4	5	6	7 Strongly Agree
68.	Whether I lose weight or not is entirely up to me.	Strongly Disagree	1	2	3	4	5	6	7 Strongly Agree
69.	I feel under social pressure to lose weight.	Strongly Disagree	1	2	3	4	5	6	7 Strongly Agree
70.	The decision to lose weight is beyond my control.	Strongly Disagree	1	2	3	4	5	6	7 Strongly Agree
71.	I am confident that I can lose weight.	Strongly Disagree	1	2	3	4	5	6	7 Strongly Agree
72.	It is expected of me to lose weight.	Strongly Disagree	1	2	3	4	5	6	7 Strongly Agree

Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

myHeartRisk

In order to find out more about the people who have used this site, we would be grateful if you could provide the following information.

73. What is your level of education?
(Please check the box corresponding to the highest level attained)

- Left school before age 16 (no formal qualifications)
- Left school at 16 (GCSE, CSE, O level or equivalent)
- Left school at 18 (A levels or equivalent)
- College certificate or diploma
- University degree or higher
- Other (please state) _____
- Do not wish to disclose

74. Where did you find out about this website?

- Email invitation at workplace (please state workplace) _____
- Found link on the internet (please state website) _____
- Social networking sites
- From personal contacts
- Poster or card advertisements
- Advertisement in local newspaper
- Other (please state) _____

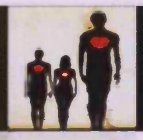
Click to Continue

Progress

A study into public perceptions of heart disease risk

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

myHeartRisk



End of Study

Many thanks for taking part in this study

If you would like us to send you an electronic copy of your risk output to take to your doctor, or would like further information about the study, please click here.

If not, you may now close the web browser.

For further information about the study please contact:

The Research Team at Cardiff University

Cherry-Ann Waldron WaldronC@cardiff.ac.uk

Professor Glyn Elwyn ElwynG@cardiff.ac.uk

For further information about heart health please contact:

The British Heart Foundation

http://www.bhf.org.uk/

British Heart Foundation main telephone number: 020 7554 0000

Heart Helpline: 0300 330 3311 (open Monday to Friday 9am-6pm)

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Please enter your contact details

Name:

Email:

Telephone:

Address:

Preferred method of contact: Email Telephone Letter

Nature of enquiry:

If you would like us to send you an electronic copy of your risk output, please check the box and remember to leave your email address.

Submit

Progress

A study into public perceptions of heart disease risk

myHeartRisk

Thank you

Your details have been submitted.
A member of the research team will contact you shortly

You can now close the web browser.

Progress

A study into public perceptions of heart disease risk

Appendix 40. Why the original algorithm was biased towards two conditions.

Adobe Flash gets a random value between 0 and 1 by calling the built in flash function Math.random. This value is inputted into the following equation.

Flash calls the Math.random function to generate the number to be inputted into the following algorithm.

Algorithm: Pathway = Math.round (3 x Math.random( )) +1

For example,

Random value = 0.74

1) Pathway = Math.round (3 x 0.74) + 1

2) Pathway = Math.round (2.22) +1

3) Pathway = 2 + 1

4) Pathway = 3

Taking the +1 into account (to compensate for the random number starting

from 0 and going up to 3), the following applies:

To end up with 1 = the random number needs to be in the range 0 to 0.49999.
To end up with 2 = the random number needs to be in the range 0.50 to 1.4999.
To end up with 3 = the random number needs to be in the range 1.50 to 2.4999.
To end up with 4 = the random number needs to be in the range 2.50 to 3.

Due to the nature of the Adobe Flash function math.round rounding up or down to the nearest integer, the number 2 or 3 has double the chances of being created.

Appendix 41. The alternative algorithm used by the website for randomisation.

Adobe Flash gets a random value between 0 and 1 by calling the built in flash function Math.random. This value is inputted into the following equation.

Flash calls the Math.random function to generate the number to be inputted into the following algorithm.

Algorithm:

High = 4
Low = 1
Pathway = Math.floor (Math random()*(1+High-low)) + Low

Pathway = remove any numbers following the decimal place from (random number generated by Math.random between 0 and 1 x (1+(4-1)) + 1

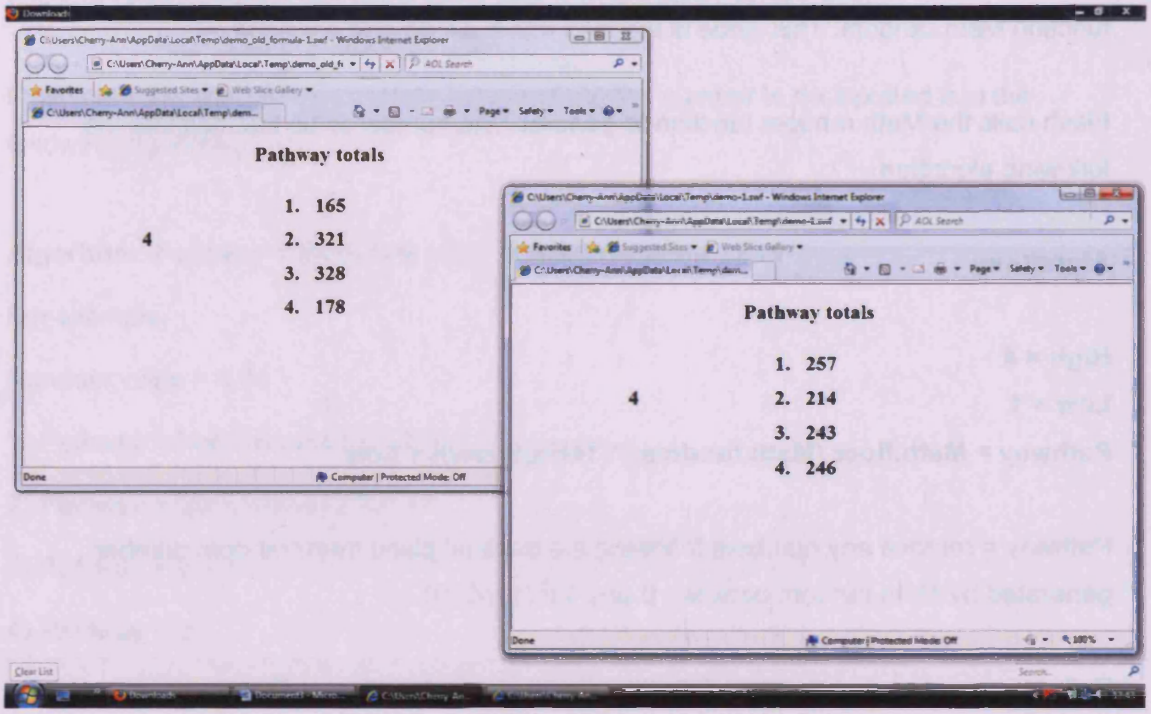
Pathway= remove any numbers following the decimal place from (Random number between 0 and 1 x (1 + (4-1)) + 1

For example:

Random value = 0.7

1) Pathway = remove any numbers following the decimal place from (0.7 x (1 + (4-1)) + 1
2) Pathway = remove any numbers following the decimal place from (0.7 x 4) + 1
3) Pathway = remove any numbers following the decimal place from 2.8 + 1
4) Pathway = remove any numbers following the decimal place from 3.8
5) Pathway = 3

Appendix 42. Screenshot of the dummy runs of the random pathways using original and alternative algorithms.



Top left screen = original algorithm.

Bottom right screen= new algorithm.

Appendix 43. Goodness of fit Chi-square tests on the dummy runs of the original and alternative algorithms.

	A	B	C	D	E
1	**Check randomisation results from screenshots**				2/16/10
2					
3	Algorithm	Old	Old	New	New
4	Run	1	2	1	2
5					
6	Numbers in 4 groups				
7	Group 1	165	71	257	114
8	Group 2	321	137	214	90
9	Group 3	328	146	243	90
10	Group 4	178	71	246	99
11					
12	Total	992	425	960	393
13					
14	Chisq (3 df)	94.83	47.16	4.21	3.92
15	p-value	0	0.0	0.240	0.271
16					
17	Groups 1 & 4 together	343	142	503	213
18	Groups 2 & 3 together	649	283	457	180
19					
20	Chisq (1 df)	94.39	46.78	2.20	2.77
21	p-value	0	0.0	0.138	0.096
22					

Appendix 44. Goodness of fit Chi-square test to assess distributions of respondents to the four conditions.

Test Statistics

	Condition_allocation
Chi-Square	1.965[a]
df	3
Asymp. Sig.	.580

a. 0 cells (.0%) have expected frequencies less than 5.

The minimum expected cell frequency is 227.0.

Appendix 45. Descriptive statistics of continuous variables assessed in the RCT.

Statistics

		Total Pre Positive Affect score	Total Pre Negative Affect score	Total post Positive Affect score	Total post Negative Affect score	Pre Worry	Post Worry	Understanding – confidence	Level of understanding	Total exercise intention score	Total lose weight intention score	Total smoking intention score	Age	BMI
N	Valid	903	903	903	903	903	903	903	903	903	903	81	903	903
	Missing	0	0	0	0	0	0	0	0	0	0	882	0	0
Mean		18.11	10.68	17.64	7.59	2.80	2.15	6.07	1.09	5.00	4.65	4.06	53.12	27.0069
Median		18.00	10.00	18.00	6.00	3.00	2.00	6.00	1.00	5.00	5.00	4.00	52.00	25.7725
Mode		19	10	20	5	3	2	7	1	5	5	4	45	24.80
Std. Deviation		2.988	2.776	3.856	3.348	1.043	.984	1.241	.414	1.217	1.600	1.609	6.058	5.76006
Skewness		-.493	.666	-.528	1.503	.024	.660	-1.585	.596	-.429	-.594	-.024	.266	1.653
Kurtosis		.637	.726	.423	2.207	-.506	-.066	2.290	2.329	-.148	-.249	-.737	-1.179	4.546
Minimum		5	5	5	5	1	1	1	0	1	1	1	45	17.31
Maximum		25	23	25	25	5	5	7	2	7	7	7	64	62.00

Appendix 46. Chi-square test of the level of education of respondents across conditions.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24.544[a]	18	.138
Likelihood Ratio	27.834	18	.065
Linear-by-Linear Association	1.402	1	.236
N of Valid Cases	903		

a. 4 cells (14.3%) have expected count less than 5. The minimum expected count is .94.

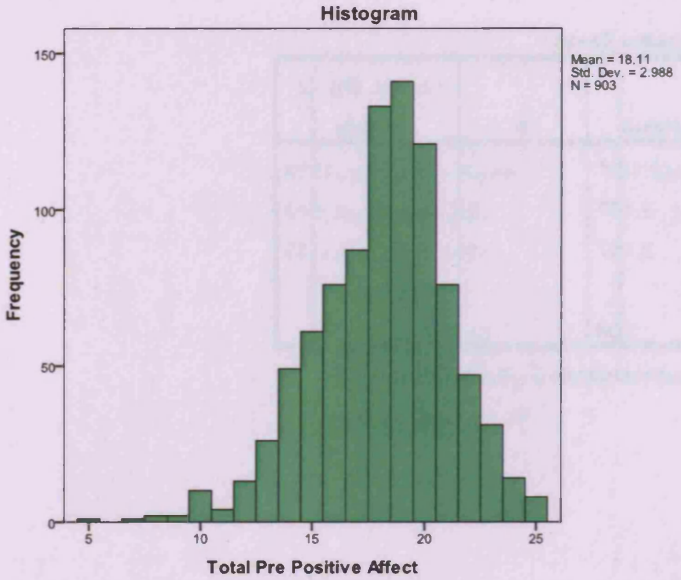
Appendix 47. Chi-square test of those who requested copy of risk output results and those who did not across conditions.

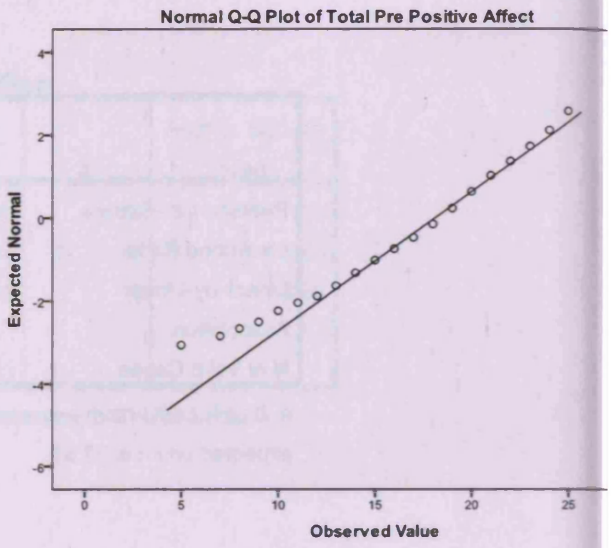
Chi-Square Tests

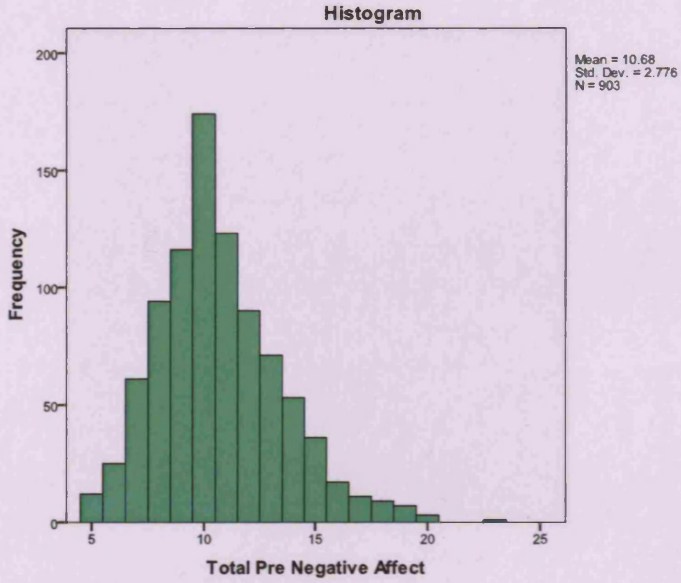
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.163[a]	3	.539
Likelihood Ratio	2.157	3	.540
Linear-by-Linear Association	2.147	1	.143
N of Valid Cases	903		

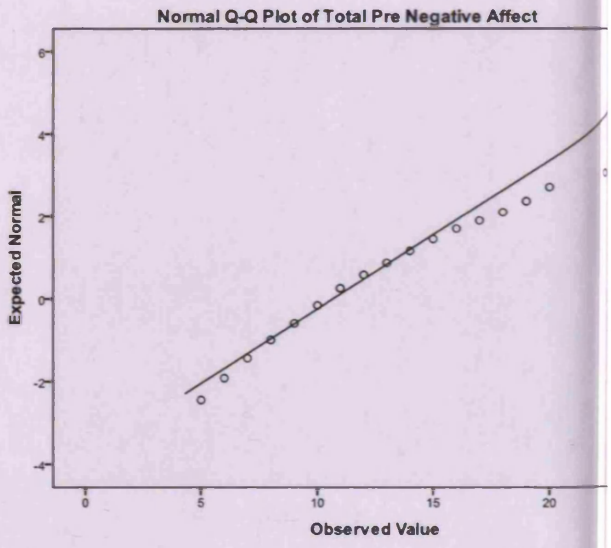
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 33.57.

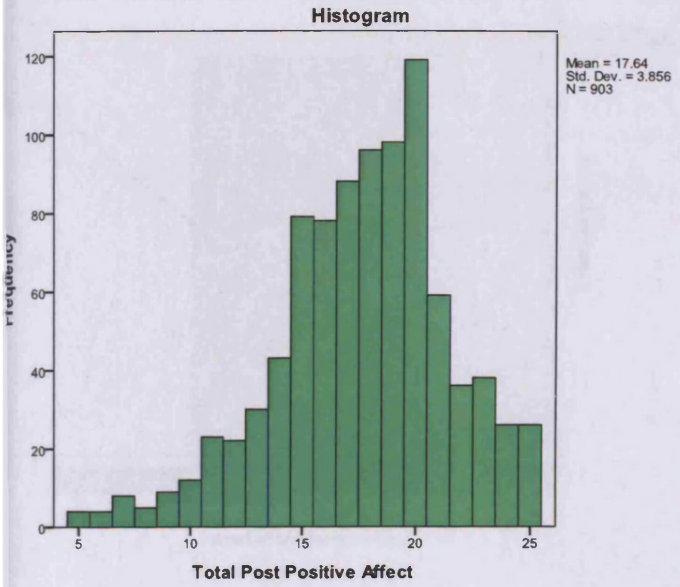
Appendix 48. Normality testing of continuous variables.

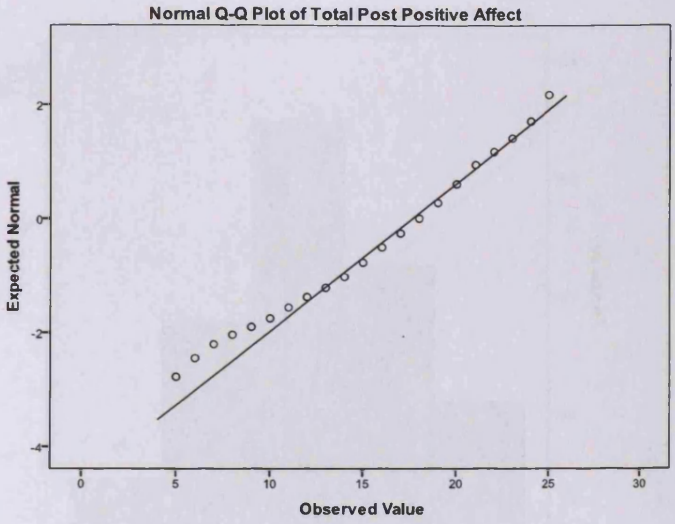


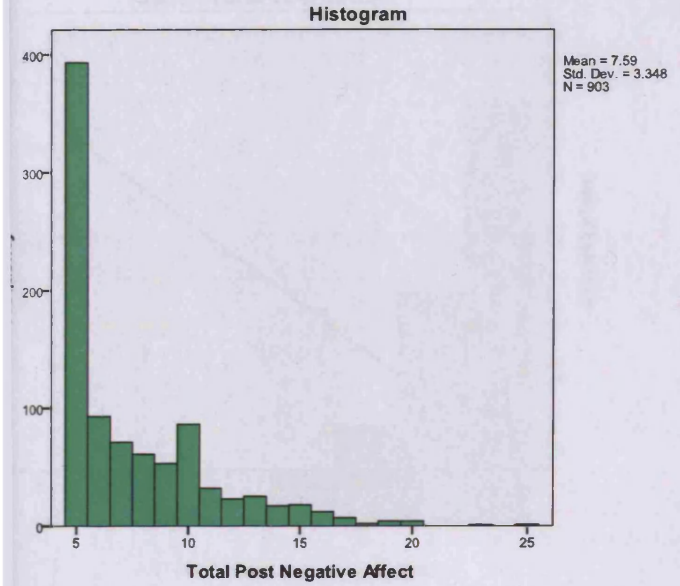


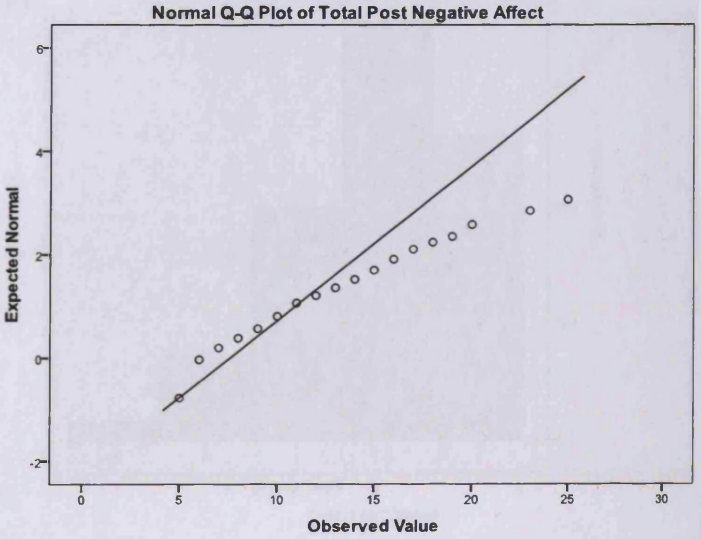


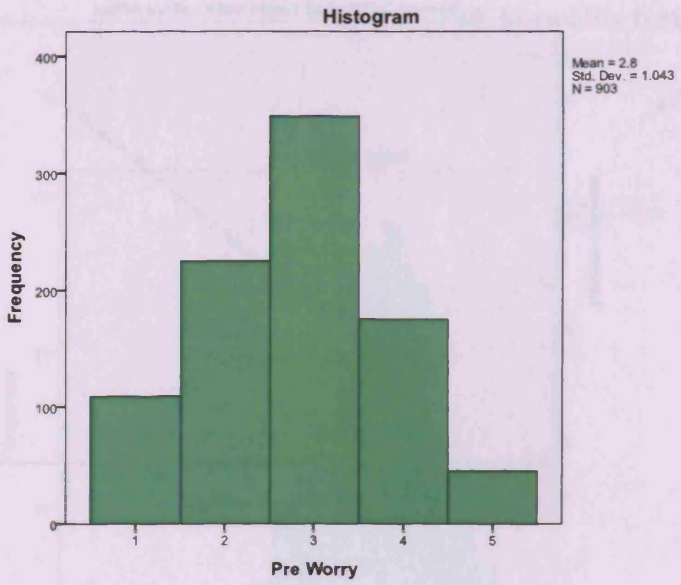


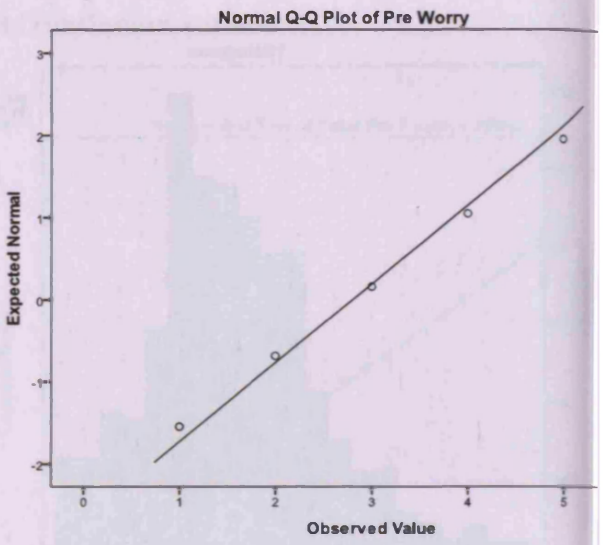

Histogram
Mean = 17.64
Std. Dev. = 3.856
N = 903
Frequency
Total Post Positive Affect

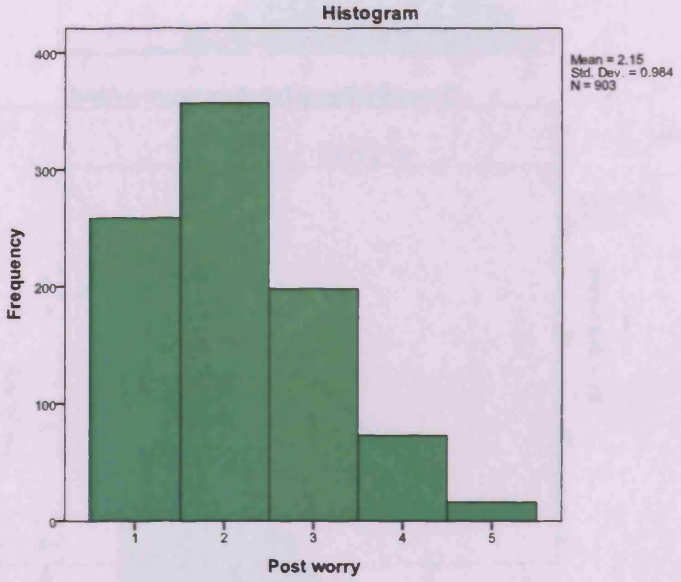

Normal Q-Q Plot of Total Post Positive Affect
Expected Normal
Observed Value

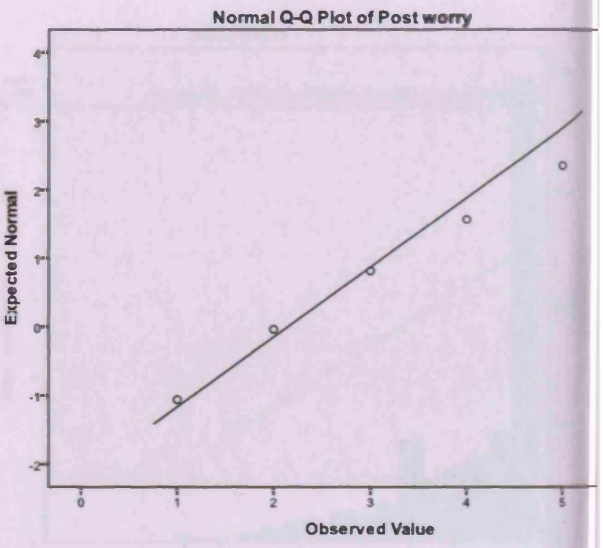

Histogram
Mean = 7.59
Std. Dev. = 3.348
N = 903
Total Post Negative Affect

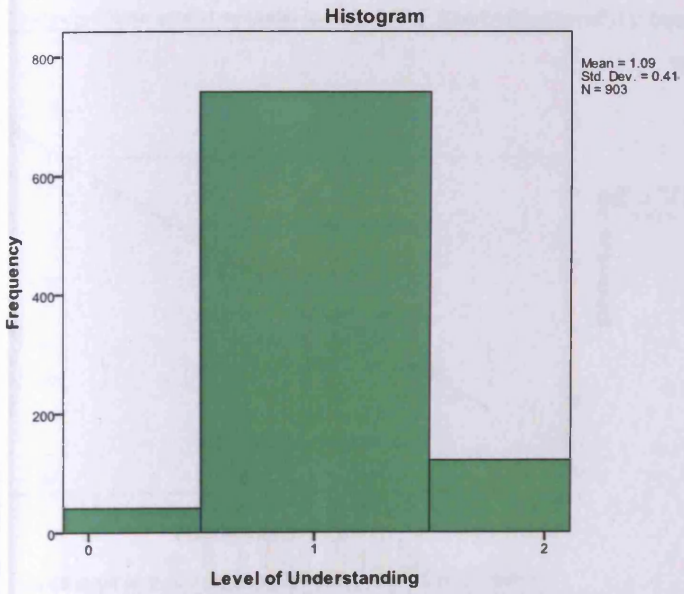

Normal Q-Q Plot of Total Post Negative Affect
Expected Normal
Observed Value

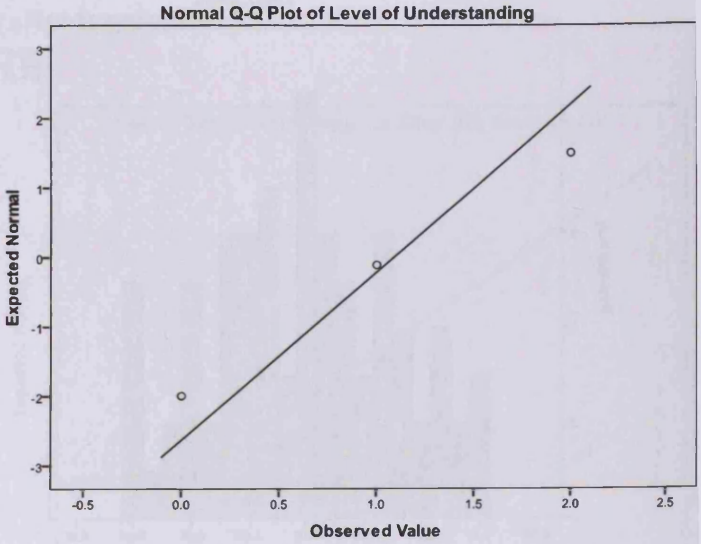

Histogram
Mean = 2.8
Std. Dev. = 1.043
N = 903
Frequency
Pre Worry

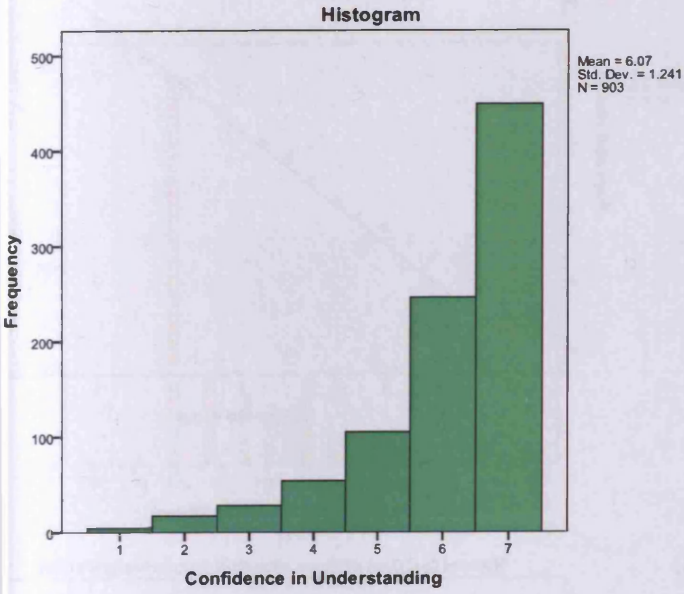

Normal Q-Q Plot of Pre Worry
Expected Normal
Observed Value

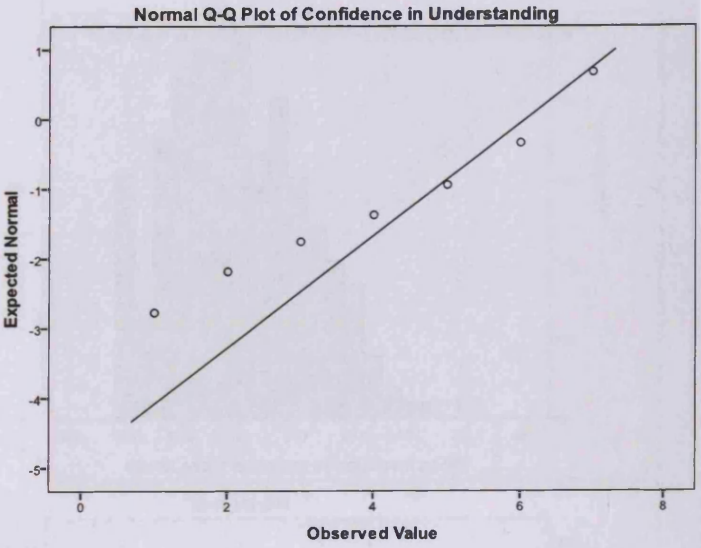

Histogram
Mean = 2.15
Std. Dev. = 0.984
N = 903
Frequency
Post worry

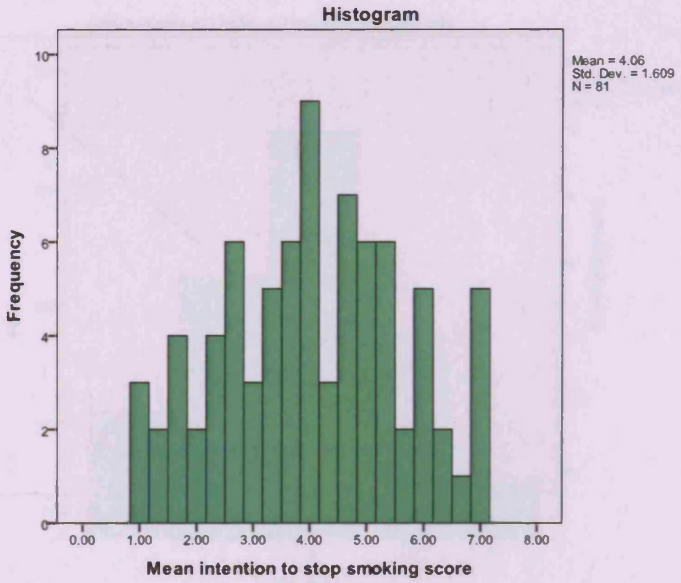

Normal Q-Q Plot of Post worry
Expected Normal
Observed Value

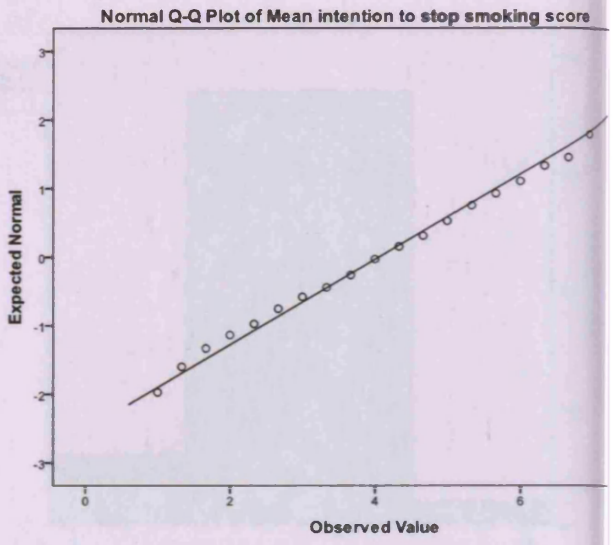

Histogram
Mean = 1.09
Std. Dev. = 0.41
N = 903
Frequency
800
600
400
200
0
0
1
2
Level of Understanding

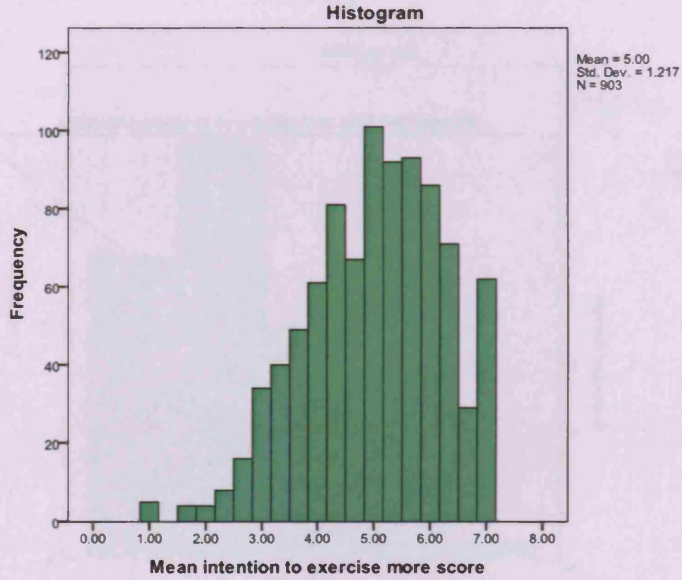

Normal Q-Q Plot of Level of Understanding
Expected Normal
3
2
1
0
-1
-2
-3
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
Observed Value

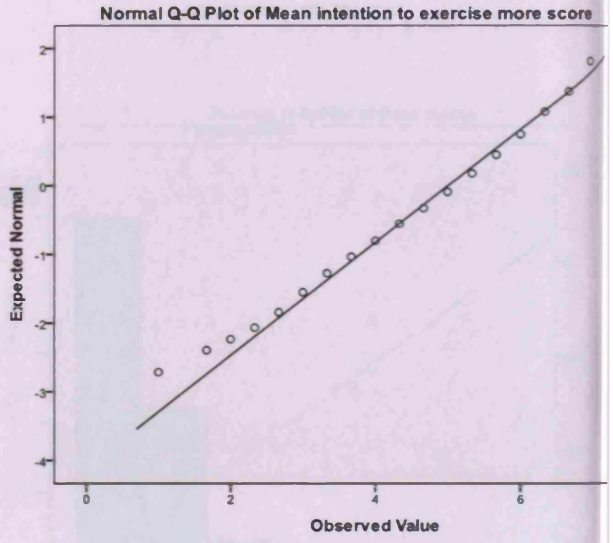

Histogram
Mean = 6.07
Std. Dev. = 1.241
N = 903
Frequency
500
400
300
200
100
0
1
2
3
4
5
6
7
Confidence in Understanding

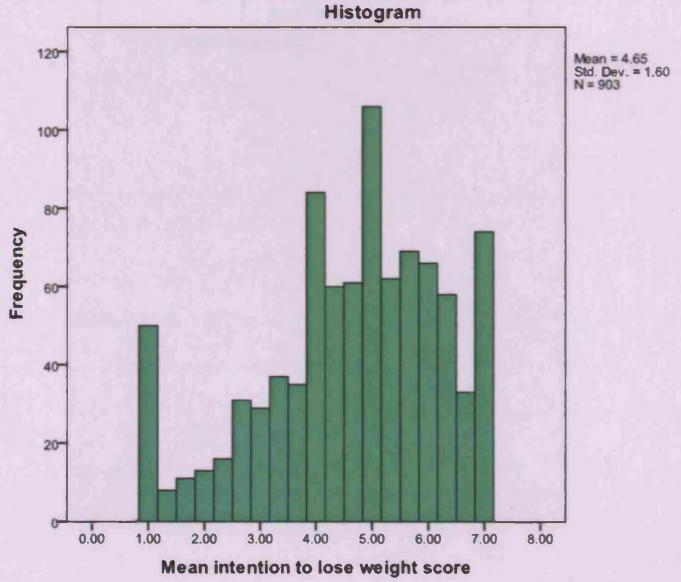

Normal Q-Q Plot of Confidence in Understanding
Expected Normal
1
0
-1
-2
-3
-4
-5
0
2
4
6
8
Observed Value

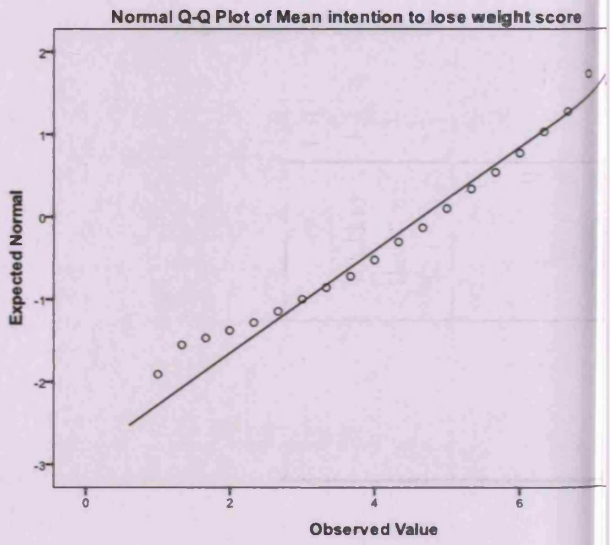

Histogram
Mean = 4.06
Std. Dev. = 1.609
N = 81
Frequency
Mean intention to stop smoking score


Normal Q-Q Plot of Mean intention to stop smoking score
Expected Normal
Observed Value

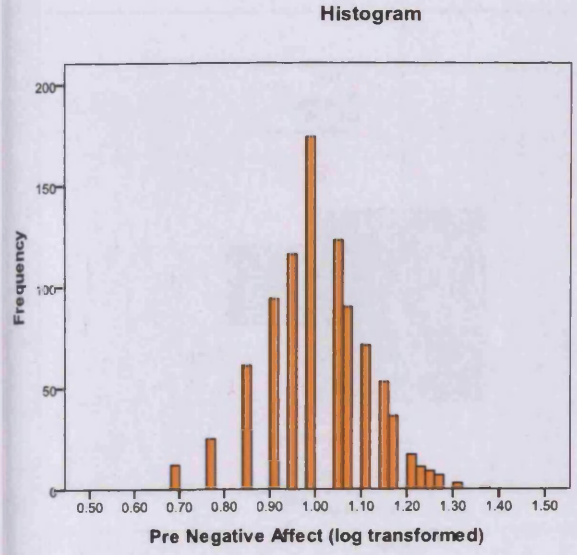

Histogram
Mean = 5.00
Std. Dev. = 1.217
N = 903
Frequency
Mean intention to exercise more score

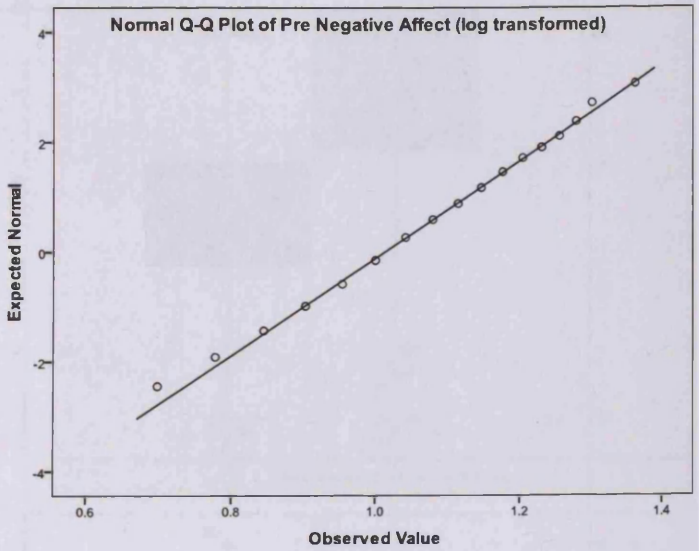

Normal Q-Q Plot of Mean intention to exercise more score
Expected Normal
Observed Value

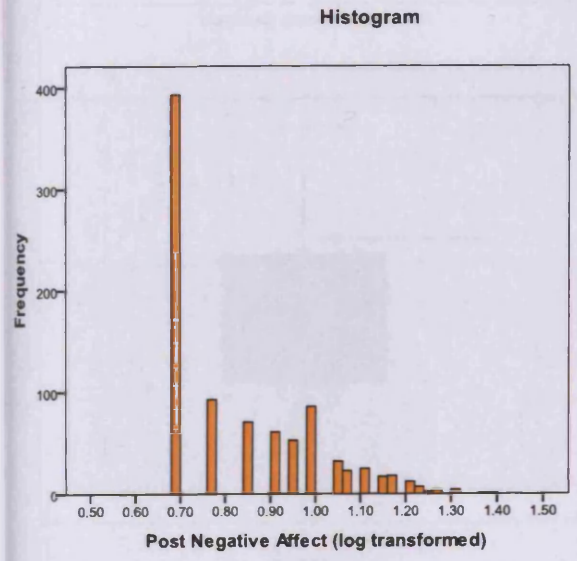

Histogram
Mean = 4.65
Std. Dev. = 1.60
N = 903
Frequency
Mean intention to lose weight score

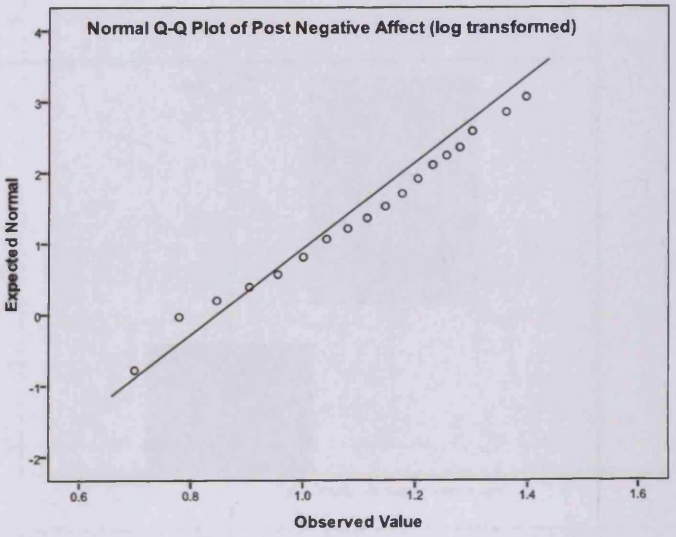

Normal Q-Q Plot of Mean intention to lose weight score
Expected Normal
Observed Value

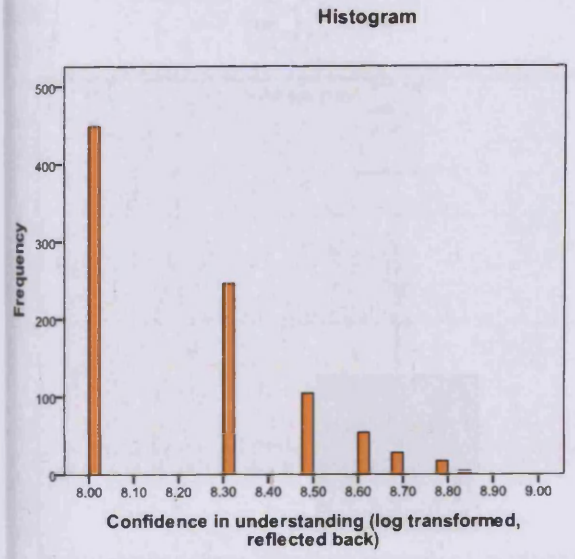
Appendix 49. Normality testing after log tranformation.

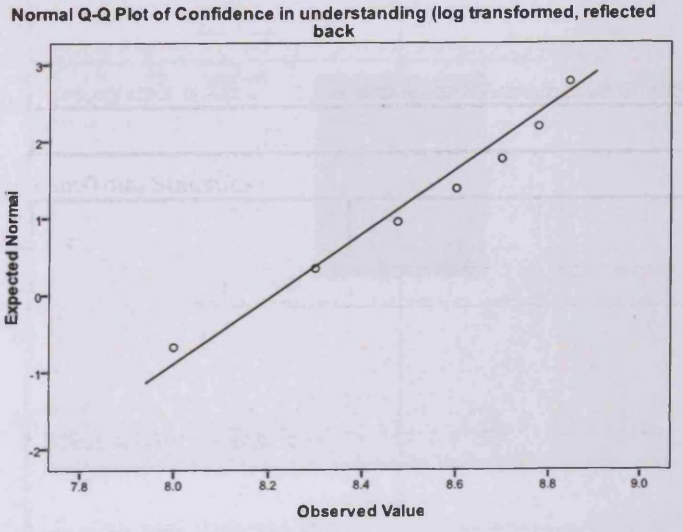




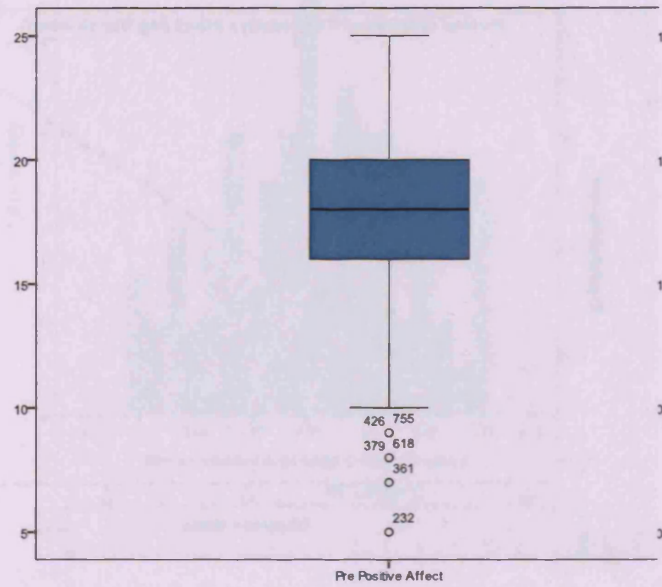


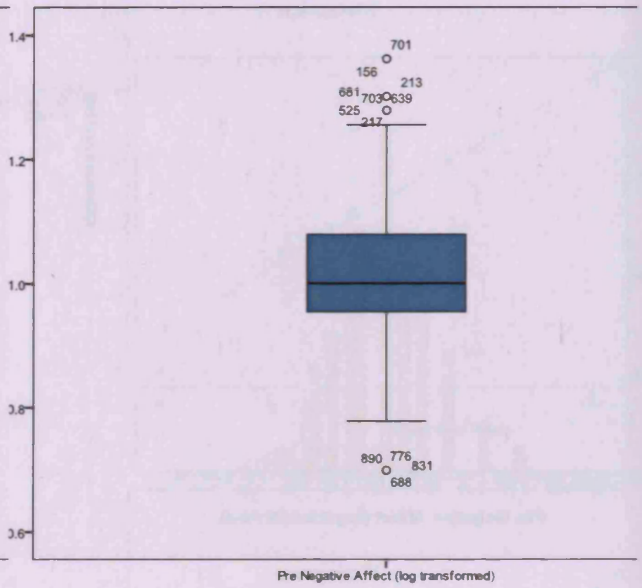


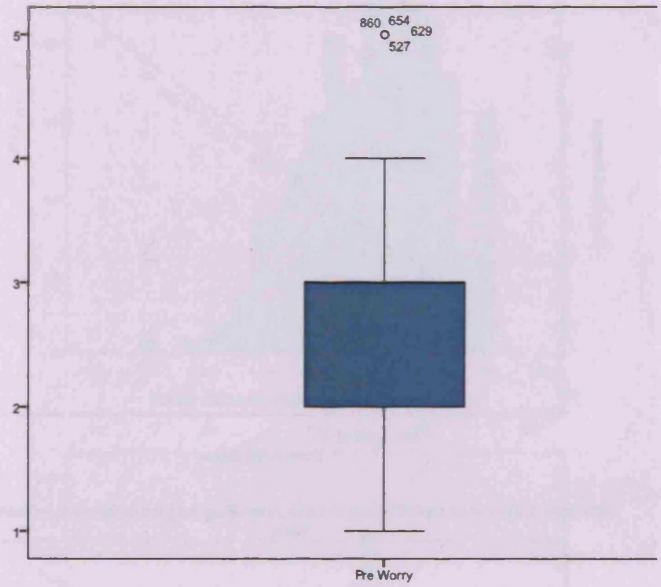


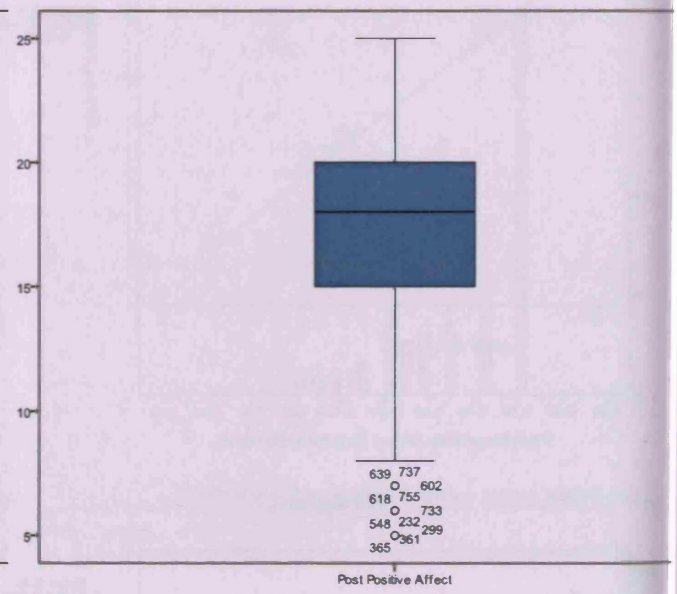


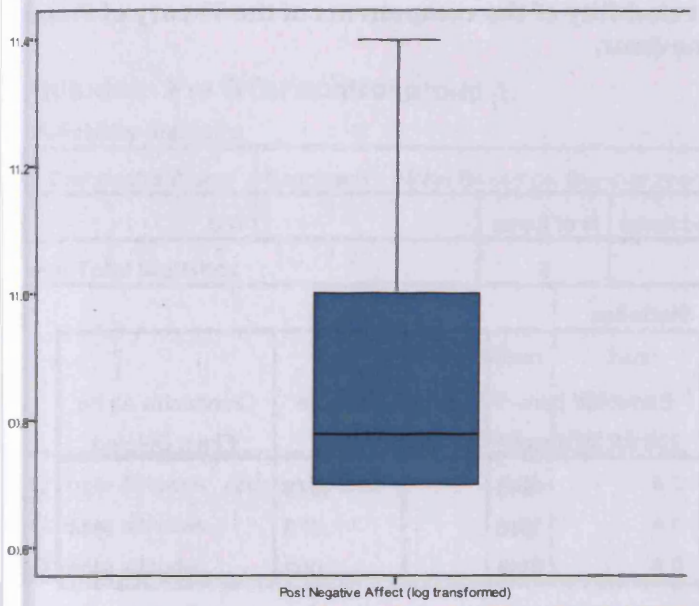
Appendix 50. Indentifying univariate outliers.

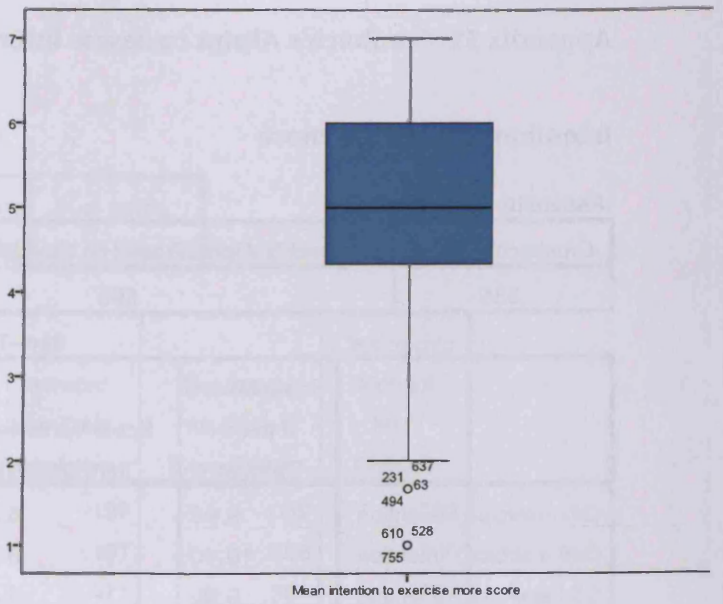


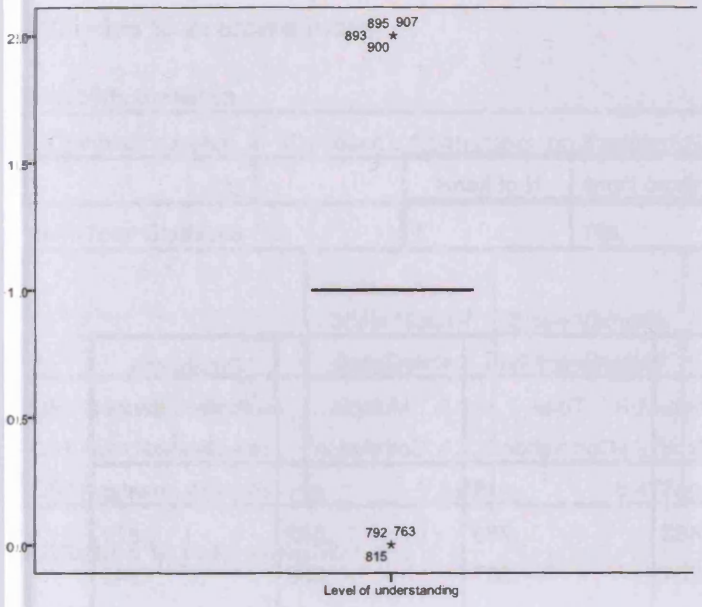


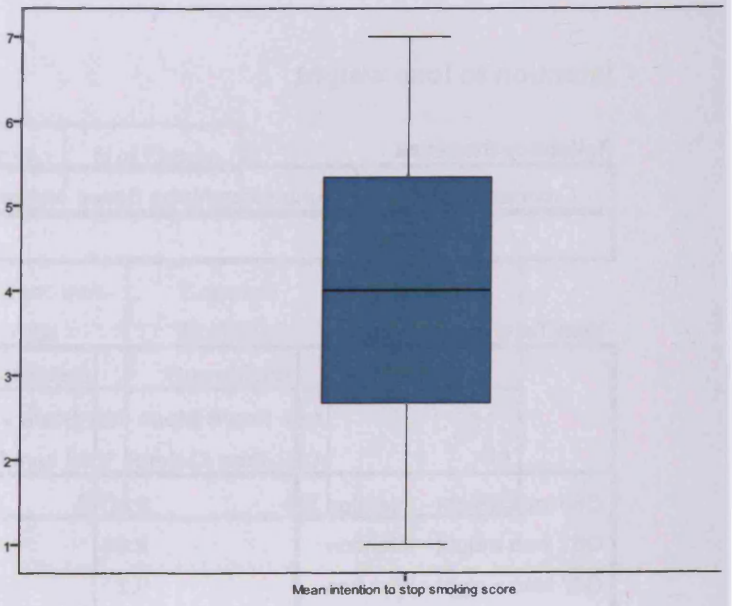


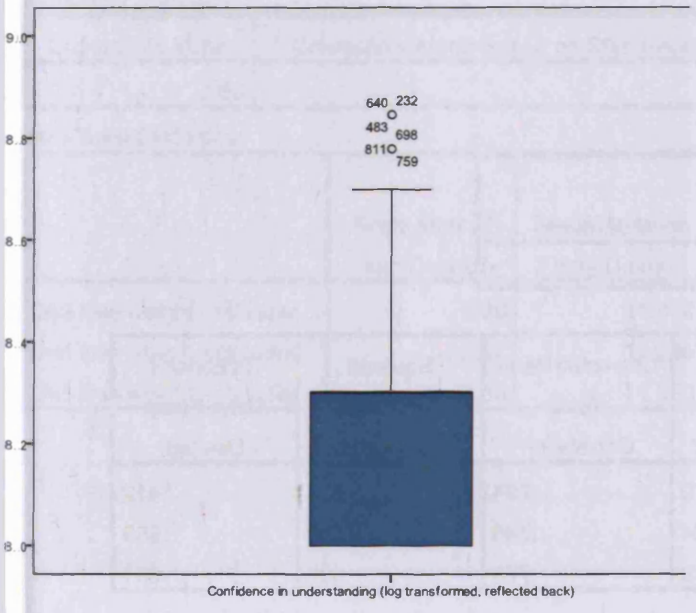


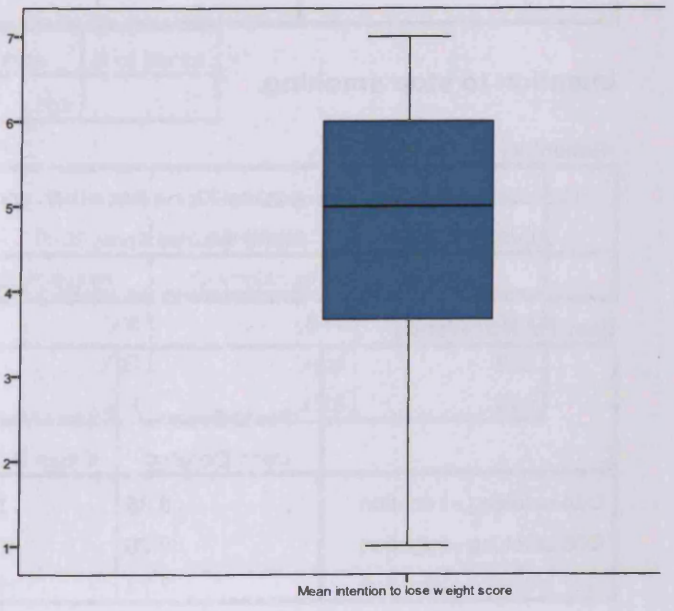

Post Negative Affect (log transformed)


637
231
63
494
610
528
755
Mean intention to exercise more score


895
907
893
900
792
763
815
Level of understanding


Mean intention to stop smoking score


640
232
483
698
811
759
Confidence in understanding (log transformed, reflected back)


Mean intention to lose weight score

Appendix 51. Cronbach's Alpha to assess internal reliability of the components of the Theory of Planned Behaviour.

Intention to exericse more

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.535	.593	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q47 exercise - intention	9.98	6.740	.543	.679	.139
Q48 exercise - intention	10.40	6.755	.540	.679	.144
Q54 exercise - intention	9.65	8.404	.083	.007	.903

Intention to lose weight

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.897	.897	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q60 lose weight - intention	9.00	10.601	.818	.671	.835
Q61 lose weight - intention	9.68	11.483	.769	.592	.877
Q67 lose weight - intention	9.22	10.234	.807	.658	.845

Intention to stop smoking.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.882	.882	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q34 smoking - intention	8.35	10.279	.794	.634	.812
Q35 smoking - intention	8.26	11.194	.748	.559	.853
Q41 smoking - intention	7.74	11.419	.775	.606	.831

Attitudes - Pre Q for control group 1.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.557	.589	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q17 pre attitudes_ reverse scored	4.85	4.316	.197	.039	.762
Q18 pre attitudes	4.21	4.045	.491	.386	.280
Q19 pre attitudes	4.19	4.072	.471	.381	.307

Attitudes to exercise more.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.735	.756	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q50 exercise - attitudes	3.26	6.135	.669	.469	.547
Q51 exercise - attitudes	4.13	4.976	.507	.280	.759
Q53 exercise - attitudes	3.32	6.472	.553	.382	.662

Attitudes to lose weight.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.958	.958	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q63 lose weight - attitudes	3.09	11.814	.906	.834	.942
Q64 lose weight - attitudes	2.97	12.285	.892	.805	.952
Q65 lose weight - attitudes	3.06	11.563	.935	.875	.920

Attitudes to stop smoking.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.581	.634	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q37 smoking - attitude	2.19	7.028	.494	.292	.339
Q38 smoking - attitude	1.80	9.210	.414	.235	.510
Q39 smoking - attitude	4.48	4.903	.370	.143	.625

Subjective norms – exercise more.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.417	.396	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q49 exercise - subjective norm converted	12.07	5.547	.364	.194	.118
Q46 exercise - subjective norm	8.27	7.914	.060	.004	.599
Q59 exercise - subjective norm	13.45	4.006	.363	.196	.061

Subjective norms – lose weight.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.820	.821	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q62 lose weight - subjective norm converted	5.92	12.110	.608	.399	.818
Q69 lose weight - subjective norms	7.15	11.521	.657	.486	.770
Q72 lose weight - subjective norm	7.12	10.694	.763	.587	.660

Subjective norms – stop smoking.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.943	.956	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q36 smoking - subjective norm converted	17.23	6.948	.893	.807	.945
Q43 smoking - subjective norm	17.36	4.880	.900	.815	.912
Q46 smoking - subjective norm	17.34	4.940	.930	.866	.882

Perceived Behavioural control - PreQ given to control group 1.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.814	.922	2

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q14 pre PBC reverse scored	7.79	5.660	.855	.731	.[a]
Q16 converted pre PBC-reversed	8.41	1.435	.855	.731	.[a]

a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. You may want to check item codings.

Perceived behavioural control – exercise more.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.528	.558	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q55 exercise - PBC (controlability)	15.50	13.401	.118	.024	.653
Q57 exercise - PBC (controlability) reverse scored	14.93	12.962	.336	.136	.442
Q52 exercise - PBC (self-efficacy) converted	16.31	11.748	.381	.306	.397
Q58 exercise - PBC (self-efficacy)	15.85	11.595	.505	.351	.304

Perceived behavioural control - Lose weight.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.528	.533	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q68 lose weight - PBC (controlability)	14.53	11.418	.212	.050	.560
Q70 lose weight - PBC (controlability) reverse scoring	14.15	12.940	.240	.059	.515
Q66 Lose weight - PBC (self-efficacy) converted	16.54	10.599	.387	.263	.392
Q71 lose weight - PBC (self-efficacy)	15.51	10.148	.453	.286	.332

Perceived behavioural control – stop smoking.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.562	.545	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q42 smoking - PBC (controlability)	12.33	14.225	.158	.055	.624
Q44 smoking - PBC (controlability) reverse scored	12.15	13.303	.309	.172	.520
Q40 smoking - PBC (self-efficacy) converted	16.16	11.361	.365	.223	.474
Q45 smoking - PBC (self-efficacy)	14.40	8.242	.587	.366	.235

Appendix 52. Cronbach's Alpha to assess internal reliability of the Positive and Negative Affect Schedule (PANAS).

Baseline / Pre-intervention Positive affect.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.781	.786	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q3 Pre PANAS + Alert	14.45	6.179	.552	.323	.741
Q5 Pre PANAS + Inspired	14.66	6.205	.525	.290	.750
Q7 Pre PANAS + Determined	14.41	5.847	.610	.395	.721
Q8 Pre PANAS + Attentive	14.37	6.091	.626	.409	.720
Q10 Pre PANAS + Active	14.54	5.807	.490	.242	.769

Baseline / Pre-intervention Negative affect.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.728	.729	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q1 Pre PANAS - Upset	8.37	5.493	.534	.289	.668
Q2 Pre PANAS - Hostile	8.74	5.794	.363	.170	.726
Q4 Pre PANAS - Ashamed	8.86	5.343	.478	.238	.685
Q6 Pre PANAS - Nervous	8.19	4.884	.505	.341	.676
Q9 Pre PANAS - Afraid	8.57	4.824	.575	.381	.645

Post-intervention Positive affect.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.849	.853	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q22 post PANAS + Alert	13.98	10.385	.616	.494	.830
Q24 post PANAS + Inspired	14.26	9.844	.660	.476	.818
Q26 post PANAS + Determined	14.02	9.415	.745	.582	.795
Q27 post PANAS + Attentive	13.88	9.950	.732	.604	.802
Q29 post PANAS + Active	14.42	9.764	.570	.343	.847

Post-intervention Negative affect.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.884	.886	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Q20 post PANAS - upset	6.03	7.227	.731	.573	.857
Q21 post PANAS - Hostile	6.22	8.033	.688	.533	.869
Q23 post PANAS - Ashamed	6.19	8.026	.679	.478	.870
Q25 post PANAS - Nervous	5.90	6.712	.756	.628	.853
Q28 post PANAS - Afraid	6.02	6.913	.780	.655	.845

Appendix 53. One-way ANOVAs for intention to change behaviour.

Intention to exercise more.

Tests of Between-Subjects Effects

Dependent Variable:Total exercise intention score

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.915[a]	3	.972	.655	.580	.002
Intercept	22577.541	1	22577.541	15232.323	.000	.944
Condition_allocation	2.915	3	.972	.655	.580	.002
Error	1332.509	899	1.482			
Total	23953.778	903				
Corrected Total	1335.424	902				

a. R Squared = .002 (Adjusted R Squared = -.001)

Intention to lose weight.

Tests of Between-Subjects Effects

Dependent Variable:Total lose weight intention score

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.458[a]	3	1.819	.710	.546	.002
Intercept	19484.166	1	19484.166	7599.572	.000	.894
Condition_allocation	5.458	3	1.819	.710	.546	.002
Error	2304.901	899	2.564			
Total	21820.444	903				
Corrected Total	2310.359	902				

a. R Squared = .002 (Adjusted R Squared = -.001)

Intention to stop smoking.

Tests of Between-Subjects Effects

Dependent Variable:Total smoking intention score (mean)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10.969[a]	3	3.656	1.436	.239	.053
Intercept	1309.154	1	1309.154	514.060	.000	.870
Condition_allocation	10.969	3	3.656	1.436	.239	.053
Error	196.096	77	2.547			
Total	1540.667	81				
Corrected Total	207.064	80				

a. R Squared = .053 (Adjusted R Squared = .016)

Appendix 54. One-way ANOVAs for understanding of risk information.

Level of understanding.

Tests of Between-Subjects Effects

Dependent Variable:level of understanding as a scale

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.486[a]	3	.162	.944	.419	.003
Intercept	1066.692	1	1066.692	6209.803	.000	.874
Condition_allocation	.486	3	.162	.944	.419	.003
Error	154.426	899	.172			
Total	1225.000	903				
Corrected Total	154.913	902				

a. R Squared = .003 (Adjusted R Squared = .000)

Confidence in understanding.

Tests of Between-Subjects Effects

Dependent Variable:confidence in understanding scores log transformed reflected back

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.189[a]	3	.063	1.108	.345	.004
Intercept	60787.106	1	60787.106	1066784.136	.000	.999
Condition_allocation	.189	3	.063	1.108	.345	.004
Error	51.226	899	.057			
Total	60970.079	903				
Corrected Total	51.416	902				

a. R Squared = .004 (Adjusted R Squared = .000)

Appendix 55. One-way ANOVAs for positive and negative affect.

Positive affect.

Tests of Between-Subjects Effects

Dependent Variable:Total post Positive Affect score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7112.245[a]	4	1778.061	253.603	.000	.530
Intercept	10.470	1	10.470	1.493	.222	.002
Total_Pre_Positive_affect	7070.636	1	7070.636	1008.476	.000	.529
Condition_allocation	33.552	3	11.184	1.595	.189	.005
Error	6296.063	898	7.011			
Total	294362.000	903				
Corrected Total	13408.308	902				

a. R Squared = .530 (Adjusted R Squared = .528)

Negative affect.

Tests of Between-Subjects Effects

Dependent Variable:Total post negative affect log transformed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.101[a]	4	1.525	74.050	.000	.248
Intercept	.127	1	.127	6.142	.013	.007
Pre_Negative_affect_log_transformed	6.085	1	6.085	295.386	.000	.248
Condition_allocation	.048	3	.016	.776	.507	.003
Error	18.498	898	.021			
Total	671.045	903				
Corrected Total	24.600	902				

a. R Squared = .248 (Adjusted R Squared = .245)

Appendix 56. One-way ANOVA for worry about future risk of heart disease.

Tests of Between-Subjects Effects

Dependent Variable:Q30 post worry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	344.425[a]	4	86.106	146.173	.000	.394
Intercept	25.946	1	25.946	44.046	.000	.047
Q11	344.018	1	344.018	584.000	.000	.394
Condition_allocation	.038	3	.013	.021	.996	.000
Error	528.986	898	.589			
Total	5037.000	903				
Corrected Total	873.411	902				

a. R Squared = .394 (Adjusted R Squared = .392)

Appendix 57. One-way ANOVAs for intention to change behaviour split by risk category.

Intention to exercise more.

Tests of Between-Subjects Effects

Dependent Variable:Total exercise intention score (mean)

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	4.875[a]	3	1.625	1.095	.350	.004
	Intercept	18720.189	1	18720.189	12618.332	.000	.944
	Condition_allocation	4.875	3	1.625	1.095	.350	.004
	Error	1103.777	744	1.484			
	Total	19842.000	748				
	Corrected Total	1108.652	747				
Moderate or High	Corrected Model	2.656[b]	3	.885	.596	.618	.012
	Intercept	3843.819	1	3843.819	2589.809	.000	.945
	Condition_allocation	2.656	3	.885	.596	.618	.012
	Error	224.116	151	1.484			
	Total	4111.778	155				
	Corrected Total	226.771	154				

a. R Squared = .004 (Adjusted R Squared = .000)

b. R Squared = .012 (Adjusted R Squared = -.008)

Intention to lose weight

Tests of Between-Subjects Effects

Dependent Variable:Total lose weight intention score (mean)

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	9.141[a]	3	3.047	1.178	.317	.005
	Intercept	16055.380	1	16055.380	6209.097	.000	.893
	Condition_allocation	9.141	3	3.047	1.178	.317	.005
	Error	1923.823	744	2.586			
	Total	17993.333	748				
	Corrected Total	1932.964	747				
Moderate or High	Corrected Model	9.579[b]	3	3.193	1.314	.272	.025
	Intercept	3433.103	1	3433.103	1412.926	.000	.903
	Condition_allocation	9.579	3	3.193	1.314	.272	.025
	Error	366.897	151	2.430			
	Total	3827.111	155				
	Corrected Total	376.476	154				

a. R Squared = .005 (Adjusted R Squared = .001)

b. R Squared = .025 (Adjusted R Squared = .006)

Intention to stop smoking.

Tests of Between-Subjects Effects

Dependent Variable:Total smoking intention score (mean)

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	6.582[a]	3	2.194	.752	.527	.048
	Intercept	718.964	1	718.964	246.322	.000	.846
	Condition_allocation	6.582	3	2.194	.752	.527	.048
	Error	131.346	45	2.919			
	Total	898.111	49				
	Corrected Total	137.927	48				
Moderate or High	Corrected Model	12.121[b]	3	4.040	2.047	.130	.180
	Intercept	449.400	1	449.400	227.690	.000	.890
	Condition_allocation	12.121	3	4.040	2.047	.130	.180
	Error	55.265	28	1.974			
	Total	642.556	32				
	Corrected Total	67.385	31				

a. R Squared = .048 (Adjusted R Squared = -.016)

b. R Squared = .180 (Adjusted R Squared = .092)

Appendix 58. One-way ANOVAs for understanding of risk information split by risk category.

Level of understanding.

Tests of Between-Subjects Effects

Dependent Variable:level of understanding as a scale

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	.374[a]	3	.125	1.022	.382	.004
	Intercept	840.756	1	840.756	6889.249	.000	.903
	Condition_allocation	.374	3	.125	1.022	.382	.004
	Error	90.797	744	.122			
	Total	934.000	748				
	Corrected Total	91.171	747				
Moderate or High	Corrected Model	2.027[b]	3	.676	1.743	.161	.033
	Intercept	229.177	1	229.177	591.396	.000	.797
	Condition_allocation	2.027	3	.676	1.743	.161	.033
	Error	58.515	151	.388			
	Total	291.000	155				
	Corrected Total	60.542	154				

a. R Squared = .004 (Adjusted R Squared = .000)

b. R Squared = .033 (Adjusted R Squared = .014)

Confidence in understanding

Tests of Between-Subjects Effects

Dependent Variable:confidence in understanding scores log transformed reflected back

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	.229[a]	3	.076	1.359	.254	.005
	Intercept	50255.940	1	50255.940	894844.581	.000	.999
	Condition_allocation	.229	3	.076	1.359	.254	.005
	Error	41.784	744	.056			
	Total	50352.997	748				
	Corrected Total	42.013	747				
Moderate or High	Corrected Model	.208[b]	3	.069	1.229	.301	.024
	Intercept	10426.225	1	10426.225	184453.486	.000	.999
	Condition_allocation	.208	3	.069	1.229	.301	.024
	Error	8.535	151	.057			
	Total	10617.081	155				
	Corrected Total	8.744	154				

a. R Squared = .005 (Adjusted R Squared = .001)

b. R Squared = .024 (Adjusted R Squared = .004)

Appendix 59. One-ways ANOVA for positive and negative affect split by risk category.

Positive affect.

Tests of Between-Subjects Effects

Dependent Variable:Total post Positive Affect score

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	6213.468[a]	4	1553.367	233.708	.000	.557
	Intercept	.448	1	.448	.067	.795	.000
	Total_Pre_Positive_affect	6163.268	1	6163.268	927.280	.000	.555
	Condition_allocation	29.963	3	9.988	1.503	.213	.006
	Error	4938.429	743	6.647			
	Total	249953.000	748				
	Corrected Total	11151.897	747				
Moderate or High	Corrected Model	791.596[b]	4	197.899	23.998	.000	.390
	Intercept	64.312	1	64.312	7.799	.006	.049
	Total_Pre_Positive_affect	736.397	1	736.397	89.299	.000	.373
	Condition_allocation	38.818	3	12.939	1.569	.199	.030
	Error	1236.959	150	8.246			
	Total	44409.000	155				
	Corrected Total	2028.555	154				

a. R Squared = .557 (Adjusted R Squared = .555)

Negative Affect.

Tests of Between-Subjects Effects

Dependent Variable:Total post negative affect log transformed

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	4.666[a]	4	1.167	62.868	.000	.253
	Intercept	.094	1	.094	5.071	.025	.007
	Pre_Negative_affect_log_transformed	4.637	1	4.637	249.915	.000	.252
	Condition_allocation	.048	3	.016	.866	.458	.003
	Error	13.787	743	.019			
	Total	533.601	748				
	Corrected Total	18.453	747				
Moderate or High	Corrected Model	1.557[b]	4	.389	16.964	.000	.311
	Intercept	.029	1	.029	1.282	.259	.008
	Pre_Negative_affect_log_transformed	1.537	1	1.537	66.961	.000	.309
	Condition_allocation	.000	3	.000	.005	1.000	.000
	Error	3.443	150	.023			
	Total	137.444	155				
	Corrected Total	5.000	154				

a. R Squared = .253 (Adjusted R Squared = .249)
b. R Squared = .311 (Adjusted R Squared = .293)

Appendix 60. One-way ANOVA for worry about future risk of heart disease split by risk category.

Tests of Between-Subjects Effects

Dependent Variable:Q30 post worry

risk dichotomised	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Low	Corrected Model	224.292[a]	4	56.073	108.017	.000	.368
	Intercept	29.243	1	29.243	56.332	.000	.070
	Q11	223.270	1	223.270	430.099	.000	.367
	Condition_allocation	.182	3	.061	.117	.950	.000
	Error	385.702	743	.519			
	Total	3594.000	748				
	Corrected Total	609.995	747				
Moderate or High	Corrected Model	78.310[b]	4	19.578	33.712	.000	.473
	Intercept	5.643	1	5.643	9.718	.002	.061
	Q11	76.418	1	76.418	131.589	.000	.467
	Condition_allocation	1.740	3	.580	.999	.395	.020
	Error	87.109	150	.581			
	Total	1443.000	155				
	Corrected Total	165.419	154				

a. R Squared = .368 (Adjusted R Squared = .364)

b. R Squared = .473 (Adjusted R Squared = .459)

Appendix 61. ANOVA Planned comparisons – Bar graph versus Pictogram.

Intention to exercise more.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total exercise intention score	Assume equal variances	1	-.01	.113	-.110	899	.913
	Does not assume equal variances	1	-.01	.112	-.111	459.463	.912

Intention to lose weight.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total lose weight intention score	Assume equal variances	1	-.03	.149	-.181	899	.856
	Does not assume equal variances	1	-.03	.150	-.180	457.367	.858

Intention to stop smoking.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total smoking intention score (mean)	Assume equal variances	1	.91	.475	1.915	77	.059
	Does not assume equal variances	1	.91	.483	1.880	43.950	.067

Level of understanding.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
level of understanding as a scale	Assume equal variances	1	.00	.039	.040	899	.968
	Does not assume equal variances	1	.00	.039	.039	458.245	.969

Confidence in understanding (log transformed reflected back).

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
confidence in understanding scores log transformed reflected back	Assume equal variances	1	-.0163	.02221	-.735	899	.462
	Does not assume equal variances	1	-.0163	.02214	-.737	460.467	.461

Positive affect.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total post Positive Affect score	Assume equal variances	1	.50	.359	1.402	899	.161
	Does not assume equal variances	1	.50	.358	1.407	451.798	.160

Negative affect (log transformed).

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total post negative affect log transformed	Assume equal variances	1	.0071	.01538	.463	899	.644
	Does not assume equal variances	1	.0071	.01504	.473	459.818	.636

Worry about future risk of heart disease.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Q30 post worry	Assume equal variances	1	-.03	.092	-.324	899	.746
	Does not assume equal variances	1	-.03	.089	-.335	460.507	.738

Appendix 62. ANOVA Planned comparisons – Bar graph versus Pictogram split by risk category.

Intention to exercise more.

Contrast Tests

risk dichotomised	Contrast		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total exercise intention score (mean)	Assume equal variances	1	.00	.126	.015	744	.988
		Does not assume equal variances	1	.00	.122	.015	373.712	.988
Moderate or High	Total exercise intention score (mean)	Assume equal variances	1	-.06	.264	-.219	151	.827
		Does not assume equal variances	1	-.06	.272	-.213	83.479	.832

Intention to lose weight.

Contrast Tests

risk dichotomised		Contrast		Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total lose weight intention score (mean)	Assume equal variances	1	-.02	.166	-.150	744	.881
		Does not assume equal variances	1	-.02	.164	-.152	372.983	.879
Moderate or High	Total lose weight intention score (mean)	Assume equal variances	1	-.01	.338	-.044	151	.965
		Does not assume equal variances	1	-.01	.378	-.039	81.475	.969

Intention to stop smoking.

Contrast Tests

risk dichotomised	Contrast		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total smoking intention score (mean)	Assume equal variances	1	.26	.732	.361	45	.72
		Does not assume equal variances	1	.26	.635	.417	22.342	.68
Moderate or High	Total smoking intention score (mean)	Assume equal variances	1	1.25	.620	2.018	28	.05
		Does not assume equal variances	1	1.25	.635	1.968	17.904	.06

Level of understanding.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	level of understanding as a scale	Assume equal variances		.05	.036	1.372	744	.171
		Does not assume equal variances		.05	.038	1.309	373.046	.191
Moderate or High	level of understanding as a scale	Assume equal variances		-.22	.135	-1.651	151	.101
		Does not assume equal variances		-.22	.128	-1.734	83.101	.087

Confidence in understanding.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	confidence in understanding scores log transformed reflected back	Assume equal variances	1	-.0378	.02442	-1.547	744	.122
		Does not assume equal variances	1	-.0378	.02388	-1.582	373.993	.114
Moderate or High	confidence in understanding scores log transformed reflected back	Assume equal variances	1	.0715	.05150	1.389	151	.167
		Does not assume equal variances	1	.0715	.05515	1.297	83.426	.198

Positive affect

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total post Positive Affect score	Assume equal variances	1	.72	.398	1.817	744	.070
		Does not assume equal variances	1	.72	.391	1.848	367.073	.065
Moderate or High	Total post Positive Affect score	Assume equal variances	1	-.31	.783	-.400	151	.690
		Does not assume equal variances	1	-.31	.830	-.377	79.879	.707

Negative affect (log transformed).

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total post negative affect log transformed	Assume equal variances	1	.0075	.01622	.465	744	.642
		Does not assume equal variances	1	.0075	.01605	.470	374.962	.639
Moderate or High	Total post negative affect log transformed	Assume equal variances	1	-.0038	.03934	-.096	151	.924
		Does not assume equal variances	1	-.0038	.03696	-.103	80.652	.918

Worry about future risk of heart disease.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Q30 post worry	Assume equal variances	1	-.10	.093	-1.080	744	.280
		Does not assume equal variances	1	-.10	.092	-1.098	371.529	.273
Moderate or High	Q30 post worry	Assume equal variances	1	.20	.225	.874	151	.384
		Does not assume equal variances	1	.20	.207	.951	71.676	.345

Appendix 63. ANOVA Planned comparisons - Bar graph versus Metonym.

Intention to exercise more.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total exercise intention score	Assume equal variances	1	.11	.112	1.003	899	.316
	Does not assume equal variances	1	.11	.115	.983	462.566	.326

Intention to lose weight.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total lose weight intention score	Assume equal variances	1	.12	.148	.807	899	.420
	Does not assume equal variances	1	.12	.149	.803	465.522	.423

Intention to stop smoking.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total smoking intention score (mean)	Assume equal variances	1	.70	.535	1.300	77	.197
	Does not assume equal variances	1	.70	.454	1.534	33.669	.134

Level of understanding

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
level of understanding as a scale	Assume equal variances	1	-.04	.038	-.932	899	.352
	Does not assume equal variances	1	-.04	.039	-.912	465.728	.362

Confidence in understanding (log transformed and reflected back)

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
confidence in understanding scores log transformed reflected back	Assume equal variances	1	-.0336	.02205	-1.522	899	.128
	Does not assume equal variances	1	-.0336	.02233	-1.502	466.331	.134

Positive affect

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total post Positive Affect score	Assume equal variances	1	.04	.356	.109	899	.913
	Does not assume equal variances	1	.04	.360	.108	457.771	.914

Negative affect (log transformed).

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total post negative affect log transformed	Assume equal variances	1	.0028	.01528	.185	899	.853
	Does not assume equal variances	1	.0028	.01533	.185	464.476	.853

Worry about future risk of heart disease.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Q30 post worry	Assume equal variances	1	.02	.091	.203	899	.839
	Does not assume equal variances	1	.02	.094	.196	464.184	.845

Appendix 64. ANOVA Planned comparisons - Bar graph versus Metonym split by risk catergory.

Intention to exercise more.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total exercise intention score (mean)	Assume equal variances	1	.19	.124	1.549	744	.122
		Does not assume equal variances	1	.19	.126	1.529	381.121	.127
Moderate or High	Total exercise intention score (mean)	Assume equal variances	1	-.26	.270	-.980	151	.329
		Does not assume equal variances	1	-.26	.277	-.954	79.019	.343

Intention to lose weight.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total lose weight intention score (mean)	Assume equal variances	1	.24	.164	1.473	744	.141
		Does not assume equal variances	1	.24	.163	1.480	383.295	.140
Moderate or High	Total lose weight intention score (mean)	Assume equal variances	1	-.48	.345	-1.399	151	.164
		Does not assume equal variances	1	-.48	.355	-1.361	80.334	.177

Intention to stop smoking.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total smoking intention score (mean)	Assume equal variances	1	-.11	.780	-.142	45	.887
		Does not assume equal variances	1	-.11	.565	-.197	17.334	.846
Moderate or High	Total smoking intention score (mean)	Assume equal variances	1	1.44	.811	1.781	28	.086
		Does not assume equal variances	1	1.44	.598	2.415	9.752	.037

Level of understanding.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	level of understanding as a scale	Assume equal variances	1	.01	.036	.267	744	.789
		Does not assume equal variances	1	.01	.036	.260	383.869	.795
Moderate or High	level of understanding as a scale	Assume equal variances	1	-.28	.138	-2.002	151	.047
		Does not assume equal variances	1	-.28	.140	-1.975	74.239	.052

Confidence in understanding.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	confidence in understanding scores log transformed reflected back intention score (mean)	Assume equal variances	1	-.0408	.02412	-1.691	744	.091
		Does not assume equal variances	1	-.0408	.02399	-1.700	383.485	.090
Moderate or High	confidence in understanding scores log transformed reflected back	Assume equal variances	1	-.0224	.05266	-.426	151	.671
		Does not assume equal variances	1	-.0224	.05490	-.408	79.938	.684

Positive Affect.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total post Positive Affect score	Assume equal variances	1	.36	.393	.921	744	.357
		Does not assume equal variances	1	.36	.401	.904	373.989	.367
Moderate or High	Total post Positive Affect score	Assume equal variances	1	-1.22	.801	-1.528	151	.129
		Does not assume equal variances	1	-1.22	.747	-1.639	80.691	.105

Negative affect (log transformed)

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total post negative affect log transformed	Assume equal variances	1	.0002	.01602	.015	744	.988
		Does not assume equal variances	1	.0002	.01613	.015	383.994	.988
Moderate or High	Total post negative affect log transformed	Assume equal variances	1	-.0024	.04022	-.060	151	.952
		Does not assume equal variances	1	-.0024	.04165	-.058	68.006	.954

Worry about future risk of heart disease.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Q30 post worry	Assume equal variances	1	-.04	.092	-.390	744	.697
		Does not assume equal variances	1	-.04	.096	-.374	383.831	.709
Moderate or High	Q30 post worry	Assume equal variances	1	.08	.230	.354	151	.724
		Does not assume equal variances	1	.08	.241	.338	57.498	.737

Appendix 65. ANOVA Planned comparisons – Bar graph versus Bar graph with pre-intervention questionnaire.

Intention to exercise more.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total exercise intention score	Assume equal variances	1	.03	.115	.301	899	.764
	Does not assume equal variances	1	.03	.114	.303	444.909	.762

Intention to lose weight.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total lose weight intention score	Assume equal variances	1	.10	.151	.651	899	.515
	Does not assume equal variances	1	.10	.149	.659	446.831	.511

Intention to stop smoking.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total smoking intention score (mean)	Assume equal variances	1	-.27	.511	-.527	77	.600
	Does not assume equal variances	1	-.27	.496	-.543	35.903	.591

Level of understanding as a scale.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
level of understanding as a scale	Assume equal variances	1	-.03	.039	-.782	899	.434
	Does not assume equal variances	1	-.03	.038	-.803	450.526	.423

Confidence in Understanding (log transformed and reflected back)

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
confidence in understanding scores log transformed reflected back	Assume equal variances	1	-.0025	.02248	-.112	899	.911
	Does not assume equal variances	1	-.0025	.02268	-.111	446.108	.912

Positive affect

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total post Positive Affect score	Assume equal variances	1	-.37	.363	-1.015	899	.311
	Does not assume equal variances	1	-.37	.348	-1.058	445.011	.290

Negative affect (log transformed).

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Total post negative affect log transformed	Assume equal variances	1	-.0114	.01557	-.732	899	.464
	Does not assume equal variances	1	-.0114	.01579	-.722	438.956	.471

Worry about future risk of heart disease.

Contrast Tests

		Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Q30 post worry	Assume equal variances	1	.03	.093	.354	899	.723
	Does not assume equal variances	1	.03	.094	.349	445.421	.727

Appendix 66. ANOVA Planned comparisons – Bar graph versus Bar graph with pre-intervention Questionnaire split by risk catergory.

Intention to exercise more.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total exercise intention score (mean)	Assume equal variances	1	-.02	.126	-.196	744	.845
		Does not assume equal variances	1	-.02	.125	-.199	366.764	.843
Moderate or High	Total exercise intention score (mean)	Assume equal variances	1	.31	.277	1.108	151	.270
		Does not assume equal variances	1	.31	.274	1.119	75.524	.267

Intention to lose weight.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total lose weight intention score (mean)	Assume equal variances	1	.01	.167	.055	744	.956
		Does not assume equal variances	1	.01	.166	.055	365.909	.956
Moderate or High	Total lose weight intention score (mean)	Assume equal variances	1	.53	.354	1.499	151	.136
		Does not assume equal variances	1	.53	.314	1.691	76.116	.095

Intention to stop smoking.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total smoking intention score (mean)	Assume equal variances	1	.69	.780	.891	45	.378
		Does not assume equal variances	1	.69	.637	1.089	17.995	.291
Moderate or High	Total smoking intention score (mean)	Assume equal variances	1	-1.17	.668	-1.752	28	.091
		Does not assume equal variances	1	-1.17	.704	-1.663	12.764	.121

Level of understanding.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	level of understanding as a scale	Assume equal variances	1	-.05	.036	-1.340	744	.181
		Does not assume equal variances	1	-.05	.035	-1.397	368.067	.163
Moderate or High	level of understanding as a scale	Assume equal variances	1	.07	.141	.470	151	.639
		Does not assume equal variances	1	.07	.147	.451	65.727	.653

Confidence in understanding.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	confidence in understanding scores log transformed reflected back understanding as a scale	Assume equal variances	1	.0109	.02456	.446	744	.656
		Does not assume equal variances	1	.0109	.02482	.441	364.305	.659
Moderate or High	confidence in understanding scores log transformed reflected back	Assume equal variances	1	-.0461	.05400	-.854	151	.395
		Does not assume equal variances	1	-.0461	.05103	-.904	77.999	.369

Positive Affect.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total post Positive Affect score	Assume equal variances	1	-.44	.400	-1.094	744	.275
		Does not assume equal variances	1	-.44	.374	-1.170	368.857	.243
Moderate or High	Total post Positive Affect score	Assume equal variances	1	-.49	.821	-.595	151	.553
		Does not assume equal variances	1	-.49	.837	-.584	70.344	.561

Negative affect (log transformed).

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Total post negative affect log transformed	Assume equal variances	1	-.0152	.01631	-.933	744	.351
		Does not assume equal variances	1	-.0152	.01658	-.918	368.340	.359
Moderate or High	Total post negative affect log transformed	Assume equal variances	1	.0298	.04124	.723	151	.47
		Does not assume equal variances	1	.0298	.04091	.729	64.448	.468

Worry about future risk of heart disease.

Contrast Tests

risk dichotomised			Contrast	Value of Contrast	Std. Error	t	df	Sig. (2-tailed)
Low	Q30 post worry	Assume equal variances	1	.06	.094	.669	744	.50
		Does not assume equal variances	1	.06	.096	.652	370.899	.51
Moderate or High	Q30 post worry	Assume equal variances	1	.12	.236	.488	151	.62
		Does not assume equal variances	1	.12	.219	.528	58.589	.59

Appendix 67. Correlation Matrices for intention to exercise more, lose weight and stop smoking as dependent variables.

Intention to exercise more.

Correlations

		Mean intention to exercise more	Post Positive Affect	Post Negative Affect log transformed	Post Worry	Level of understanding	Risk dichotomised
Pearson Correlation	Mean intention to exercise more	1.000	.332	-.121	-.058	-.041	.001
	Post Positive Affect	.332	1.000	-.177	-.174	.034	-.130
	Post negative affect log transformed	-.121	-.177	1.000	.427	-.039	.216
	Post Worry	-.058	-.174	.427	1.000	-.108	.335
	Level of understanding	-.041	.034	-.039	-.108	1.000	.144
	Risk dichotomised	.001	-.130	.216	.335	.144	1.000
Sig. (1-tailed)	Mean intention to exercise more	.	.000	.000	.041	.108	.493
	Post Positive Affect	.000	.	.000	.000	.154	.000
	Post negative affect log transformed	.000	.000	.	.000	.122	.000
	Post Worry	.041	.000	.000	.	.001	.000
	Level of understanding	.108	.154	.122	.001	.	.000
	Risk dichotomised	.493	.000	.000	.000	.000	.

Intention to lose weight.

Correlations

		Mean intention to lose weight	Post Positive Affect	Post Negative Affect log transformed	Post Worry	Level of understanding	Risk dichotomis
Pearson Correlation	Mean intention to lose weight	1.000	.170	-.003	.057	-.081	.020
	Post Positive Affect	.170	1.000	-.177	-.174	.034	-.130
	Post negative affect log transformed	-.003	-.177	1.000	.427	-.039	.216
	Post Worry	.057	-.174	.427	1.000	-.108	.335
	Level of understanding	-.081	.034	-.039	-.108	1.000	.144
	Risk dichotomised	.020	-.130	.216	.335	.144	1.000
Sig. (1-tailed)	Mean intention to lose weight	.	.000	.470	.044	.008	.275
	Post Positive Affect	.000	.	.000	.000	.154	.000
	Post negative affect log transformed	.470	.000	.	.000	.122	.000
	Post Worry	.044	.000	.000	.	.001	.000
	Level of understanding	.008	.154	.122	.001	.	.000
	Risk dichotomised	.275	.000	.000	.000	.000	.

Intention to stop smoking.

Correlations

		Mean intention to stop smoking	Post Positive Affect	Post Negative Affect log transformed	Post Worry	Level of understanding	Risk dichotomised
Pearson Correlation	Mean intention to stop smoking	1.000	.269	-.093	-.033	-.019	.092
	Post Positive Affect	.269	1.000	-.230	-.213	.010	-.031
	Post negative affect log transformed	-.093	-.230	1.000	.447	-.068	.231
	Post Worry	-.033	-.213	.447	1.000	-.167	.182
	Level of understanding	-.019	.010	-.068	-.167	1.000	.240
	Risk dichotomised	.092	-.031	.231	.182	.240	1.000
Sig. (1-tailed)	Mean intention to stop smoking	.	.008	.203	.386	.432	.207
	Post Positive Affect	.008	.	.019	.028	.466	.391
	Post negative affect log transformed	.203	.019	.	.000	.275	.019
	Post Worry	.386	.028	.000	.	.069	.052
	Level of understanding	.432	.466	.275	.069	.	.016
	Risk dichotomised	.207	.391	.019	.052	.016	.

Appendix 68. Coefficient tables for intention to exercise more, lose weight and stop smoking as dependent variables.

Intention to exercise more.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	3.621	.319		11.339	.000	2.994	4.247					
	Total post Positive Affect score	.104	.010	.329	10.260	.000	.084	.124	.332	.324	.321	.951	1.051
	Total post negative affect log transformed	-.607	.258	-.082	-2.358	.019	-1.113	-.102	-.121	-.078	-.074	.802	1.247
	Q30 post worry	.006	.045	.004	.122	.903	-.083	.094	-.058	.004	.004	.733	1.364
	level of understanding as a scale	-.191	.094	-.065	-2.025	.043	-.376	-.006	-.041	-.067	-.063	.951	1.052
	risk dichotomised	.223	.110	.069	2.031	.043	.008	.439	.001	.068	.064	.844	1.184

a. Dependent Variable: Total exercise intention score

Intention to lose weight.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	3.293	.438		7.513	.000	2.433	4.153					
	Total post Positive Affect score	.078	.014	.188	5.611	.000	.051	.105	.170	.184	.183	.951	1.051
	Total post negative affect log transformed	-.111	.353	-.011	-.315	.753	-.805	.582	-.003	-.011	-.010	.802	1.247
	Q30 post worry	.120	.062	.074	1.939	.053	-.001	.242	.057	.065	.063	.733	1.364
	level of understanding as a scale	-.326	.129	-.084	-2.517	.012	-.579	-.072	-.081	-.084	-.082	.951	1.052
	risk dichotomised	.145	.151	.034	.964	.335	-.151	.441	.020	.032	.031	.844	1.184

a. Dependent Variable: Total lose weight intention score

Intention to stop smoking.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.622	1.389		1.887	.063	-.146	5.390					
	Total post Positive Affect score	.097	.043	.261	2.283	.025	.012	.182	.269	.255	.252	.929	1.076
	Total post negative affect log transformed	-.702	1.148	-.078	-.612	.543	-2.989	1.585	-.093	-.070	-.067	.756	1.323
	Q30 post worry	.040	.197	.026	.202	.841	-.353	.433	-.033	.023	.022	.753	1.329
	level of understanding as a scale	-.191	.420	-.053	-.455	.650	-1.028	.645	-.019	-.053	-.050	.894	1.118
	risk dichotomised	.412	.388	.126	1.062	.291	-.361	1.185	.092	.122	.117	.863	1.159

a. Dependent Variable: Total smoking intention score (mean)

Appendix 69. Multiple Regression Analysis to predict intention to exercise more.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.349[a]	.122	.117	1.144

a. Predictors: (Constant), risk dichotomised, Total post Positive Affect score, level of understanding as a scale, Total post negative affect log transformed, Q30 post worry

b. Dependent Variable: Total exercise intention score

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	3.621	.319		11.339	.000	2.994	4.247					
Total post Positive Affect score	.104	.010	.329	10.260	.000	.084	.124	.332	.324	.321	.951	1.051
Total post negative affect log transformed	-.607	.258	-.082	-2.358	.019	-1.113	-.102	-.121	-.078	-.074	.802	1.247
Q30 post worry	.006	.045	.004	.122	.903	-.083	.094	-.058	.004	.004	.733	1.364
level of understanding as a scale	-.191	.094	-.065	-2.025	.043	-.376	-.006	-.041	-.067	-.063	.951	1.052
risk dichotomised	.223	.110	.069	2.031	.043	.008	.439	.001	.068	.064	.844	1.184

a. Dependent Variable: Total exercise intention score

Appendix 70. Multiple Regression Analysis to predict intention to lose weight.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.209[a]	.044	.038	1.570

a. Predictors: (Constant), risk dichotomised, Total post Positive Affect score, level of understanding as a scale, Total post negative affect log transformed, Q30 post worry

b. Dependent Variable: Total lose weight intention score

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	3.293	.438		7.513	.000	2.433	4.153					
Total post Positive Affect score	.078	.014	.188	5.611	.000	.051	.105	.170	.184	.183	.951	1.051
Total post negative affect log transformed	-.111	.353	-.011	-.315	.753	-.805	.582	-.003	-.011	-.010	.802	1.247
Q30 post worry	.120	.062	.074	1.939	.053	-.001	.242	.057	.065	.063	.733	1.364
level of understanding as a scale	-.326	.129	-.084	-2.517	.012	-.579	-.072	-.081	-.084	-.082	.951	1.052
risk dichotomised	.145	.151	.034	.964	.335	-.151	.441	.020	.032	.031	.844	1.184

a. Dependent Variable: Total lose weight intention score

Appendix 71. Multiple Regression Analysis to predict intention to stop smoking.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.299[a]	.089	.028	1.586

a. Predictors: (Constant), risk dichotomised, Total post Positive Affect score, level of understanding as a scale, Total post negative affect log transformed, Q30 post worry

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	2.622	1.389		1.887	.063	-.146	5.390					
	Total post Positive Affect score	.097	.043	.261	2.283	.025	.012	.182	.269	.255	.252	.929	1.076
	Total post negative affect log transformed	-.702	1.148	-.078	-.612	.543	-2.989	1.585	-.093	-.070	-.067	.756	1.323
	Q30 post worry	.040	.197	.026	.202	.841	-.353	.433	-.033	.023	.022	.753	1.329
	level of understanding as a scale	-.191	.420	-.053	-.455	.650	-1.028	.645	-.019	-.053	-.050	.894	1.118
	risk dichotomised	.412	.388	.126	1.062	.291	-.361	1.185	.092	.122	.117	.863	1.159

a. Dependent Variable: Total smoking intention score (mean)

Appendix 72. Paired T-tests for changes in positive and negative affect and worry after viewing cardiovascular risk.

Positive Affect.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Total Pre Positive Affect score - Total post Positive Affect score	.470	2.656	.088	.296	.643	5.313	902	.000

Negative Affect.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Total Pre Negative affect log transformed - Total post negative affect log transformed	.16817	.14670	.00488	.15859	.17775	34.449	902	.000

Worry about future risk of heart disease.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Q11 Pre Worry - Q30 post worry	.656	.876	.029	.598	.713	22.494	902	.000

Appendix 73. Paired T-tests for changes in positive and negative affect and worry after viewing cardiovascular risk split by risk category.

Positive and negative affect.

Paired Samples Test

risk dichotomised			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Low	Pair 1	Total Pre Positive Affect score - Total post Positive Affect score	.404	2.580	.094	.219	.589	4.279	747	.000
	Pair 2	Total Pre Negative affect log transformed - Total post negative affect log transformed	.18539	.13972	.00511	.17536	.19542	36.289	747	.000
Moderate or High	Pair 1	Total Pre Positive Affect score - Total post Positive Affect score	.787	2.980	.239	.314	1.260	3.288	154	.001
	Pair 2	Total Pre Negative affect log transformed - Total post negative affect log transformed	.08506	.15151	.01217	.06102	.10910	6.989	154	.000

Worry about future risk of heart disease.

Paired Samples Test

risk dichotomised			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Low	Pair 1	Q11 Pre Worry - Q30 post worry	.731	.870	.032	.669	.794	22.997	747	.000
Moderator High	Pair 1	Q11 Pre Worry - Q30 post worry	.290	.814	.065	.161	.419	4.443	154	.000

Appendix 74. Paired T-tests for changes in positive and negative affect and worry after viewing cardiovascular risk split by condition.

Affect.

Paired Samples Test

Condition_allocation			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Bargraph with pre-Q	Pair 1	Total Pre Positive Affect score - Total post Positive Affect score	.561	2.766	.190	.187	.936	2.955	211	.003
	Pair 2	Total Pre Negative affect log transformed - Total post negative affect log transformed	.18281	.15134	.01039	.16232	.20330	17.589	211	.000
Bargraph only	Pair 1	Total Pre Positive Affect score - Total post Positive Affect score	.286	2.676	.172	-.053	.626	1.661	240	.098
	Pair 2	Total Pre Negative affect log transformed - Total post negative affect log transformed	.16052	.14593	.00940	.14200	.17904	17.076	240	.000
Pictogram	Pair 1	Total Pre Positive Affect score - Total post Positive Affect score	.748	2.540	.170	.412	1.084	4.386	221	.000
	Pair 2	Total Pre Negative affect log transformed - Total post negative affect log transformed	.16747	.14754	.00990	.14795	.18698	16.912	221	.000
Metonym	Pair 1	Total Pre Positive Affect score - Total post Positive Affect score	.307	2.629	.174	-.036	.650	1.764	227	.079
	Pair 2	Total Pre Negative affect log transformed - Total post negative affect log transformed	.16332	.14222	.00942	.14476	.18188	17.340	227	.000

Worry about future risk of heart disease.

Paired Samples Test

Condition_allocation			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Bargraph with pre-Q	Pair 1	Q11 Pre Worry - Q30 post worry	.656	1.002	.069	.520	.791	9.527	211	.000
Bargraph only	Pair 1	Q11 Pre Worry - Q30 post worry	.643	.897	.058	.529	.757	11.125	240	.000
Pictogram	Pair 1	Q11 Pre Worry - Q30 post worry	.676	.803	.054	.569	.782	12.531	221	.000
Metonym	Pair 1	Q11 Pre Worry - Q30 post worry	.649	.796	.053	.545	.753	12.309	227	.000

Appendix 75. Correlation between level of understanding and confidence in understanding.

Parametric

Correlations

		confidence in understanding scores log transformed reflected back	level of understanding as a scale
confidence in understanding scores log transformed reflected back	Pearson Correlation	1	-.107**
	Sig. (2-tailed)		.001
	N	903	903
level of understanding as a scale	Pearson Correlation	-.107**	1
	Sig. (2-tailed)	.001	
	N	903	903

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 76. Correlation between level of understanding and confidence in understanding split by risk dichotomised.

Correlations

risk dichotomised			confidence in understanding scores log transformed reflected back	level of understanding as a scale
Low	confidence in understanding scores log transformed reflected back	Pearson Correlation	1	-.173**
		Sig. (2-tailed)		.000
		N	748	748
	level of understanding as a scale	Pearson Correlation	-.173**	1
		Sig. (2-tailed)	.000	
		N	748	748
Moderate or High	confidence in understanding scores log transformed reflected back	Pearson Correlation	1	-.013
		Sig. (2-tailed)		.875
		N	155	155
	level of understanding as a scale	Pearson Correlation	-.013	1
		Sig. (2-tailed)	.875	
		N	155	155

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 77. Correlation between level of understanding and intention to change behaviour.

Intention to exercise more.

Correlations

		level of understanding as a scale	Total exercise intention score (mean)
level of understanding as a scale	Pearson Correlation	1	-.041
	Sig. (1-tailed)		.108
	N	903	903
Total exercise intention score (mean)	Pearson Correlation	-.041	1
	Sig. (1-tailed)	.108	
	N	903	903

Intention to lose weight.

Correlations

		level of understanding as a scale	Total lose weight intention score (mean)
level of understanding as a scale	Pearson Correlation	1	-.081**
	Sig. (1-tailed)		.008
	N	903	903
Total lose weight intention score (mean)	Pearson Correlation	-.081**	1
	Sig. (1-tailed)	.008	
	N	903	903

**. Correlation is significant at the 0.01 level (1-tailed).

Intention to stop smoking.

Correlations

		level of understanding as a scale	Total smoking intention score (mean)
level of understanding as a scale	Pearson Correlation	1	-.019
	Sig. (1-tailed)		.432
	N	903	81
Total smoking intention score (mean)	Pearson Correlation	-.019	1
	Sig. (1-tailed)	.432	
	N	81	81

Appendix 78. Correlation between level of understanding and intention to change behaviour split by risk category.

Intention to exercise more.

Correlations

risk dichotomised			level of understanding as a scale	Total exercise intention score (mean)
Low	level of understanding as a scale	Pearson Correlation	1	-.026
		Sig. (1-tailed)		.240
		N	748	748
	Total exercise intention score (mean)	Pearson Correlation	-.026	1
		Sig. (1-tailed)	.240	
		N	748	748
Moderate or High	level of understanding as a scale	Pearson Correlation	1	-.090
		Sig. (1-tailed)		.133
		N	155	155
	Total exercise intention score (mean)	Pearson Correlation	-.090	1
		Sig. (1-tailed)	.133	
		N	155	155

Intention to lose weight.

Correlations

risk dichotomised			level of understanding as a scale	Total lose weight intention score (mean)
Low	level of understanding as a scale	Pearson Correlation	1	-.104**
		Sig. (1-tailed)		.002
		N	748	748
	Total lose weight intention score (mean)	Pearson Correlation	-.104**	1
		Sig. (1-tailed)	.002	
		N	748	748
Moderate or High	level of understanding as a scale	Pearson Correlation	1	-.043
		Sig. (1-tailed)		.300
		N	155	155
	Total lose weight intention score (mean)	Pearson Correlation	-.043	1
		Sig. (1-tailed)	.300	
		N	155	155

Correlations

risk dichotomised			level of understanding as a scale	Total lose weight intention score (mean)
Low	level of understanding as a scale	Pearson Correlation	1	-.104**
		Sig. (1-tailed)		.002
		N	748	748
	Total lose weight intention score (mean)	Pearson Correlation	-.104**	1
		Sig. (1-tailed)	.002	
		N	748	748
Moderate or High	level of understanding as a scale	Pearson Correlation	1	-.043
		Sig. (1-tailed)		.300
		N	155	155
	Total lose weight intention score (mean)	Pearson Correlation	-.043	1
		Sig. (1-tailed)	.300	
		N	155	155

**. Correlation is significant at the 0.01 level (1-tailed).

Intention to stop smoking.

Correlations

risk dichotomised			level of understanding as a scale	Total smoking intention score (mean)
Low	level of understanding as a scale	Pearson Correlation	1	-.111
		Sig. (1-tailed)		.225
		N	748	49
	Total smoking intention score (mean)	Pearson Correlation	-.111	1
		Sig. (1-tailed)	.225	
		N	49	49
Moderate or High	level of understanding as a scale	Pearson Correlation	1	.018
		Sig. (1-tailed)		.461
		N	155	32
	Total smoking intention score (mean)	Pearson Correlation	.018	1
		Sig. (1-tailed)	.461	
		N	32	32

Appendix 79. Relationship between intention to change behaviour and worry about future risk of heart disease.

Intention to exercise more.

ANOVA

Total exercise intention score (mean)

			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		5.946	4	1.487	1.004	.404
	Linear Term	Unweighted	.514	1	.514	.347	.556
		Weighted	4.492	1	4.492	3.034	.082
		Deviation	1.454	3	.485	.327	.806
	Quadratic Term	Unweighted	.587	1	.587	.397	.529
		Weighted	1.275	1	1.275	.861	.354
		Deviation	.179	2	.090	.060	.941
Within Groups			1329.477	898	1.480		
Total			1335.424	902			

Intention to lose weight.

ANOVA

Total lose weight intention score (mean)

			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		13.904	4	3.476	1.359	.246
	Linear Term	Unweighted	5.958	1	5.958	2.330	.127
		Weighted	7.473	1	7.473	2.922	.088
		Deviation	6.432	3	2.144	.838	.473
	Quadratic Term	Unweighted	1.008	1	1.008	.394	.530
		Weighted	4.338	1	4.338	1.697	.193
		Deviation	2.093	2	1.047	.409	.664
Within Groups			2296.455	898	2.557		
Total			2310.359	902			

Intention to stop smoking.

ANOVA

Total smoking intention score (mean)

			Sum of Squares	df	Mean Square	F	Sig.
Between Groups	(Combined)		4.225	4	1.056	.396	.811
	Linear Term	Unweighted	.648	1	.648	.243	.624
		Weighted	.223	1	.223	.084	.773
		Deviation	4.002	3	1.334	.500	.684
	Quadratic Term	Unweighted	.398	1	.398	.149	.700
		Weighted	1.174	1	1.174	.440	.509
		Deviation	2.827	2	1.414	.530	.591
Within Groups			202.840	76	2.669		
Total			207.064	80			

Appendix 80. Relationship between intention to change behaviour and worry about future risk of heart disease split by risk category.

Intention to exercise more.

ANOVA

Total exercise intention score (mean)

risk dichotomised				Sum of Squares	df	Mean Square	F	Sig.
Low	Between Groups	(Combined)		7.010	4	1.753	1.182	.317
		Linear Term	Unweighted	.689	1	.689	.465	.496
			Weighted	6.368	1	6.368	4.295	.039
			Deviation	.643	3	.214	.144	.933
		Quadratic Term	Unweighted	.336	1	.336	.226	.634
			Weighted	.001	1	.001	.001	.981
			Deviation	.642	2	.321	.216	.805
	Within Groups			1101.641	743	1.483		
	Total			1108.652	747			
Moderate or High	Between Groups	(Combined)		6.484	4	1.621	1.104	.357
		Linear Term	Unweighted	.343	1	.343	.234	.629
			Weighted	.002	1	.002	.001	.973
			Deviation	6.482	3	2.161	1.471	.225
		Quadratic Term	Unweighted	1.419	1	1.419	.966	.327
			Weighted	2.346	1	2.346	1.598	.208
			Deviation	4.136	2	2.068	1.408	.248
	Within Groups			220.287	150	1.469		
	Total			226.771	154			

Intention to lose weight.

ANOVA

Total lose weight intention score (mean)

risk dichotomised				Sum of Squares	df	Mean Square	F	Sig.
Low	Between Groups	(Combined)		9.890	4	2.472	.955	.431
		Linear Term	Unweighted	3.820	1	3.820	1.476	.225
			Weighted	.000	1	.000	.000	.992
			Deviation	9.889	3	3.296	1.274	.282
		Quadratic Term	Unweighted	4.785	1	4.785	1.849	.174
			Weighted	.447	1	.447	.173	.678
			Deviation	9.443	2	4.721	1.824	.162
	Within Groups			1923.075	743	2.588		
	Total			1932.964	747			
Moderate or High	Between Groups	(Combined)		35.062	4	8.766	3.851	.005
		Linear Term	Unweighted	29.286	1	29.286	12.867	.000
			Weighted	31.077	1	31.077	13.654	.000
			Deviation	3.985	3	1.328	.584	.627
		Quadratic Term	Unweighted	3.305	1	3.305	1.452	.230
			Weighted	3.898	1	3.898	1.713	.193
			Deviation	.087	2	.044	.019	.981
	Within Groups			341.414	150	2.276		
	Total			376.476	154			

Intention to stop smoking.

ANOVA

Total smoking intention score (mean)

risk dichotomised				Sum of Squares	df	Mean Square	F	Sig.
Low	Between Groups	(Combined)		1.936	4	.484	.157	.959
		Linear Term	Unweighted	.013	1	.013	.004	.948
			Weighted	.583	1	.583	.189	.666
			Deviation	1.353	3	.451	.146	.932
		Quadratic Term	Unweighted	.417	1	.417	.135	.715
			Weighted	.054	1	.054	.017	.896
			Deviation	1.299	2	.650	.210	.811
	Within Groups			135.991	44	3.091		
	Total			137.927	48			
Moderate or High	Between Groups	(Combined)		13.420	4	3.355	1.679	.184
		Linear Term	Unweighted	1.955	1	1.955	.978	.331
			Weighted	.030	1	.030	.015	.904
			Deviation	13.390	3	4.463	2.233	.107
		Quadratic Term	Unweighted	1.428	1	1.428	.714	.405
			Weighted	4.199	1	4.199	2.101	.159
			Deviation	9.190	2	4.595	2.299	.120
	Within Groups			53.966	27	1.999		
	Total			67.385	31			

Appendix 81. Paired T-tests to assess within group changes to intention to change behaviour scores for control group 1 (pre and post intervention).

Intention to exercise more.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Q13 pre intention reverse scored - Total exercise intention score (mean)	1.203	1.766	.121	.964	1.442	9.915	211	.000

Intention to lose weight.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Q13 pre intention reverse scored - Total lose weight intention score (mean)	1.513	1.892	.130	1.256	1.769	11.641	211	.000

Intention to stop smoking.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Q13 pre intention reverse scored - Total smoking intention score (mean)	1.930	1.871	.429	1.028	2.832	4.496	18	.000

Appendix 82. Paired T-tests to assess within group changes to intention to change behaviour scores for control group 1 (pre and post intervention) split by risk dichotomised.

Intention to exercise more

Paired Samples Test

risk dichotomised			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Low	Pair 1	Q13 pre intention reverse scored - Total exercise intention score (mean)	1.23836	1.79409	.13410	.97374	1.50299	9.235	178	.000
Moderate or High	Pair 1	Q13 pre intention reverse scored - Total exercise intention score (mean)	1.01010	1.61908	.28185	.43600	1.58420	3.584	32	.001

Intention to lose weight.

Paired Samples Test

risk dichotomised			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Low	Pair 1	Q13 pre intention reverse scored - Total lose weight intention score (mean)	1.57728	1.91667	.14326	1.29458	1.85998	11.010	178	.000
Moderate or High	Pair 1	Q13 pre intention reverse scored - Total lose weight intention score (mean)	1.16162	1.73630	.30225	.54595	1.77728	3.843	32	.001

Intention to stop smoking.

Paired Samples Test

risk dichotomised			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Low	Pair 1	Q13 pre intention reverse scored - Total smoking intention score (mean)	1.88889	1.84409	.53234	.71721	3.06057	3.548	11	.005
Moderate or High	Pair 1	Q13 pre intention reverse scored - Total smoking intention score (mean)	2.00000	2.06380	.78004	.09131	3.90869	2.564	6	.043

Appendix 83. Independent T-tests to compare intention to change behaviour scores for those who requested a copy of their risk output results and those that did not.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Total exercise intention score (mean)	Equal variances assumed	1.520	.218	-1.348	901	.178	-.149	.111	-.367	.068
	Equal variances not assumed			-1.440	212.295	.151	-.149	.104	-.354	.055
Total lose weight intention score (mean)	Equal variances assumed	4.366	.037	-1.881	901	.060	-.274	.146	-.560	.012
	Equal variances not assumed			-2.080	220.331	.039	-.274	.132	-.533	-.014
Total smoking intention score (mean)	Equal variances assumed	.555	.458	1.263	79	.210	.565	.447	-.325	1.455
	Equal variances not assumed			1.292	23.620	.209	.565	.437	-.338	1.468

Appendix 84. Independent T-tests to compare intention to change behaviour scores for those who requested a copy of their risk output results and those that did not split by risk dichotomised.

Independent Samples Test

risk dichotomised			Levene's Test for Equality of Variances		t-test for Equality of Means						
										95% Confidence Interval of the Difference	
			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Low	Total exercise intention score (mean)	Equal variances assumed	.622	.431	-1.513	746	.131	-.197	.130	-.453	.059
		Equal variances not assumed			-1.618	140.272	.108	-.197	.122	-.438	.044
	Total lose weight intention score (mean)	Equal variances assumed	2.706	.100	-1.086	746	.278	-.187	.172	-.525	.151
		Equal variances not assumed			-1.179	142.050	.240	-.187	.159	-.500	.127
	Total smoking intention score (mean)	Equal variances assumed	.801	.375	.399	47	.692	.234	.586	-.944	1.412
		Equal variances not assumed			.421	17.634	.679	.234	.555	-.935	1.402
Moderate or High	Total exercise intention score (mean)	Equal variances assumed	1.561	.213	-.108	153	.914	-.024	.220	-.458	.411
		Equal variances not assumed			-.114	81.898	.909	-.024	.209	-.439	.391
	Total lose weight intention score (mean)	Equal variances assumed	1.797	.182	-1.765	153	.080	-.495	.281	-1.050	.059
		Equal variances not assumed			-1.983	94.525	.050	-.495	.250	-.991	.000
	Total smoking intention score (mean)	Equal variances assumed	.000	.984	1.650	30	.109	1.153	.699	-.274	2.580
		Equal variances not assumed			1.503	5.202	.191	1.153	.767	-.797	3.103

Appendix 85. Pearson product-moment correlation coefficients to examine the relationship between direct and indirect measures of intention to change behaviour.

Intention to exercise more.

Correlations

		Copy of risk output requested?	Total exercise intention score (mean)
Copy of risk output requested?	Pearson Correlation	1	.045
	Sig. (2-tailed)		.178
	N	903	903
Total exercise intention score (mean)	Pearson Correlation	.045	1
	Sig. (2-tailed)	.178	
	N	903	903

Intention to lose weight.

Correlations

		Copy of risk output requested?	Total lose weight intention score (mean)
Copy of risk output requested?	Pearson Correlation	1	.063
	Sig. (2-tailed)		.060
	N	903	903
Total lose weight intention score (mean)	Pearson Correlation	.063	1
	Sig. (2-tailed)	.060	
	N	903	903

Intention to stop smoking.

Correlations

		Copy of risk output requested?	Total smoking intention score (mean)
Copy of risk output requested?	Pearson Correlation	1	-.141
	Sig. (2-tailed)		.210
	N	903	81
Total smoking intention score (mean)	Pearson Correlation	-.141	1
	Sig. (2-tailed)	.210	
	N	81	81

Appendix 86. Pearson product-moment correlation coefficients to examine the relationship between direct and indirect measures of intention to change behaviour split by risk category.

Intention to exercise more

Correlations

risk dichotomised			Copy of risk output requested?	Total exercise intention score (mean)
Low	Copy of risk output requested?	Pearson Correlation	1	.055
		Sig. (2-tailed)		.131
		N	748	748
	Total exercise intention score (mean)	Pearson Correlation	.055	1
		Sig. (2-tailed)	.131	
		N	748	748
Moderate or High	Copy of risk output requested?	Pearson Correlation	1	.009
		Sig. (2-tailed)		.914
		N	155	155
	Total exercise intention score (mean)	Pearson Correlation	.009	1
		Sig. (2-tailed)	.914	
		N	155	155

Intention to lose weight

Correlations

risk dichotomised			Copy of risk output requested?	Total lose weight intention score (mean)
Low	Copy of risk output requested?	Pearson Correlation	1	.040
		Sig. (2-tailed)		.278
		N	748	748
	Total lose weight intention score (mean)	Pearson Correlation	.040	1
		Sig. (2-tailed)	.278	
		N	748	748
Moderate or High	Copy of risk output requested?	Pearson Correlation	1	.141
		Sig. (2-tailed)		.080
		N	155	155
	Total lose weight intention score (mean)	Pearson Correlation	.141	1
		Sig. (2-tailed)	.080	
		N	155	155

Intention to stop smoking.

Correlations

risk dichotomised			Copy of risk output requested?	Total smoking intention score (mean)
Low	Copy of risk output requested?	Pearson Correlation	1	-.058
		Sig. (2-tailed)		.692
		N	748	49
	Total smoking intention score (mean)	Pearson Correlation	-.058	1
		Sig. (2-tailed)	.692	
		N	49	49
Moderate or High	Copy of risk output requested?	Pearson Correlation	1	-.289
		Sig. (2-tailed)		.109
		N	155	32
	Total smoking intention score (mean)	Pearson Correlation	-.289	1
		Sig. (2-tailed)	.109	
		N	32	32

Appendix 87. Correlation matrices to assess the assumptions of multicolinearity and singularity.

Intention to exercise more.

n= 903	Mean intention to exercise more	Mean attitude towards exercising more	Mean perceived behavioural control for exercising more	Mean subjective norms for exercising more	Risk category (dichotomised)
	r	r	r	r	r
Mean intention to exercise more	1.000	-	-	-	-
Mean attitude towards exercising more	.509***	1.000	-	-	-
Mean perceived behavioural control for exercising more	.701***	.444***	1.000	-	-
Mean subjective norms for exercising more	.071*	.103***	.005	1.000	-
Risk category (dichotomised)	.001	.006	-.069*	.042	1.000

*** Significant (1-tailed) correlation at $p<0.001$
* Significant (1-tailed) correlation at $p<0.05$

Intention to lose weight.

n= 903	Mean intention to lose weight	Mean attitude towards losing weight	Mean perceived behavioural control for losing weight	Mean subjective norms for losing weight	Risk category (dichotomised)
	r	r	r	r	r
Mean intention to lose weight	1.000	-	-	-	-
Mean attitude towards losing weight	.761***	1.000	-	-	-
Mean perceived behavioural control for losing weight	.336***	.084**	1.000	-	-
Mean subjective norms for losing weight	.415***	.569***	-.159***	1.000	-
Risk category (dichotomised)	.020	.063*	-.038	.070*	1.000

*** Significant (1-tailed) correlation at $p<0.001$
** Significant (1-tailed) correlation at $p<0.01$
* Significant (1-tailed) correlation at $p<0.05$

Intention to stop smoking.

n= 81	Mean intention to stop smoking	Mean attitude towards stopping smoking	Mean perceived behavioural control for stopping smoking	Mean subjective norms for stopping smoking	Risk category (dichotomised)
	r	r	r	r	r
Mean intention to stop smoking	1.000	-	-	-	-
Mean attitude towards stopping smoking	.591***	1.000	-	-	-
Mean perceived behavioural control for stopping smoking	.483***	.363***	1.000	-	-
Mean subjective norms for stopping smoking	.310**	.277**	-.035	1.000	-
Risk category (dichotomised)	.092	.067	-.036	.135	1.000

*** Significant (1-tailed) correlation at $p<0.001$
** Significant (1-tailed) correlation at $p<0.01$

Appendix 88. Multiple Regression Analysis to assess the sub components of the TPB – intention to exercise more.

Intention to exercise more.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.738[a]	.544	.542	.82356

a. Predictors: (Constant), risk dichotomised, Total exercise attitude score, Total exercise subjective norm score, Total exercise PBC score

b. Dependent Variable: Total exercise intention score (mean)

Correlations

Model	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	.663	.219		3.024	.003	.233	1.093					
Total exercise attitude score	.256	.027	.240	9.454	.000	.203	.309	.509	.301	.213	.791	1.264
Total exercise PBC score	.665	.028	.597	23.647	.000	.610	.721	.701	.619	.533	.796	1.256
Total exercise subjective norm score	.048	.026	.042	1.835	.067	-.003	.099	.071	.061	.041	.986	1.014
risk dichotomised	.124	.073	.039	1.704	.089	-.019	.268	.001	.057	.038	.992	1.008

a. Dependent Variable: Total exercise intention score (mean)

Appendix 89. Multiple Regression Analysis to assess the sub components of the TPB – intention to lose weight.

Intention to lose weight.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.810[a]	.657	.655	.93979

a. Predictors: (Constant), risk dichotomised, Total lose weight PBC score, Total lose weight attitudes score, Total lose weight subjective norm score

b. Dependent Variable: Total lose weight intention score (mean)

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	1.304	.211		6.189	.000	.890	1.717					
	Total lose weight attitudes score	.660	.023	.703	28.870	.000	.615	.705	.761	.694	.564	.644	1.553
	Total lose weight PBC score	.439	.031	.286	14.081	.000	.378	.501	.336	.425	.275	.928	1.077
	Total lose weight subjective norm score	.061	.024	.061	2.499	.013	.013	.108	.415	.083	.049	.632	1.582
	risk dichotomised	-.075	.083	-.018	-.897	.370	-.238	.089	.020	-.030	-.018	.993	1.007

a. Dependent Variable: Total lose weight intention score (mean)

Appendix 90. Multiple Regression Analysis to assess the sub components of the TPB – intention to stop smoking.

Intention to stop smoking.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.688[a]	.474	.446	1.19717

a. Predictors: (Constant), risk dichotomised, Total smoking PBC score, Total smoking subjective norm score, Total smoking attitude score

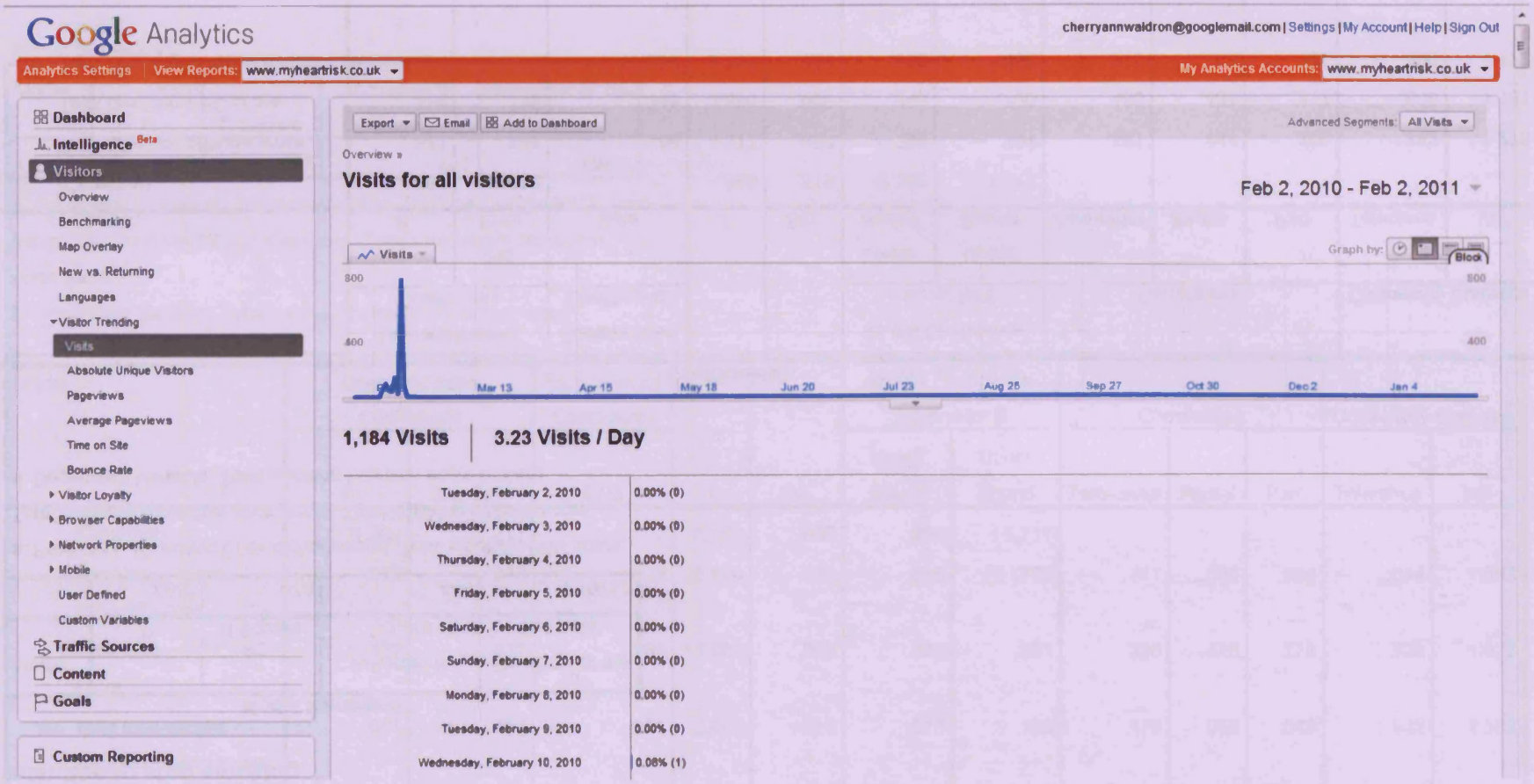
b. Dependent Variable: Total smoking intention score (mean)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-.584	.902		-.648	.519	-2.380	1.212					
	Total smoking attitude score	.541	.125	.406	4.317	.000	.292	.791	.591	.444	.359	.782	1.278
	Total smoking PBC score	.519	.136	.345	3.816	.000	.248	.790	.483	.401	.317	.846	1.181
	Total smoking subjective norm score	.245	.107	.203	2.297	.024	.033	.458	.310	.255	.191	.890	1.123
	risk dichotomised	.163	.275	.050	.594	.554	-.384	.711	.092	.068	.049	.979	1.022

a. Dependent Variable: Total smoking intention score (mean)

Appendices 91. Example of the report generated by *Google Analytics*.

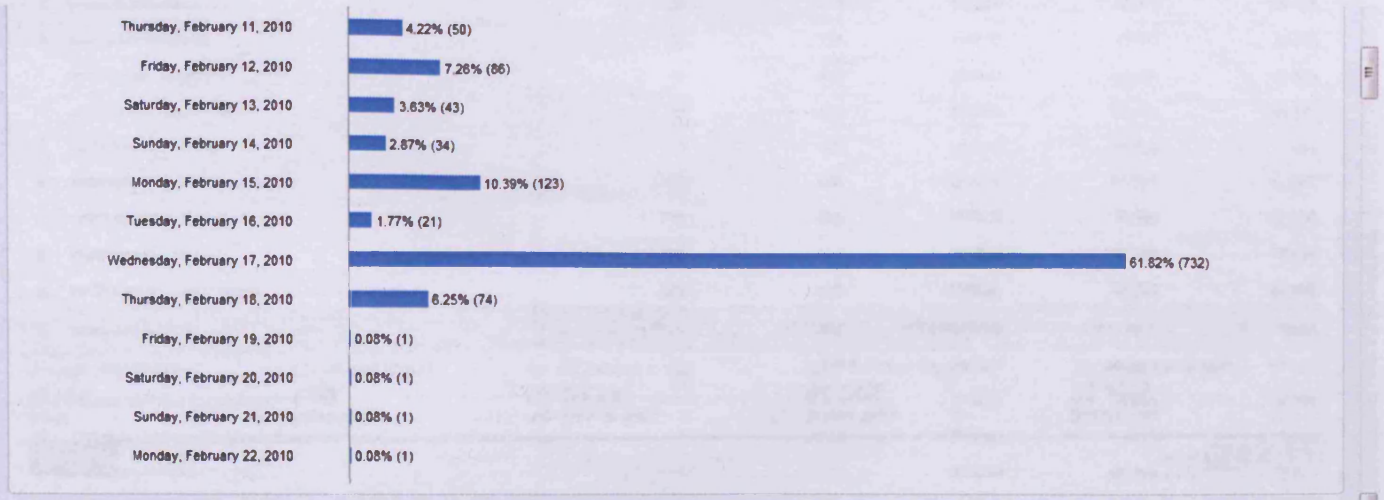


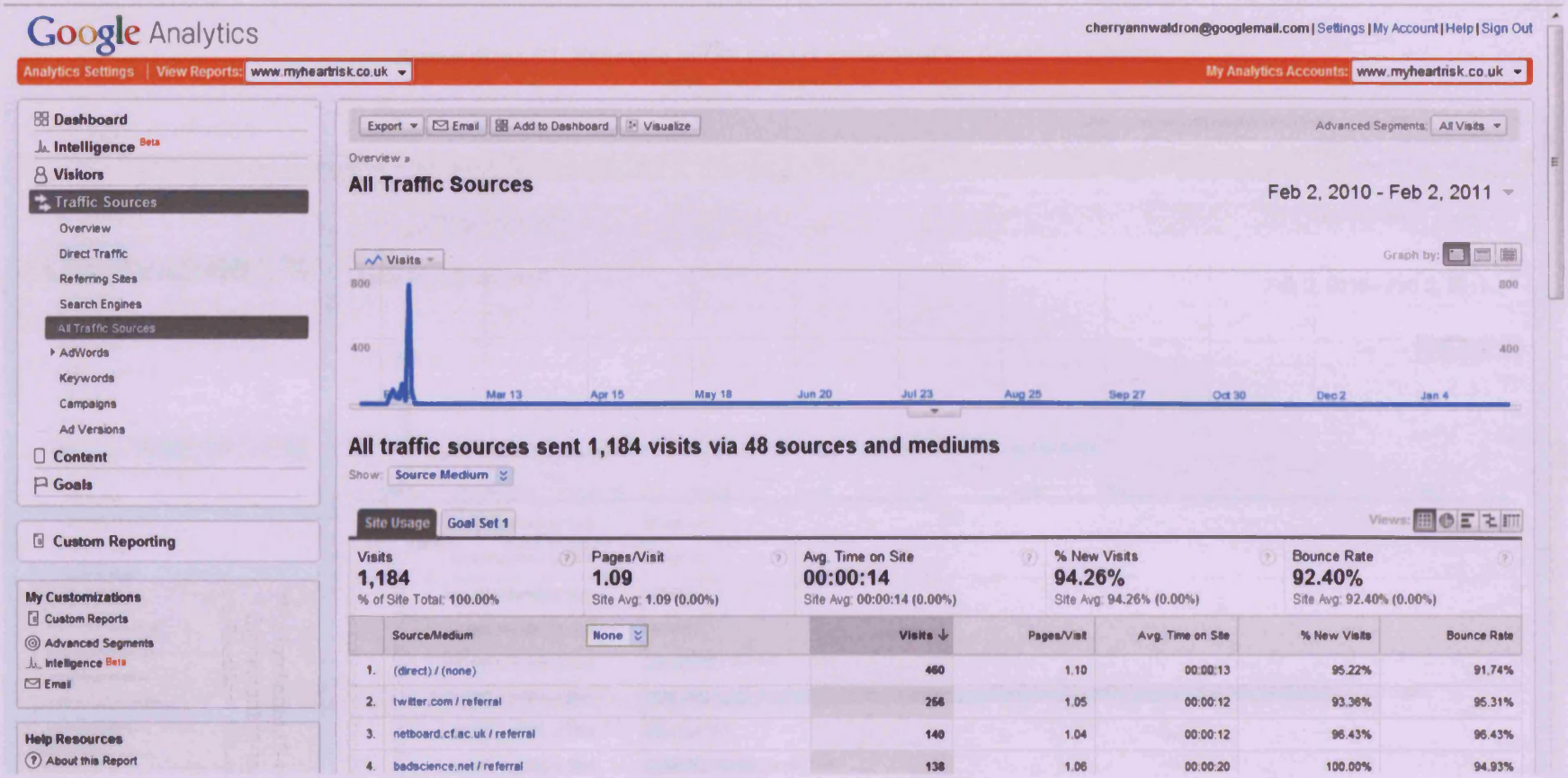
My Customizations

- Custom Reports
- Advanced Segments
- Intelligence Beta
- Email

Help Resources

- About this Report
- Conversion University
- Common Questions




Google Analytics
cherryannwaldron@googlemail.com | Settings | My Account | Help | Sign Out
Analytics Settings | View Reports: www.myheartrisk.co.uk
My Analytics Accounts: www.myheartrisk.co.uk
Dashboard
Intelligence Beta
Visitors
Traffic Sources
Overview
Direct Traffic
Referring Sites
Search Engines
All Traffic Sources
AdWords
Keywords
Campaigns
Ad Versions
Content
Goals
Custom Reporting
My Customizations
Custom Reports
Advanced Segments
Intelligence Beta
Email
Help Resources
About this Report
Export
Email
Add to Dashboard
Visualize
Advanced Segments: All Visits
Overview »
All Traffic Sources
Feb 2, 2010 - Feb 2, 2011
Visits
Graph by:
800
400
Mar 13
Apr 15
May 18
Jun 20
Jul 23
Aug 25
Sep 27
Oct 30
Dec 2
Jan 4
All traffic sources sent 1,184 visits via 48 sources and mediums
Show: Source Medium
Site Usage
Goal Set 1
Views:
Visits 1,184 % of Site Total: 100.00%
Pages/Visit 1.09 Site Avg: 1.09 (0.00%)
Avg. Time on Site 00:00:14 Site Avg: 00:00:14 (0.00%)
% New Visits 94.26% Site Avg: 94.26% (0.00%)
Bounce Rate 92.40% Site Avg: 92.40% (0.00%)
Source/Medium
None
Visits ↓
Pages/Visit
Avg. Time on Site
% New Visits
Bounce Rate
1. (direct) / (none) 460 1.10 00:00:13 95.22% 91.74%
2. twitter.com / referral 268 1.05 00:00:12 93.36% 95.31%
3. netboard.cf.ac.uk / referral 140 1.04 00:00:12 96.43% 96.43%
4. badscience.net / referral 138 1.06 00:00:20 100.00% 94.93%

Conversion University

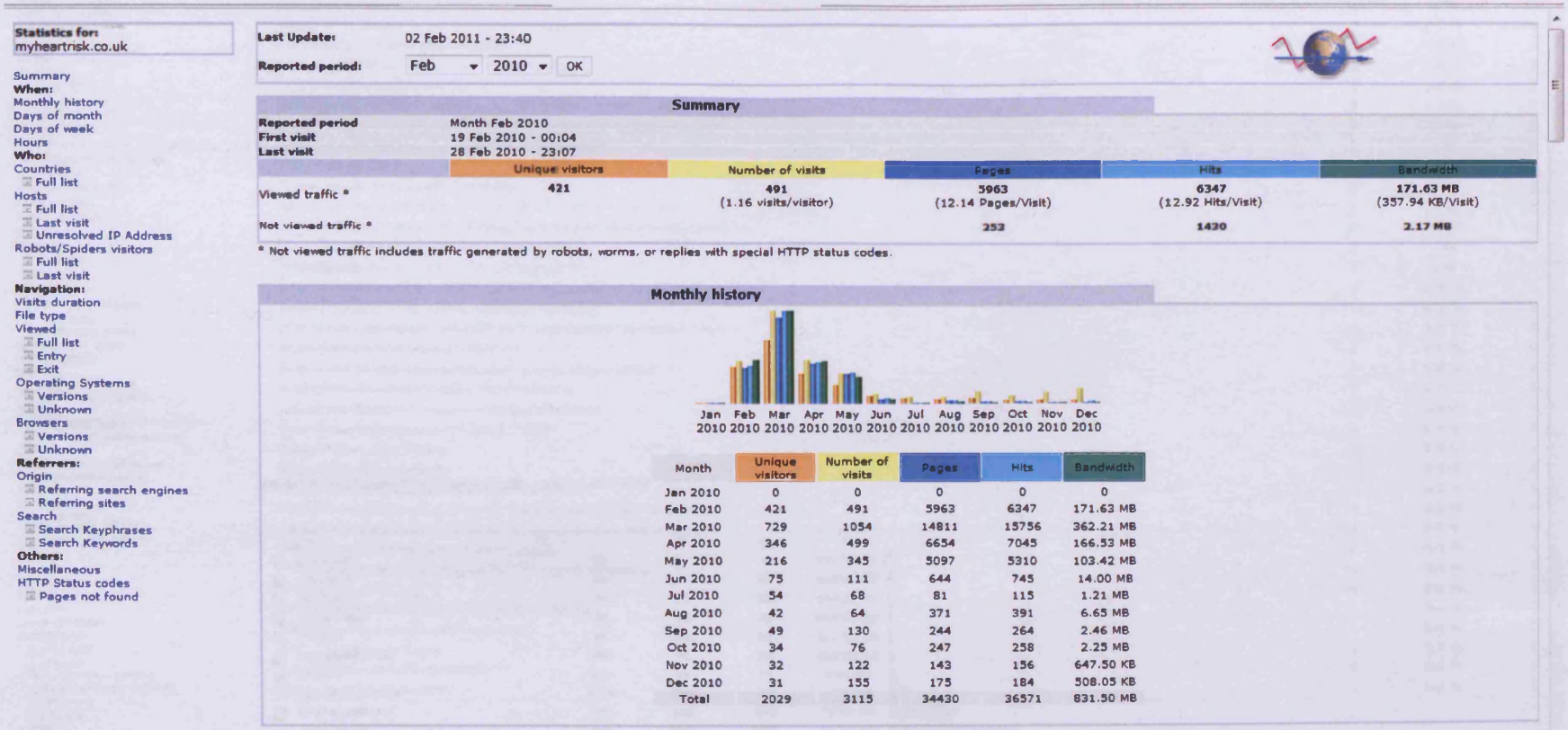
Common Questions

5.	google.com / referral	29	1.14	00:00:13	96.55%	89.66%
6.	google / organic	25	1.12	00:00:19	84.00%	92.00%
7.	google.co.uk / referral	23	1.00	00:00:00	100.00%	100.00%
8.	facebook.com / referral	20	1.15	00:00:27	95.00%	85.00%
9.	delicious.com / referral	16	1.12	00:00:07	100.00%	87.50%
10.	twittergadget.com / referral	10	1.00	00:00:00	100.00%	100.00%
11.	iconfactory.com / referral	8	1.25	00:00:08	100.00%	75.00%
12.	healthandwellnesstimes.com / referral	4	1.00	00:00:00	100.00%	100.00%
13.	noticeboard.cf.ac.uk / referral	4	1.00	00:00:00	75.00%	100.00%
14.	bit.ly/forexmarket / referral	3	2.00	00:00:00	0.00%	0.00%
15.	decisionlaboratory.com / referral	3	1.33	00:00:00	66.67%	66.67%
16.	golbnet.com / referral	3	2.67	00:00:00	0.00%	0.00%
17.	netvibes.com / referral	3	1.00	00:00:00	100.00%	100.00%
18.	uk.mg.bt.mail.yahoo.com / referral	3	1.00	00:00:00	100.00%	100.00%
19.	aluguel-de-computadores.golbnet.com / referral	2	2.50	00:00:00	0.00%	0.00%
20.	brizzly.com / referral	2	3.00	00:08:32	100.00%	50.00%
21.	estabilizador-e-nobreak.golbnet.com / referral	2	2.00	00:00:00	0.00%	50.00%
22.	google.com.au / referral	2	1.00	00:00:00	100.00%	100.00%
23.	mobile.twitter.com / referral	2	1.00	00:00:00	100.00%	100.00%
24.	search.bt.com / referral	2	1.00	00:00:00	100.00%	100.00%
25.	aol / organic	1	1.00	00:00:00	100.00%	100.00%
26.	ask / organic	1	1.00	00:00:00	100.00%	100.00%

27.	betwittered.com / referral	1	1.00	00:00:00	100.00%	100.00%
28.	bit.ly/forwebmasters / referral	1	2.00	00:00:00	0.00%	0.00%
29.	camera-digital.golbnet.com / referral	1	1.00	00:00:00	0.00%	100.00%
30.	fragmentadora-de-papel.golbnet.com / referral	1	3.00	00:00:01	0.00%	0.00%
31.	google.be / referral	1	1.00	00:00:00	100.00%	100.00%
32.	google.co.nz / referral	1	1.00	00:00:00	100.00%	100.00%
33.	google.es / referral	1	1.00	00:00:00	100.00%	100.00%
34.	google.ie / referral	1	1.00	00:00:00	100.00%	100.00%
35.	hootsuite.com / referral	1	1.00	00:00:00	100.00%	100.00%
36.	ig.gmodules.com / referral	1	1.00	00:00:00	100.00%	100.00%
37.	m.delicious.com / referral	1	1.00	00:00:00	100.00%	100.00%
38.	m.netvibes.com / referral	1	1.00	00:00:00	100.00%	100.00%
39.	mouse-e-teclado.golbnet.com / referral	1	3.00	00:00:00	0.00%	0.00%
40.	my.yahoo.com / referral	1	1.00	00:00:00	100.00%	100.00%
41.	search.sky.com / referral	1	2.00	00:06:26	100.00%	0.00%
42.	seesmic.com / referral	1	1.00	00:00:00	100.00%	100.00%
43.	smartphone.golbnet.com / referral	1	3.00	00:00:00	0.00%	0.00%
44.	sn125w.snt125.mail.live.com / referral	1	1.00	00:00:00	100.00%	100.00%
45.	themetroguy.golbnet.com / referral	1	1.00	00:00:00	0.00%	100.00%
46.	valeriebenandkids.blogspot.com / referral	1	1.00	00:00:00	100.00%	100.00%
47.	webmail.aol.com / referral	1	1.00	00:00:00	100.00%	100.00%
48.	webmail.livemail.co.uk / referral	1	1.00	00:00:00	100.00%	100.00%

Filter Source/Medium: containing Go Advanced Filter Go to: 1 Show rows: 100 1 - 48 of 48

Appendices 92. Example of the report generated by *AW Stats*.



Statistics for: myheartrisk.co.uk

Summary
When:
Monthly history
Days of month
Days of week
Hours
Who:
Countries
Full list
Hosts
Full list
Last visit
Unresolved IP Address
Robots/Spiders visitors
Full list
Last visit
Navigation:
Visits duration
File type
Viewed
Full list
Entry
Exit
Operating Systems
Versions
Unknown
Browsers
Versions
Unknown
Referrers:
Origin
Referring search engines
Referring sites
Search
Search Keyphrases
Search Keywords
Others:
Miscellaneous
HTTP Status codes
Pages not found

Last Update: 02 Feb 2011 - 23:40
Reported period: Feb 2010 OK

Summary

Reported period	Month Feb 2010
First visit	19 Feb 2010 - 00:04
Last visit	28 Feb 2010 - 23:07

	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Viewed traffic *	421	491 (1.16 visits/visitor)	5963 (12.14 Pages/Visit)	6347 (12.92 Hits/Visit)	171.63 MB (357.94 KB/Visit)
Not viewed traffic *			252	1430	2.17 MB

* Not viewed traffic includes traffic generated by robots, worms, or replies with special HTTP status codes.

Monthly history

Jan 2010 Feb 2010 Mar 2010 Apr 2010 May 2010 Jun 2010 Jul 2010 Aug 2010 Sep 2010 Oct 2010 Nov 2010 Dec 2010

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2010	0	0	0	0	0
Feb 2010	421	491	5963	6347	171.63 MB
Mar 2010	729	1054	14811	15756	362.21 MB
Apr 2010	346	499	6654	7045	166.53 MB
May 2010	216	345	5097	5310	103.42 MB
Jun 2010	75	111	644	745	14.00 MB
Jul 2010	54	68	81	115	1.21 MB
Aug 2010	42	64	371	391	6.65 MB
Sep 2010	49	130	244	264	2.46 MB
Oct 2010	34	76	247	258	2.25 MB
Nov 2010	32	122	143	156	647.50 KB
Dec 2010	31	155	175	184	508.05 KB
Total	2029	3115	34430	36571	831.50 MB

Statistics for:
myheartrisk.co.uk

Summary
When:
Monthly history
Days of month
Days of week
Hours
Who:
Countries
- Full list

Hosts
- Full list
- Last visit
- Unresolved IP Address

Robots/Spiders visitors
- Full list
- Last visit

Navigation:
Visits duration
File type
Viewed
- Full list
- Entry
- Exit

Operating Systems
- Versions
- Unknown

Browsers
- Versions
- Unknown

Referrers:
Origin
- Referring search engines
- Referring sites

Search
- Search Keyphrases
- Search Keywords

Others:
Miscellaneous
HTTP Status codes
- Pages not found

Last Update: 02 Feb 2011 - 23:40
Reported period: Feb 2010 OK

Back to main page

Visitors domains/countries

Domains/Countries		Pages	Hits	Bandwidth
Unknown	ip	3095	3341	105.41 MB
Commercial	com	1583	1637	30.82 MB
United Kingdom	uk	820	875	22.68 MB
Old style Arpanet	arpa	244	262	7.73 MB
Network	net	68	73	2.22 MB
USA Educational	edu	37	38	476.22 KB
Canada	ca	35	36	475.67 KB
Netherlands	nl	33	34	474.93 KB
Portugal	pt	32	33	474.56 KB
Germany	de	11	12	466.85 KB
Denmark	dk	5	6	464.65 KB
Others		0	0	0

Advanced Web Statistics 6.95 (build 1.943) - Created by awstats

Statistics for:
myheartrisk.co.uk

Links from an external page (other web sites except search engines)

Total: 37 different pages-url

	Pages	Percent	Hits	Percent
http://www.badscience.net	103	51.5 %	103	51.5 %
http://www.badscience.net/2010/02/how-do-you-regulate-wu/	21	10.5 %	21	10.5 %
http://delicious.com/bengoldacre	10	5 %	10	5 %
http://longurl.org	9	4.5 %	9	4.5 %
http://delicious.com/bengoldacre/	9	4.5 %	9	4.5 %
http://twitter.com	5	2.5 %	5	2.5 %
http://twitter.com/glynelwyn	3	1.5 %	3	1.5 %
http://www.badscience.net/2010/01/oh-i-found-you-a-new-job/	3	1.5 %	3	1.5 %
http://www.badscience.net/2010/02/guns-dont-kill-people-puppies-...	2	1 %	2	1 %
http://www.badscience.net/about-dr-ben-goldacre/upcoming-talks-r...	2	1 %	2	1 %
http://dlvr.it/23V6	2	1 %	2	1 %
http://www.facebook.com/home.php	2	1 %	2	1 %
http://www.badscience.net/2010/01/the-wakefield-mmr-verdict/	2	1 %	2	1 %
http://www.badscience.net/2010/02/how-do-you-regulate-wu/#more-1...	2	1 %	2	1 %
http://www.talktalk.co.uk/search/results.html	2	1 %	2	1 %
http://feeds.delicious.com/v2/rss/bengoldacre	2	1 %	2	1 %
http://www.badscience.net/2006/12/homeopathy-video-stream/	1	0.5 %	1	0.5 %
http://facebook.tweetmeme.com/user/zenbuffy	1	0.5 %	1	0.5 %
http://www.badscience.net/2010/01/if-you-want-to-be-trusted-more...	1	0.5 %	1	0.5 %
http://www.badscience.net/1007/01/	1	0.5 %	1	0.5 %
http://www.badscience.net/about-dr-ben-goldacre/twitter/	1	0.5 %	1	0.5 %
http://www.decisionlaboratory.com/news.php	1	0.5 %	1	0.5 %
http://www.badscience.net/what-is-the-miniblog/	1	0.5 %	1	0.5 %
http://www.badscience.net/2006/11/324/	1	0.5 %	1	0.5 %
http://twitter.com/JRBtrip	1	0.5 %	1	0.5 %
http://twitter.com/search	1	0.5 %	1	0.5 %
http://noticeboard.cf.ac.uk/archive/items.var	1	0.5 %	1	0.5 %
http://www.badscience.net/how-to-use-this-website/the-bad-scienc...	1	0.5 %	1	0.5 %
http://www.badscience.net/2009/10/jabs-as-bad-as-the-cancer/	1	0.5 %	1	0.5 %
http://www.bloglines.com/myblogs_display	1	0.5 %	1	0.5 %
http://www.badscience.net/2010/02/moments-of-genius/	1	0.5 %	1	0.5 %
http://icio.us/1eqtvg	1	0.5 %	1	0.5 %
http://www.badscience.net/2007/11/free-energy/	1	0.5 %	1	0.5 %
http://www.badscience.net/index.php	1	0.5 %	1	0.5 %
http://twitter.com/home	1	0.5 %	1	0.5 %
http://twitter.com/bengoldacre	1	0.5 %	1	0.5 %
http://www.netvibes.com	1	0.5 %	1	0.5 %