Management Risk Factors Associated with Foodborne Disease Outbreaks in the Catering Industry in England and Wales

Thesis submitted in accordance with the requirements of the School of Medicine, Cardiff University, for the degree of Doctor of Philosophy

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2008

SUMMARY

Despite structured enforcement of food safety requirements known to prevent foodborne disease outbreaks, catering businesses continue to be the most common setting for outbreaks in England and Wales. Limited published evidence suggests that the way catering businesses are managed and operated may contribute to food safety control failures which in turn can result in an outbreak. The purpose of this study, funded by the Food Standards Agency[1,2] was to identify the underlying management factors that may contribute to or prevent outbreaks in the catering industry. A matched case control study compared the management and operational practices of 148 catering businesses associated with foodborne outbreaks with 148 control catering businesses. High response rates were achieved: case businesses 90%, and control businesses 93%. To minimise false inferences from chance associations analysis followed a predefined hypothesised causal pathway. Hazard analysis critical control point systems and formal food hygiene training were found not to be protective and food hygiene inspection scores were not useful in predicting which businesses were likely to be associated with outbreaks. Larger small medium sized (SME) businesses were more likely to be associated with outbreaks compared to micro SME businesses. Operational and management practices did not differ significantly between case and control businesses when adjusted for SME size. SME size was not explained by other staff employment and management variables. However, businesses associated with *Salmonella* outbreaks were significantly more likely to use regional egg suppliers, the only significantly independent operational practice associated with *Salmonella* outbreaks. Regional egg suppliers were also more likely to supply businesses associated with outbreaks that were attributed to food vehicles containing eggs. Businesses associated with egg outbreaks were less likely to use eggs produced under an approved quality assurance scheme suggesting that the underlying risk associated with using regional suppliers may relate to the use of contaminated eggs.

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[1] Jones, S.L. Parry, S.M. O'Brien, S.J. and Palmer, S.R. 2008. Are staff management practices and inspection risk ratings associated with foodborne disease outbreaks in the catering industry in England and Wales? *Journal of Food Protection* 71:3:550 – 557.
[2] Jones, S.L. Parry, S.M. O'Brien, S.J. and Palmer, S.R. 2008a. Operational practices associated with foodborne disease outbreaks in the catering industry in England and Wales. *Journal of Food Protection* 71:8: 1659 – 1665.

ACNOWLEDGEMENTS

I would like to offer my sincere gratitude to my project supervisor Professor Stephen Palmer without whom this study would not have been possible. I am indebted to his invaluable advice, expertise and patience.

My thanks are also extended to: the project team at CMi PLC, Oxford who supported this project, undertook interviews and provided the administrative support during data collection, Celia Penman from the Centre for Infection, Environmental and Enteric Diseases Department at the Health Protection Agency in London for coordinating outbreaks reported to the national surveillance scheme, Professor Sarah O'Brien and Dr. Sharon Parry for their advice and support during study development and data collection, all the catering businesses and local authorities who participated in this study and Mrs Marie York and Mrs. Marie Platt for their proof reading skills.

I also acknowledge the funding provided by the Food Standards Agency, London to undertake this project.

Most of all my thanks and all my love go to my husband Kerry and son Luke.

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List of Abbreviations

ACMSF	Advisory Committee on the Microbiological Safety of Food
BHA	British Hospitality Association
CAC	Codex Alimentarius Commission
CIEH	Chartered Institute of Environmental Health
EC	European Community
FH	Food hygiene
FSA	Food Standards Agency
FSHWG	Food Safety and Hygiene Working Group
HACCP	Hazard Analysis Critical Control Point
HPA	Health Protection Agency
IGD	Institute of Grocery Distribution
IID	Infectious Intestinal Disease
OCT	Outbreak Control Team
ONS	Office of National Statistics
People 1st	The Sector Skills Council for the Hospitality, Leisure, Travel and tourism industries.
PT	Phage type
SFBB	Safer Food Better Business
U.K.	United Kingdom
U.S.A.	United States of America

Glossary

Bias	deviation of results or inferences from the truth, or processes leading to such deviation[1].
Confidence intervals	the range (usually 95%) that will include, with stated probability, the actual population parameter estimated from a sample[2].
Epidemiology	the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control health problems[1].
Incidence	the number of new cases in a defined population within a specified period of time[1].
Phage type	phages are bacterial viruses that adsorb specifically to receptors on the bacterial surface, they maybe species specific or strain specific which enables them to be used for typing in epidemiology[3].
P value	the probability of obtaining a given result by chance alone[2].
Risk factor	a characteristic that is of value in predicting risk[2].
Serogroup	a group of serologically related organisms[3].
Serotype	a single bacterial strain or type, defined by antigenic structure[3].
Stratification	the process of separating a study group into subsamples according to specified criteria[1].
Target population	that population about which the study inferences apply to, in this case the catering industry in England and Wales[1].

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1 INTRODUCTION

Foodborne disease outbreaks constitute an important public health problem in England and Wales (Roberts 2000; Little et al. 2008); they cause significant morbidity (FSA 2000; Adak et al. 2005; Hughes et al. 2007), undermine public confidence in the food industry (Schlundt 2002; Smith et al. 2005) and can dominate the media and political agenda (Fowler 1986; Agriculture Committee 1998; FSA 2001; Welsh Assembly Government 2005). In 2005, the largest outbreak of *Escherichia coli* O157 reported to date in Wales resulted in 157 cases of illness, 31 hospitalisations and one death. Most cases were school children (OCT 2006). The 'Wishaw' outbreak in central Scotland in 1996 resulted in over 512 cases and 17 deaths (Cowden et al. 2001). In 1984 an outbreak of *Salmonella* enterica serotype typhimurium phage type 49 at the Stanley Royd Hospital in Wakefield, Yorkshire was reported to have resulted in 461 cases of illness and 19 deaths (Committee of Inquiry 1986). All three outbreaks resulted in public enquiries (Pennington Group 1997; Committee of Inquiry 1986) and changed the public's perception of food safety.

The food preparation, storage and handling factors that lead to foodborne outbreaks are well documented: unrefridgerated food storage, under-cooked or reheated food, use of the same equipment and working surfaces for the preparation of raw and cooked foods, and food handlers working with viral gastrointestinal illness (Bryan 1978; Roberts 1982; Djuretic et al. 1996; Jones and Angulo 2006). Such factors have been the subject of Government legislation, regulation, codes of practice and industry guidance for over half a century. For example, in the European Union legal requirements are now in place that mandate that food businesses ensure that staff members are supervised, instructed, and/or trained and that hazard analysis critical control point (HACCP) practices are applied to food preparation processes (European Union 2004). Yet despite this attention, foodborne disease outbreaks continue to occur frequently in the catering industry (HPA 2004; Hughes et al. 2007). Between 1992 and 2003, 949 out of 1729 (55%) foodborne disease outbreaks reported to the Public Health Laboratory Service's Communicable Disease Surveillance Centre occurred in commercial catering premises (Hughes et al. 2007).

One set of factors that has not been systematically investigated are management level factors associated with operating a catering business. Issues relating to staff employment and management and the way in which catering businesses operate might in part explain the failure to implement adequate food safety in the catering industry. Management factors have been identified in public enquiries. The Report of the Committee of Inquiry into the Stanley Royd Outbreak (1986) concluded that poor communication between managers and staff, confusion over individual responsibilities, and inadequate supervision led to unauthorised changes to menus and lack of adherence to safe food preparation practices, which ultimately contributed to the outbreak. In the late 1980s, the Committee on the Microbiological Safety of Food (known as the Richmond Committee) examined the increased incidence of foodborne infection, particularly Salmonellosis, Campylobacteriosis and Listeriosis in relation to changes in agriculture and food production, food technology and distribution, retail, catering and food handling practices

(Richmond et al. 1990; Richmond et al. 1991). The authors suggested that unskilled, agency and casual staff, commonly employed in the catering industry required good management and supervision particularly where high staff turnover was experienced. This was endorsed by the Agricultural Committee on Food Safety (Agriculture Committee 1998) which reviewed the continued increased incidence in food poisoning and the level of food safety risk at all stages of the human food chain and commented that the catering industry at the time experienced poor working conditions, unhygienic practices and high staff turnover which would have a negative impact on food safety. In contrast, peer reviewed articles on outbreaks tend to focus on identification of the causative pathogen, and failures in preparing and storing food, and only occasionally is management level data reported.

An investigation which did refer to management level factors, was a *Campylobacter* outbreak associated with the consumption of stir-fried food that found that cooking times were compromised by commercial pressures to serve food promptly to large parties of customers (Evans et al. 1998). Other references can be found in the literature; in a review of infectious intestinal disease (IID) outbreaks that occurred between 1992 and 1994 in England and Wales, the HPA commented that staff shortages and increased workload could possibly contribute to the occurrence of outbreaks (Djuretic et al. 1996). In the U.S.A. a national outbreak of *Salmonella* Enteritidis associated with the consumption of ice cream caused illness in 224, 000 people in 1994. The investigation concluded that the outbreak was the result of cross contamination of the pasteurised ice-cream pre-mix during transport in tanker trailers that had previously carried unpasteurised liquid egg and that future outbreaks could be prevented by ensuring that food products not destined for re-pasteurisation were transported in dedicated containers (Hennessy et al. 1996). In this outbreak, the environmental investigation found that two months before the outbreak the trucking company had taken on a new contract which increased the amount of liquid egg being transported; it had become common practice to use the same tankers to transport ice-cream premix and liquid egg. Company procedures were in place to clean and disinfect the tankers between deliveries but on some occasions there were no records to confirm that this had been undertaken correctly.

These examples illustrate the potential importance of management level factors in explaining the occurrence of outbreaks, and if the incidence of outbreaks is to be reduced it is clearly important to understand better the contribution of specific management factors like staff employment and management and business operational procedures to the occurrence of outbreaks.

The concept that management level factors are important is acknowledged in Food Standards Agency (FSA) guidance, but the evidence for implicating specific factors is not apparent. For example environmental health practitioners employed by local authorities enforce statutory food hygiene requirements during inspections (European Union 2004) and the frequency of inspections is determined by a risk rating system outlined in "The Food Law Code of Practice (England) Annex 5" (FSA 2005). The scoring system takes account of the type of food and method of handling, methods of processing, consumers at risk, level of compliance and confidence in management/control systems but the predictive power of this tool in relation to outbreaks has not been validated. The 'Confidence in Management' section requires judgement on "the track record of the company, management's attitude to food hygiene and the knowledge and implementation of HACCP based management systems" but there is no underpinning source quoted in the guidance (FSA 2005). Mullen et al. (2002) have challenged the predictive value of this risk rating system in relation to outbreaks. Following two outbreaks of infection with *Salmonella* Enteritidis in Scotland, they investigated food businesses where outbreak cases had eaten and neighbouring food businesses where no outbreak cases had eaten and compared the risk rating scores of the businesses prior to the outbreaks occurring. They found that there was no significant difference between risk rating scores of case and control food businesses. The FSA are currently reviewing the food law enforcement monitoring system in England and Wales and this includes changes to the risk rating system (FSA 2006a; FSA 2006b).

This thesis reports on an FSA funded study which resulted in two publications (Jones et al. 2008; Jones et al 2008a) and contributes to the gap in evidence on the association between management level factors and the occurrence of foodborne disease outbreaks.

<u>Aim of the study:</u> To identify management factors associated with foodborne disease outbreaks in England and Wales in the catering industry.

Achieved by undertaking:

1. A systematic literature review of management risk factors associated with foodborne disease outbreaks in the catering industry, and,
2. carrying out a case control study of foodborne disease outbreaks that occur in the catering industry in England and Wales.

2 AN OVERVIEW OF FOODBORNE DISEASE OUTBREAKS

2.1 Introduction

This chapter reviews foodborne disease outbreaks in the catering industry in England and Wales from three key perspectives; epidemiology, the industry itself and environmental health. The epidemiological perspective considers the distribution and determinants of foodborne disease and outbreaks over the last two decades. Since the catering industry is the most common setting for these outbreaks an understanding of the main operational and management characteristics of this industry is important. The environmental health perspective considers the impact of legislative food safety controls on food safety standards and the incidence of foodborne disease in the catering industry.

2.2 Epidemiological perspective

This section considers the main epidemiological characteristics of foodborne disease outbreaks in England and Wales; features of foodborne disease, trends in the incidence of outbreaks, the common causative pathogens, outbreak investigations and food safety factors known to contribute to their occurrence.

2.2.1 Foodborne disease outbreaks

Foodborne disease is one of the most common causes of acute illness (Chin 2000). It is usually caused by the consumption of food contaminated with bacterial or viral pathogens or their toxins, resulting in symptoms of nausea, vomiting, abdominal pain, diarrhoea and fever (FSA 2000), although more long term health complications can occur such as Guillian-Barre syndrome associated with Campylobacter infection (Hahn 1998) and Haemolytic-Uraemic syndrome associated with E. coli O157:H7 infection (Parry et al. 1998). Infection occurs either as sporadic cases or as part of an outbreak, defined by the Department of Health (D.o.H) as:

> "An incident where two or more people (who are members of more than one private residence) were thought to have a common exposure and experience a similar proven infection"
>
> (D.o.H working Group 1994)

2.2.2 Data sources of foodborne disease outbreaks

In England and Wales there is one main source of routinely collected data on foodborne disease outbreaks (Wall, de Louvais, Gilbert, and Rowe, 1996). This is a voluntary national surveillance scheme operated by the Health Protection Agency (HPA). HPA is made aware of outbreaks from a number of sources including the national laboratory reporting scheme, local health protection units, environmental health officers (EHOs) and microbiologists (Wall, de Louvais, Gilbert, and Rowe, 1996). When the outbreak investigation is finished a structured questionnaire is completed by the lead investigator and returned to the HPA. Analyses of data from this scheme are then regularly reported in HPA literature.

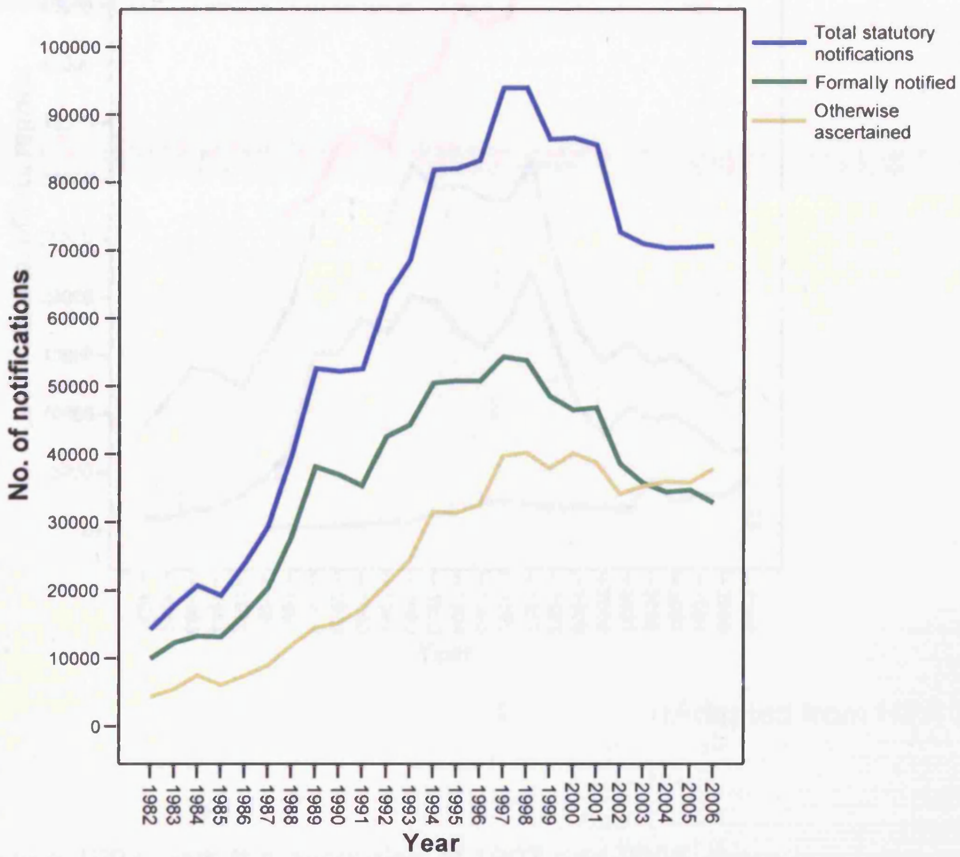
Two other data sources on foodborne disease which can also provide information on foodborne disease outbreaks are the statutory notifications by which general practitioners are required under the Public Health (Control of Diseases) Act 1984 to notify the 'proper officer' of the local authority of cases and suspected cases of food poisoning that they have diagnosed. This system also identifies cases 'otherwise ascertained' which comprise data received by EHOs as a result of complaints from members of the public or from outbreak investigations. Notifications are collated by the HPA on behalf of the Office of National Statistics (ONS). HPA also operates a voluntary national surveillance scheme for the collection of laboratory diagnosed cases (Wall, de Louvais, Gilbert, and Rowe, 1996).

There is considerable under-reporting of data to each of the systems described above (Wall, de Louvais, Gilbert, and Rowe, 1996; FSA 2000b) but despite this, trends in statutory notifications, laboratory reports and outbreak reports received over the last 20 years are considered to be a true reflection of the actual incidence of foodborne disease in the community (POST 1997; Hughes et al. 2007). Further, in a review of outbreaks reported to the national surveillance system between 1992 and 2003 Hughes et al. (2007) concluded that the IID outbreak dataset was one of the most comprehensive in the world.

2.2.3 Trends in foodborne disease in England and Wales

All three data sources show similar trends in the incidence of foodborne disease. The statutory notification system indicated a general increase in the incidence of foodborne illness between 1982 and 1998 (Figure 1) followed by an overall decline (HPA, 2006a).

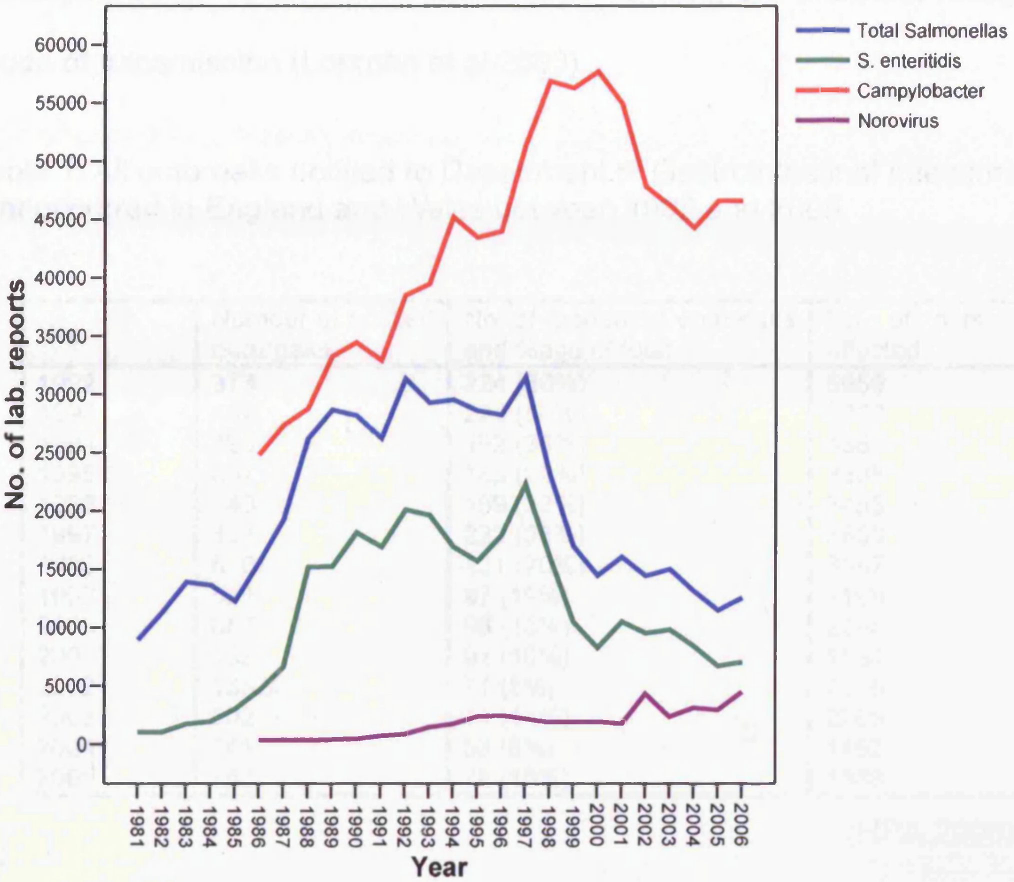
Figure 1: Statutory foodborne disease notifications in England and Wales between 1982 – 2006.



(Adapted from HPA 2006b)

The FSA (2000) reported that *Campylobacter* and *Salmonella* account for most food poisoning notifications in England and Wales as well as most laboratory reports (Figure 2).

Figure 2: Laboratory reports of *Salmonella* species, *Campylobacter* and Norovirus reported to CDSC



(Adapted from HPA 2006b)

Since 1993, with the exception of 1997 and 2005, there has been a decline in foodborne disease outbreaks reported to the national surveillance scheme (Table 1). The trend in incidence of reported outbreaks reflected the trend in laboratory reports of cases of *Salmonella* Enteritidis (Figure 2), the most common pathogen associated with foodborne disease outbreaks in England and Wales (Table 2). In contrast *Campylobacter*, the most common cause of sporadic cases of foodborne disease in England and Wales is less frequently associated with foodborne disease outbreaks and the trend in laboratory reports (Figure 2) thus reflects the trend in statutory notifications (Figure 1).

Norovirus is the second most common pathogen associated with foodborne disease outbreaks (Table 2) although person to person spread through the faecal-oral route or aerosol formation after vomiting are the most recognized mode of transmission (Lopman et al 2003).

Table 1: All outbreaks notified to Department of Gastrointestinal Infections that occurred in England and Wales between 1992 and 2005.

Year	Number of notified outbreaks	No. of foodborne outbreaks and %age of total	No. of persons affected
1992	373	224 (60%)	5950
1993	454	225 (50%)	5030
1994	490	192 (39%)	4385
1995	837	183 (22%)	3866
1996	740	169 (23%)	3453
1997	591	222 (38%)	3850
1998	610	121 (20%)	3087
1999	521	97 (19%)	2199
2000	657	98 (15%)	2295
2001	552	91 (16%)	1534
2002	1332	71 (5%)	2025
2003	502	71 (14%)	2285
2004	741	56 (8%)	1462
2005	758	78 (10%)	1388

(HPA 2006)

Table 2: Foodborne disease outbreaks reported to the national surveillance scheme in England and Wales between 2000 -2005 by causative pathogen

CAUSATIVE PATHOGEN	YEAR						
	2000	2001	2002	2003	2004	2005	Total
B. CEREUS	0	4	3	2	0	1	10
CAMPYLOBACTER	8	3	7	2	3	7	30
CL. PERFRINGENS	6	15	4	2	5	9	41
E. COLI O157	6	1	1	1	1	3	13
MIXED	0	1	0	0	0	0	1
NOROVIRUS	11	9	10	5	3	9	47
OTHER	0	1	2	1	1	0	5
OTHER *SALMONELLA*	4	5	4	2	3	0	18
S. ENTERITIDIS NON-PT4	7	16	15	31	19	17	105
S. ENTERITIDIS PT4	17	10	10	8	8	10	63
S. TYPHIMURIUM	7	3	3	3	1	5	12
S. AUREUS	0	6	2	0	2	0	10
UNKNOWN	28	12	6	9	7	9	71

(HPA 2006)

Campylobacter:

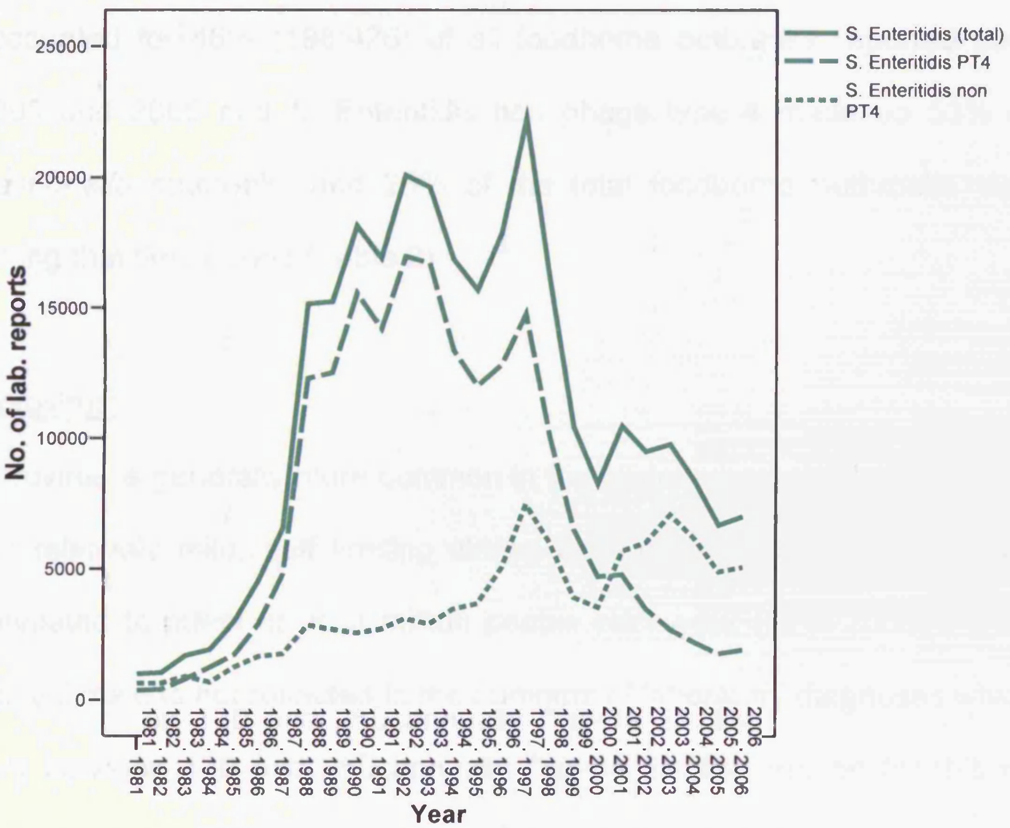
Campylobacter is the most commonly reported bacterial cause of IID in England and Wales (FSA 2000) and the pathogen most commonly associated with sporadic foodborne illness in England and Wales (Figure 2). Outbreaks of Campylobacter are relatively rare, and, although the proportion of outbreaks attributed to Campylobacter increased significantly between 1992 and 2003, they only accounted for 4% (67/1729) of all reported IID outbreaks (Hughes et al. 2007). Campylobacter outbreaks (and sporadic cases) tend to peak in early summer. Frost et al. (2002) reported that between 1995 and 1999 a third of Campylobacter outbreaks (18/48, 36%) occurred in May and June. Studies into risk factors associated with the occurrence of sporadic cases have been inconclusive (Takkinen and Ammon 2003), but it is known that Campylobacter can be transmitted by inadequately cooked poultry and this is considered to be the most significant risk factor in leading to human illness (ACMSF 2005). Other risk factors include raw and contaminated pasteurised milk and contaminated water (FSA 2000). Work undertaken in Europe on the surveillance and diagnostics of Campylobacter (Takkinen et al 2003a) concluded that the lack of standard molecular sub-typing methods for Campylobacter has made it difficult to recognise outbreaks and identify their sources.

Salmonella:

The incidence of reports of human cases of *Salmonella* increased from 1981 to 1997 (Figure 2) and has since declined year on year with the exception of 2006. The predominant pathogen throughout this time period has been *S.*

Enteritidis (Figure 2). The Advisory Committee on the Microbiological Safety of Food (ACMSF) (2001) reported that a decrease in incidence of human *Salmonella* cases in England and Wales reflected a corresponding fall in the levels of Salmonella in eggs which was primarily due to the widespread vaccination programme of egg laying flocks against *S.* enteritidis and improved flock hygiene measures. The number of *S.* Typhimurium and *S.* Enteritidis phage type (PT) 4 cases also decreased markedly over this time period but there was a substantial increase in the proportion of reported cases (Figure 3) and outbreaks associated with *S.* Enteritidis non PT 4 (Table 2).

Figure 3: Laboratory reports of *S.* Enteritidis, *S.* enteritidis PT4 and *S.* enteritidis non PT4 reported to CDSC



(Adapted from HPA 2006c)

National and local outbreak investigations together with surveillance activities in England and Wales implicated imported eggs from a number of European countries as a contributory factor (HPA 2003). By 2004, the HPA reported that the increased incidence in *S.* Enteritidis non phage type 4 was linked to changes in the market supply of imported eggs from egg producers in European Union member states where there was a lack of vaccination of layer flocks against Salmonella or a lack of controlled assurance schemes. The catering industry received the majority of imported shell eggs and U.K. eggs not produced under U.K. assurance schemes (HPA 2004), and the use of Spanish eggs by the catering industry was identified as a consistently significant factor in many of the *S.* Enteritidis non phage type 4 outbreaks in England and Wales during 2002 – 2004 (HPA 2005). *Salmonella* species accounted for 46% (198/426) of all foodborne outbreaks reported between 2000 and 2005 and *S.* Enteritidis non phage type 4 made up 53% of the *Salmonella* outbreaks and 25% of the total foodborne outbreaks reported during that time period (Table 2).

<u>Norovirus:</u>

Norovirus is generally more common in the winter months with an acute onset but relatively mild, self limiting illness commonly lasting 1 – 2 days. It is estimated to affect up to a million people each year (HPA 2006d), although this estimate is not reflected in the numbers of laboratory diagnoses which are only between 130 and 250 annually (Figure 2). The reason for this is that Norovirus was difficult to identify until recent developments in laboratory tests (Reacher 2003). Foodborne transmission is reported as the most common form of transmission in the catering sector (Lopman et al. 2003) and Norovirus was responsible for 11% of foodborne disease outbreaks notified to the national surveillance system between 2000 and 2005 (Table 2). Since 2003, Norovirus infections have been recognised; the emergence of a more virulent strain of the virus in 2002 coincided with a marked increase in Norovirus outbreaks throughout Europe (Lopman et al. 2004). Frequently within the hotel sector a viral foodborne outbreak will be increased in size and duration by secondary person to person transmission and therefore become even more disruptive to the operation of that business (Reid et al. 1988; McDonnell et al. 1995; Sala et al. 2005). Compared to other catering sectors Norovirus can be difficult to eradicate from a hotel environment since there is a large human reservoir of infection temporarily sharing living, working and recreational facilities. This is then compounded by a very low infective dose and the frequent introduction of incoming guests increases the population at risk and therefore the duration of the outbreak (Lopman et al. 2003; HPA 2006). For these reasons foodborne gastroenteritis due to Norovirus is increasingly recognised as a public health problem (Sala et al. 2005).

<u>Outbreak settings</u>

Since the 1970s the catering industry in England and Wales has been the most common sector of the food industry to be associated with foodborne disease outbreaks (Roberts 1982; Djuretic et al. 1996; O'Brien et al. 2002; Hughes et al 2007). Djuretic et al. (1996) reviewed 1,280 outbreaks of infectious intestinal disease between 1992 and 1994 and found that 27% (347/1280) were associated with commercial catering businesses.

Restaurants were found to be the most common catering business (53%, 184/347) followed by hotels (36%, 126/347). A multi-agency national outbreak control team on *S.* Enteritidis non-PT 4 infections in England and Wales (HPA 2004) reported that 52% (25/48) of outbreaks associated with *S.* Enteritidis non-PT4 were in restaurants and that 72% of these restaurants served Chinese cuisine. Hughes et al. (2007) undertook a review 1729 foodborne outbreaks reported to the HPA between 1992 and 2003 and found that 55% (949/1729) of foodborne outbreaks were associated with commercial catering business which included restaurants, hotels, pubs or bars, canteens, mobile, private and mobile caterers and shop caterers although the common individual catering businesses were not identified.

Food vehicles

Since 1992, poultry has consistently been reported as the most common food vehicle associated with foodborne outbreaks in England and Wales. Hughes et al. (2007) examined 1729 foodborne outbreaks between 1992 and 2003 and found that poultry (24%) was the most common implicated food vehicle, followed by red meat (20%) and desserts (15%). Eggs (64%) were the most common ingredient in outbreaks in which desserts were the vehicles of infection. A similar trend was found in a review of 1426 foodborne outbreaks that were reported to the national surveillance system between 1992 and 1999 (O'Brien et al 2002). Work undertaken by Adak et al. (2005) found that eggs were used as an ingredient in a wide variety of complex foods including desserts, sauces and savouries. They estimated around 70% of outbreaks associated with complex foods included egg as an ingredient and suggested that eggs were probably a major source of infection for disease related to complex foods.

2.2.4 Investigation of foodborne disease outbreaks

Foodborne disease outbreak investigations require a multi-disciplinary approach using epidemiology, microbiology and environmental services (Table 3), (Jamasji-Parvi 2006).

Table 3: Steps in an outbreak investigation

Epidemiological component Verify existence of outbreak Confirm diagnosis Take immediate control measures Develop case definition Institute case finding Collect descriptive data (time, person, place) to determine common factors Develop hypotheses about the exposure responsible for the outbreak Test hypotheses using analytical epidemiological studies Execute control measures Communicate findings
Microbiological component Determine type of specimens to be collected Collect specimens to be collected Conduct tests on specimens for the appropriate pathogen as indicated by epidemiological hypothesis Send positive specimens to reference laboratory for serotyping/phage typing
Environmental investigation Conduct visual inspections of the environment Take appropriate samples for testing

(Jamasji-Parvi 2006)

Outbreak investigations are observational studies which usually involve a descriptive epidemiological study which enables hypothesis generation about contributory factors, followed sometimes by an analytical study which tests the hypothesis and provides confirmatory evidence of contributory factors (Ungchusak 2002).

O'Brien el al (2002) reported that the strongest evidence linking contaminated food with illness came from outbreak investigations that used both microbiological and epidemiological information. This information is more likely to come from investigations of larger outbreaks and outbreaks associated with a defined cohort such as a social function (Palmer 1990; O'Brien et al 2002). In a comparison of outbreak investigation information from the national surveillance system and peer review journals, O'Brien et al (2006) found that outbreaks published in peer review journals tended to relate to an unusual or novel event rather than the common or usual cause. The authors argued that greater public health gain would be achieved through increased knowledge of the usual as well as unusual events that occurred in foodborne disease outbreaks. The outcome of this study confirmed previous work undertaken by Palmer et al. (2000) where the authors reviewed the role of outbreaks in developing food safety policy and suggested that the availability of information on the epidemiology of foodborne disease outbreaks was biased towards large, unusual or high profile outbreaks and caution was required before generalising the outcome of these investigations to all outbreak situations.

2.2.5 Food safety control failures contributin g to foodborne disease outbreaks

One of the first published reviews of foodborne disease outbreaks was undertaken by Roberts (1982). She looked into factors which contributed to 1,044 foodborne disease outbreaks reported to the national surveillance system that occurred between 1970 and 1979 in England and Wales and identified food prepared too far in advance and poor temperature control during storage and preparation as the most common contributory factors (Table 4). Infected food handlers did not play an important role in outbreaks at that time apart from outbreaks of *Staphylococcus* aureus. Similar observations were reported in the United States by Bryan (1978), and a further review of 642 foodborne disease outbreaks reported between 1992 and 1994 (Djuretic et al. 1996) revealed that poor temperature control was still a prominent contributory factor. Of increasing importance was the role of cross contamination and the infected food handler (Djuretic et al. 1996) (Table 4). More recent outbreak reviews associated with specific food vehicles endorsed these earlier findings; inadequate heat treatment, inappropriate storage and cross contamination were the main contributory factors of foodborne outbreaks associated with the consumption of poultry (Kessel et al. 2001) and the consumption of fish and shellfish (Gillespie et al. 2001). In outbreaks associated with the consumption of salad vegetables and fruit (Long et al. 2002) investigators found that cross contamination, inappropriate storage and infected food handlers were the main contributory factors.

Table 4: Contributory factors identified in reviews of outbreaks undertaken by Bryan (1978); Roberts (1982) and Djuretic et al (1996).

Contributory factors identified by Bryan (1978)	% of 1152 outbreaks 1961 - 1976	Contributory factors identified by Roberts (1982)	% of 1044 outbreaks 1970 - 1979	Contributory factors identified by Djuretic et al. (1996)	% of 405 outbreaks 1992 - 1994
Inadequate cooling	46	Preparation too far in advance	61	Food stored inappropriately	45
Preparation too far in advance	21	Storage at ambient temperature	40	Inadequate cooking or reheating	40
Infected person	20	Inadequate cooling	32	Cross contamination	36
Inadequate thermal processing, canning or cooking	16	Inadequate reheating	29	Infected food handler	21
Inadequate hot storage	16	Contaminated processed food	19	Other	19
Inadequate reheating	12	Undercooking	15		
Ingestion of contaminated raw food or ingredient	11	Inadequate thawing	6		
Cross contamination	7	Cross contamination	6		
Inadequate cleaning of equipment	7	Improper warm holding	6		
Obtaining food from unsafe sources	5	Infected food handler	5		
Using leftovers	4	Use of leftovers	5		
		Raw food consumed	4		
		Extra large quantities prepared	3		

Investigation into foodborne disease outbreaks reported in peer review literature (O'Brien et al. 2006) also identified similar contributory factors (Table 5).

Table 5: Contributory faults linked to foodborne disease outbreaks reported to the national surveillance scheme and peer review literature

Contributory faults	Number (%) of outbreaks reporting	
	Literature	General
Infected food handlers	6 (11)	210 (12)
Inadequate heat treatment	27 (49)	498 (28)
Cross contamination	28 (51)	486 (28)
Inappropriate storage	16 (29)	501 (28)
Other faults	18 (33)	201 (11)

(Adapted from O'Brien et al. 2006)

2.2.6 Summary

The most common pathogens associated with foodborne disease outbreaks in England and Wales are *Salmonella* species, predominantly *S.* Enteritidis, and Norovirus. *Campylobacter* is the most common pathogen associated with sporadic foodborne illness and is less commonly associated with foodborne outbreaks. Reviews of outbreak data collected by the HPA indicate that the catering industry is the most common setting for foodborne disease outbreaks in England and Wales and that poultry is the most commonly reported food vehicle. Eggs are considered to be the most likely source of infection related to complex foods. Food safety control failures; inadequate temperature control, cross contamination and infected food handlers, are commonly implicated in foodborne disease outbreaks in England and Wales.

2.3 Catering Industry Perspective

This section reviews the characteristics of the catering industry; the classification of catering businesses, the diversity in catering operations including menu preparation and types of meals served and the employment and management of the workforce.

2.3.1 Catering industry

The catering industry provides meals for sale for consumption away from home. It includes the food and drink provision in hotels, health care, education and leisure, restaurants, cafes, public houses, fast food outlets, takeaways, and commercial catering (BHA 2005). The British Hospitality Association (BHA) (2005) in their "Report on Trends and Statistics in the Hospitality Industry" commented that the diversity of the catering sector had resulted in problems in defining the industry which had led to inaccuracy of data collection. The Office of National Statistics (ONS) which provides independent information on the U.K.'s economy and society (ONS 2008) has produced the most widely accepted classification of the catering industry (Table 6).

Table 6: ONS classifications for the catering industry

GROUP	DESCRIPTION
55.1	HOTELS: Includes hotels and motels with or without a licensed or unlicensed restaurant
55.3	RESTAURANTS: Includes licensed or unlicensed restaurants and cafes, takeaways and mobile food stands
55.4	BARS: Includes bars and licensed clubs, independent, managed and tenanted public houses and bars
55.5	CANTEENS AND CATERING: Includes canteens and catering

(ONS, 2003)

Data provided by ONS is used by trade associations like the British Hospitality Association (BHA 2008) and People 1st (People 1st 2008), the Sector Skills Council for Hospitality, Leisure, Travel and Tourism and research organisations such as Institute of Grocery Distribution (IGD 2008) to provide more specific information on different sectors within the catering industry. Market research companies like Mintel (Mintel 2008) and Horizons (Horizons 2008) provide additional information on consumer behaviour, product innovation and market analysis. Pellegrini (2005) in a review of research into the food industry found that the majority of research was on the consumer end of the market rather than the specific operational aspects of the industry. The author found that in general, one-off reports produced by industry in conjunction with the ONS provided the most informative insight into the operation and management of catering businesses.

2.3.2 Catering establishments

The BHA (2005) reported that the number of catering establishments in the U.K. remained relatively static between 2001 and 2004 (Table 7); the largest proportion of this industry comprised restaurants (21%), pubs (20%) and hotels (18%). Geographically, the largest proportion (28%) of catering establishments was located in London and the south east of England (Hospitality Training Foundation 2002) mirroring the concentration in population and workforce (People 1st 2004). Data from People 1st (2006) indicated that the catering industry was dominated by small businesses with 81% operating as micro or small businesses (employing < 49 staff), and large businesses (employing > 250 staff) accounting for only 0.2% of catering establishments (People 1st 2006).

Table 7: Number of catering establishments, 2001 – 2004, in the U.K.

OUTLET TYPE/YEAR	2001	2002	2003	2004
Hotels	48,329 (18%)	48,089 (18%)	47,725 (18%)	47,389 (18%)
Restaurants	54,892 (21%)	55,335 (21%)	55,423 (21%)	55,704 (21%)
Pubs	51,564 (20%)	51,506 (20%)	51,352 (20%)	51,267 (19%)
Leisure	18,731 (7%)	18,841 (7%)	18,869 (7%)	18,995 (7%)
Staff catering	20,872 (8%)	20,869 (8%)	20,875 (8%)	20,839 (8%)
Healthcare	30,517 (12%)	30,670 (12%)	30,926 (12%)	31,048 (12%)
Education	34,543 (13%)	34,592 (13%)	34,592 (13%)	34,630 (13%)
Services	3,063 (1%)	3,068 (1%)	3,068 (1%)	3,076 (1%)
Total	262,511 (100%)	262,970 (100%)	262,911 (100%)	262,948 (100%)

(Adapted from BHA 2005)

2.3.3 Meals served

According to the BHA (2005) between 2001 and 2004 the annual number and proportion of meals served within the catering industry remained constant (Table 8). The quick service sector which includes fast food outlets, cafes and takeaways served the highest proportion of meals (23%) followed by the education sector(15%), staff catering, pubs (13%) and healthcare (12%).

More detailed data on the types of meals and ingredients used by different types of businesses comes from "The Foodservice Industry Report 1997" (Taylor and Green 1997), a market sector report on the food service industry which was based on official statistics from the ONS and data from the Booker

Foodservice Group (the UK's largest food supplier to retailers, caterers and food businesses). The report was the first of its type within this sector to provide catering businesses with evidence on menu characteristics and product trends

Table 8: Number of meals served (million), 2001 – 2004, in the U.K.

OUTLET TYPE/YEAR	2001	2002	2003	2004
Hotels	657 (8%)	696 (8%)	702 (8%)	721 (8%)
Restaurants	688 (8%)	645 (7%)	627 (7%)	642 (7%)
Quick service*	1,895 (22%)	1,946 (23%)	1,962 (23%)	1,981 (23%)
Pubs	1,064 (13%)	1,070 (13%)	1,081 (13%)	1,095 (13%)
Leisure	539 (6%)	532 (6%)	523 (6%)	523 (6%)
Staff catering	1,070 (13%)	1,062 (13%)	1,064 (13%)	1,065 (12%)
Healthcare	1,042 (12%)	1,020 (12%)	1,021 (12%)	1,040 (12%)
Education	1,256 (15%)	1,272 (15%)	1,275 (15%)	1,271 (15%)
Services	228 (3%)	228 (3%)	234 (3%)	240 (3%)
Total	8,439 (100%)	8,471 (100%)	8,489 (100%)	8,578 (100%)

*Includes fast food outlets, cafes and takeaways

(BHA 2005, based on data from Horizons)

The evidence from the report (Taylor and Green 1997) indicated that hotels operated the most varied menu, preparing the majority of meals from fresh or raw ingredients; providing hot and cold buffets for conferences and functions was an increasingly important revenue. In contrast, pub menus focused on fried food; 60% of food bought by pubs was frozen. The majority of frozen meals were individually and multi portioned ready meals that only required reheating; these included lasagne, curries, chilli and vegetarian food (Taylor and Green 1997). Pub menus typically require limited catering skills and minimum preparation.

Restaurants comprised the most diverse type of catering outlets including different ethnic cuisines; menu characteristics were therefore also diverse. Commonly 30% of the total purchases were frozen including desserts, side dishes, multi portion meals and potato products such as frozen chips (Taylor and Green 1997).

Catering within the leisure sector was limited to snack products and bar food (Taylor and Green 1997). In healthcare, education and services frozen products made up 70% of purchases and the menu focused on providing a complete meal to the customer, although increasingly snack and savoury pastries provided an alternative (Taylor and Green 1997).

2.3.4 Catering workforce

Based on data from the ONS (2004), the BHA (2005) reported that an estimated 1.72 million people worked in the U.K. catering industry, of which 1.31 million (74%) were employed in hotels, restaurants, pubs, clubs, bars and contract catering (Table 9). A further 402,000 (20%) were employed in the healthcare, education and services sector, and approximately 6% had a second job in the catering industry. The restaurant sector as a whole employed 39% of the catering workforce, the largest proportion of staff.

Table 9: Employees in catering businesses, 2000 and 2004, in the U.K.

BUSINESS SECTOR/YEAR	2004	
Hotel	247,071	(19%)
Restaurants	518,738	(39%)
Pubs, clubs and bars	368,394	(28%)
Contract catering	179,589	(14%)
Total	1,313,792	(100%)

(adapted from BHA, 2005, based on data from ONS, 2004)

In 2005, approximately 15% of the workforce was from ethnic minorities, higher than the average percentage across the whole U.K. economy. The proportion was highest in restaurants (20%) where people from ethnic minorities tended to own or manage their own businesses (Sector Skills Development Agency 2007). The traditional ethnic minorities are now being superseded by migrant workers from eastern European countries. Between 2000 and 2001, 150,600 migrants arrived officially in the U.K. and two thirds moved to London and the south east (Robinson 2002), the catering sector was the third most popular industry for them to take up employment. In a survey of catering employers undertaken in 2005 by People 1st (2006a), the authors reported that in general the British workforce did not consider the catering sector to be a first choice career and as a result English employers in the catering industry place an increasing reliance on international workers to meet business needs. In 2005, 72,000 workers from European Union Accession States officially entered the hospitality industry but tended to work in the UK for only one to two years before returning to their home country (Tokarzewsha 2006). Migrant workers tended to start employment as kitchen assistants, domestic roles and support staff in pubs and clubs, and, as their

English improves they tend either to be promoted in the kitchen or move to 'front of house' positions (Tokarzewsha 2006).

The catering industry employs a young workforce. Based on data from the ONS (2004), the BHA (2005) reported that 50% of the workforce was between the age of 16 and 29 years. Work undertaken by People 1st (2005) indicated that full-time students made up a considerable proportion. Nearly 25% of the restaurant workforce, 20% of pub employees (People 1st 2006b) and 15% of hotel employees were full-time students (People 1st 2005b) who use the employment to fund their education and tend to be employed on a casual or temporary basis.

The catering industry is frequently driven by seasonality which means that staff are employed temporarily or on a casual basis to manage peaks in trade, and businesses located in rural areas are most likely to take on seasonal staff (People 1st 2005c). People 1st (2006) reported that 50% of the catering workforce was employed on a full-time basis, 53% in the restaurant sector (People 1st 2005a) and 61% in the hotel sector (People 1st 2005b). Table 10 shows full-time and part-time employment within the catering industry by occupation. As would be expected, positions of management, including the position of chef, had the highest proportions of full-time staff.

Table 10: Full time and part-time employment by occupation, 2001 in the U.K.

EMPLOYMENT BY OCCUPATION	FULL-TIME %	PART-TIME %
Hotel/accommodation managers	88.0	12.0
Restaurant/catering managers	89.0	11.0
Publicans/club stewards etc.	89.0	11.0
Chefs/cooks	69.0	31.0
Waiting staff	25.0	75.0
Bar staff	26.0	74.0
Hotel porters	86.0	14.0
Kitchen porters and catering assistants	29.2	70.8

(ONS 2002a)

In a market assessment of the catering industry People 1st (2004) reported that in restaurants, cafes and takeaways there were low barriers of entry for employment, generally requiring no specific skills, academic or professional qualifications either to start up a business or get a job within this industry. The BHA (2005) reported that an estimated 11% of employees in the catering industry had no professional or academic qualifications. National Vocation Qualifications (NVQs) which are work related competence based qualifications, are the common qualification in this industry, but only about 25% had NVQ level 1 (GCSE equivalent D – G grade), (BHA 2005). People 1st (2005a) reported that 15% of the hotel workforce had no qualifications and 17% of the restaurant workforce had no qualifications (People 1st 2005a).

Traditionally, the catering industry has suffered from high levels of labour turnover which is in part due to strong competition from other industries offering higher pay and, in part due to an industry employing a relatively young, transient workforce on low wages with long working hours (Hospitality Training Foundation 2002). All sectors of the catering industry experience high labour turnover, but a recruitment and retention survey undertaken by People 1st (2005c) reported that pubs experience the greatest labour turnover (40%), followed by hotels (34%), and restaurants (33%). Data from the Labour Force Survey undertaken by People 1st (2005) on behalf of the ONS indicated that labour turnover varied with business size; the level of turnover was highest in SMEs (micro SMEs: 26%, small SMEs: 37% and small medium SMEs: 27%), large companies experienced a lower labour turnover of about 18%. Businesses in rural areas had more difficulty filling vacancies, whilst labour turnover was higher in urban areas where there were more employment opportunities. Food and drink service occupations (bar and waiting staff) had the highest labour turnover (37%), followed by chefs and cooks (People 1st 2005c). The recruitment and retention survey (People 1st 2005c) revealed that chef skills were scarce and in high demand. Consequently, skilled chefs tended to move jobs frequently and the position of 'sous chef' (usually assistant to the head chef) also became difficult to retain. The survey (People 1st 2005c) indicated that in the past businesses had addressed the shortages of skilled chefs by adapting and simplifying cooking practices, but the current demand for freshly prepared food is driving the trend towards more cooking from raw. Employers also commented that it was difficult to recruit managers with the required skills and experience (People 1st 2005c).

2.3.5 Summary

The catering industry comprises a diverse range of businesses reflected in the quantity of meals served, the range of cuisine offered and the method of preparation. The workforce is typically young and transient with many businesses employing staff on a casual or temporary basis. The industry is characterised by difficulties in staff recruitment and retention.

2.4 Environmental health perspective

In the U.K. to operate legally and produce safe food, catering businesses are required to comply with a considerable body of legislation (Hampton 2005). This section considers the key enforcement and food safety control aspects of this legislation which impact on the operation and management of catering businesses.

2.4.1 Food safety legislation

In the U.K. food safety legislation applies to the safety of food throughout the food chain from primary production to final sale. As part of the final link in the food chain, catering businesses are required to comply with all relevant food hygiene legislation and the legal responsibility for most offences lies with the 'proprietor' of the business, usually the owner, senior manager, or, in the case of a limited company, the company secretary (Engel MacDonald and Nash 2001).

The Food Safety Act 1990 is the principal legislation controlling food safety; it outlines enforcement procedures, administration and offences. Codes of Practice provide guidance on the execution and enforcement of the Act and Regulations made under it. The current Food Hygiene (England) Regulations 2006 (SI 2006 No.14) and Food Hygiene (Wales) Regulations 2006 (SI 2006

No. 31) implement Regulation (EC) No. 852/2004 of the European Parliament on the Hygiene of Foodstuffs and contain specific food safety standards to which catering businesses must comply. The standards relate to hygienic operations, business structure and equipment, staff illness, temperature control requirements, staff supervision, instruction and training and the provision of a food safety management system (European Union 2004).

The Food Safety Act and food hygiene regulations are enforced during routine food hygiene inspections undertaken by Environmental Health Practitioners (EHPs) who are professional officers employed by local authorities (Yapp and Fairman 2005). Food hygiene inspections can be either primary or secondary inspections (FSA 2005). Primary inspections are standardised inspections which include a review of the scope of the business by examining and recording information on procedures and practices, undertaking interviews with food handlers, identifying breaches of food hygiene legislation and determining appropriate enforcement action. Secondary inspections are any other visit connected with food law enforcement, including revisits to check progress of works required by a primary inspection, sampling visits and investigation of food safety complaints and allegations of foodborne disease. Failure to comply with the Regulations and Act are addressed either by informal or formal action. Informal action includes verbal or written advice by the enforcing officer to the business concerned, whereas formal action includes prosecution for contraventions found during an inspection which can ultimately lead to fines and imprisonment, or the service of an improvement notice on the proprietor, specifying measures which must be taken in a specified time period to secure compliance. Should the business present an imminent risk of personal injury an emergency prohibition notice which has the effect of immediate business closure, can be served (FSA 2005).

Local authority food safety activities are regulated by the Food Standards Agency (FSA) which is an independent Government department set up by the Food Standards Act 1999 to protect the public's health and consumer interests in relation to food (FSA 2008). The FSA monitors local authority performance and enforcement activity through the collection of data known as summary returns (FSA 2007). Summary returns provide information on the number and type of registered food establishments, the number of businesses inspected and the type of enforcement action taken. However, this only gives a general indication of the level of compliance with the food hygiene regulations because the data are incomplete (FSA 2007). The FSA (2004) reported that many food authorities fail to meet their planned inspection targets and not all authorities submit their annual returns correctly.

Food safety standards in food businesses are also assessed by ad hoc national surveys; in the last 20 years two surveys have been undertaken. In 1990, the Audit Commission for Local Authorities in England and Wales undertook a survey of 5, 000 food premises and found that 12% presented a significant health risk (Audit Commission 1990). Takeaways, food manufacturers and restaurants were found to present the greatest risk. More recently in 2005 the FSA (2006) undertook a similar survey. Three hundred and sixteen local authorities (67%) returned questionnaires based on their inspections and 4,846 food premises were surveyed, including 3,188 (65%) catering businesses (FSA 2006). Assessment was based on the level of legislative compliance (FSA 2005) and the 'risk to public health', which was a subjective term not based on any nationally recognised standards (FSA 2006). The survey (FSA 2006) found that 13% of premises showed major statutory non compliances; that is, formal action (service of a notice or prosecution) was required to rectify the non-compliance. Nineteen percent of premises showed a low standard in terms of the physical condition and facilities provided, and 7% of premises were considered to present a 'high risk' to public health. Caterers had the highest proportion of businesses in this 'high risk' category. The FSA (2006) acknowledged that the interpretation of 'risk to public health' was open to inconsistencies because it was a subjective judgement.

2.4.2 Inspection frequencies

The frequency of inspections is prescribed under Food Law Code of Practice (England) (FSA 2005). Businesses are assigned an inspection rating score, calculated at the conclusion of each primary inspection, which indicates the timing of the next inspection. Annex 5 of the Code of Practice (Table 11) indicates how to assess the potential risk posed by food businesses and guidance on the frequency of inspection (Table 12). According to Griffith (2005) the intention of the scheme is to provide a more efficient use of public resources. Businesses with the highest score (Category A) are to be inspected most frequently (at least every 6 months). A high score shows poor standards of compliance with food safety legislation and indicates a higher level of risk (Yapp and Fairman 2005).

Table 11: The risk rating scoring system

The potential hazard	
Type of food and method of handling	
Handling low risk foods	5
Handling pre-packed high risk foods	10
Preparation, cooking and handling of high risk foods	30
Manufacture of high risk foods	40
Method of processing	
High risk activities e.g. Cooked and chilled foods	
Aseptic packing low acid food	20
Retail and small producers of cooked meats	
Thermal processing, low acid foods	
Consumers at Risk	
Less than 20 customers a day	0
Customers from local area	5
Substantial number of customers of a wide area	10
Manufactured food distributed nationally/internationally	15
* additional score of to above for businesses catering For vulnerable groups	*22
Level of current compliance	
Food hygiene and safety	
High standard of compliance, conforms with trade good practice	0
High standard of compliance, some minor non compliances	5
Some non compliances, standards being maintained/improved	10
Some major non compliances	15
General failure to comply, standards low	20
Almost total non compliance	25
Structural	
High standard of compliance, conforms with trade good practice	0
High standard of compliance, some minor non compliances	5
Some non compliances, standards being maintained/improved	10
Some major non compliances	15
General failure to comply, standards low	20
Almost total non compliance	25
Confidence in management/control systems	
Good record of compliance, complies with documented food safety management system	0
Reasonable record of compliance, satisfactory documented food safety management system	5
Satisfactory record of compliance, progress with documented food safety management system	10
Varying record of compliance no food safety management system	20
Poor track record of compliance, no food safety management system	30
Plus an additional score of 20 if significant risk of food being contaminated with *Clostridium* botulinum or ready to eat food being of becoming contaminated with *E.* coli O157, *Salmonella* species or Bacillus cereus	
Inspection rating total:	

(FSA 2005)

Table 12: Food hygiene inspection frequencies

Category	Inspection rating	Minimum frequency of inspection
A	92 or higher	(at least) every 6 months
B	72 – 91	(at least) every year
C	42 – 71	(at least) every 18 months
D	32 – 41	(at least) every 2 years
E	22 – 31	(at least) every 3 years

(FSA 2005)

There is, however, some published evidence which suggests that Category A businesses do not present the greatest risk of foodborne disease. In a study undertaken in Scotland, Mullen et al. (2002) found that there was no significant difference between the risk rating scores of businesses associated with foodborne disease outbreaks and businesses who were not associated with foodborne disease outbreaks. In Canada, Riben et al. (1994) undertook a literature review to evaluate the effectiveness of routine inspections and concluded that there was no evidence to demonstrate the effectiveness of routine inspection programmes in preventing foodborne illness.

There has been some debate in the U.S.A. revolving around three studies which evaluated restaurant hygiene inspection scores. The first was a matched case control study undertaken by Irwin et al. (1989) in Seattle-King County. The preceding restaurant inspection scores in each of 28 restaurants associated with foodborne disease outbreaks were compared with two control restaurants. The authors found that restaurants with poorer inspection scores were five time more likely to have a foodborne disease outbreak than restaurants with better scores and suggested that Seattle-King County's restaurant inspection form was successful in identifying restaurants at increased risk. Cruz et al (2001) in Miami-Dade County, Florida, also used a case control study to compare 51 restaurants associated with outbreaks and 76 randomly selected control restaurants. The authors found that case and control restaurants did not differ in overall inspection scores nor in the mean number of 'critical violations' (factors associated with the preparation, handling and storage of food thought to have a significant impact on food safety), except for one critical violation – evidence of vermin; case restaurants were 3 times more likely to have evidence of vermin. Cruz et al (2001) concluded that restaurant inspections in Miami-Dade County, Florida did not reliably identify restaurants that were at increased risk of foodborne disease outbreaks. These findings were in contrast to work undertaken by Buchholz et al. (2002) which found that restaurants with an overall poorer inspection score were more than three times more likely to be associated with an investigated foodborne incident than a restaurant that had a good inspection score. But, in this retrospective cohort study, foodborne incidents were not confirmed cases of foodborne illness but were customer generated complaints. This study therefore only shows that inspection scores may be a predictor of foodborne illness complaint rather than confirmed foodborne disease outbreaks.

2.4.3 Legislative controls requiring a risk based approach

One of the most important changes to legislative requirements in food safety in the U.K. over the last 10 years has been a move from prescriptive controls to a risk based approach (FSA 2001a). Since 1995 there have been two new legal requirements for businesses to (a) identify hazards present in their operations, implement and monitor controls, known as a HACCP approach (Hazard Analysis Critical Control Point), and, (b) instruct, supervise and/or train staff handling food (Little, Lock, Barnes and Mitchell 2003). Food businesses including catering businesses are now legally required to focus their controls on the risks specific to their operations and apply controls that are proportionate to the nature of the hazard rather than implementing prescriptive measures which may or may not improve food safety in their business (FSA 2001a). Similarly staff training, instruction and supervision is to be proportionate to individual staff duties and responsibilities within the catering operation (FSHWG 1997).

2.4.4 Hazard Analysis Critical Control Point

HACCP is an internationally recognised food safety management system used to improve food safety and reduce the incidence of foodborne disease (WHO 1999). It originated as a means of assuring the safe production of food for the United States manned space programme in the 1960s and was originally designed for the manufacture of food (Mortimore and Wallace 1994). HACCP requires the identification of 'critical points' in a food preparation process where failures in food safety could result in the production of unsafe or poor quality food. Procedures are then introduced at the 'critical points' to prevent failures occurring (Mortimore and Wallace 1994).

In the early 1990s the Codex Alimentarius Commission (CAC) (an international agency which sets standards for food) advocated worldwide use of HACCP by the food industry and regulatory authorities. The current Codex HACCP document (CAC 1997) is considered to be the first authoritative internationally agreed document that not only includes the HACCP principles from the original 1969 document (CAC/RCP 1 - 196 9) but also includes guidelines for its application (Mayes 2001). The 7 HACCP principles are:

- Conduct a hazard analysis
- Determine the critical control points
- Establish critical limits
- Establish a system to monitor control of the critical control points
- Establish corrective actions to be taken
- Establish procedures for verification
- Establish documentation

(CAC/RCP 1 – 1969)

Adopting the 7 HACCP principles enables identification of the points in the food preparation process which present the greatest hazard, allowing the business to target resources and training at the points that matter the most. If the critical points are correctly identified and controlled, safe food should be produced (Harrigan 1998). In 1993 the European Community introduced HACCP into legislation in Council Directive 93/43/EEC on hygiene of foodstuffs. This was implemented in U.K. legislation under the Food Safety (General Food Hygiene) Regulations 1995 (SI. 1995 No. 1763) and required the application of the first 5 principles of HACCP in the catering industry. The 1995 Regulations were then replaced in 2006 by the Regulation (EC) No.852/2004 of the European Parliament and of the Council of 29th April 2004 on the hygiene of foodstuffs. Article 5 states that:

> "Food business operators shall put in place, implement and maintain a permanent procedure or procedures based on HACCP principles'
>
> (European Union 2004)

All food businesses including catering businesses are now required to implement all 7 HACCP principles.

The introduction of HACCP as a legal requirement was one of the main recommendations of the Pennington Group (1997). This Group was established by the Government in 1996 to 'report on the circumstances leading to the 1996 outbreak of infection with E. coli O157 in Central Scotland, the implications for food safety and the lessons to be learned'. The outbreak was associated with a butcher's shop which also operated as a caterer and food supplier to local catering businesses. It resulted in 496 cases, 127 hospitalisations and 18 deaths (Pennington Group 1997). The Group's investigations were based on HACCP principles from food production to sale and many of the recommendations required food businesses throughout the food chain to adopt the 7 HACCP principles. The Group considered that HACCP was the most appropriate food safety control system to tackle the challenges presented by E. coli O157 but warned that HACCP would only be effective in producing safe food in a business where there was full commitment of the management and their workforce. In the late 1990s the WHO (WHO 1999) recognised that small businesses, particularly catering businesses, would have difficulties in implementing HACCP, not only because of its origin in food manufacture, but also because of the size of the business, lack of technical expertise and limited resources. Work undertaken by Panisello et al. (1999) supported this view. The authors found that the application of HACCP in smaller food businesses was influenced by:

- the size of the business,
- the business's customers,
- food product produced
- the main processing operation.

In particular, businesses employing 50 staff or less were decreasingly less likely to have HACCP. Taylor (2000) suggested that one of the reasons for this was that HACCP is customer driven in national food companies, particularly those supplying the national retail and catering industry, whereas the only pressure to apply HACCP in SME catering businesses was from legislation where the risk of prosecution from non compliance was low. Further studies undertaken specifically in the catering industry in the U.K. (Mortlock et al. 1999; Taylor and Kane 2005) confirmed that effective implementation of HACCP was a problem because of the diversity of food preparation, equipment and service, and also because of the lack of technical expertise and resources. Also a number of national microbiological food surveys in catering and retail businesses coordinated by the HPA (Gillespie, Little and Mitchell 2000; Little, Gillespie and Mitchell 2001; Little, Lock, Barnes and Mitchell 2003) in partnership with local authorities found that lower microbiological quality food samples tended to come from premises that did not have HACCP.

In 2004 the FSA working with the catering industry and local authorities (Taylor and Kane 2005) developed a HACCP toolkit called "Safer Food Better Business" (SFBB) to enable catering businesses to apply HACCP to their operation and comply with the 2006 Regulations. SFBB is a practical approach to HACCP which focuses on 4 key food safety controls: cross contamination, cleaning, chilling and cooking (FSA 2008a). The FSA have invested £10.5 million over 3 years to support the implementation of SFBB in businesses in England, targeting approximately 20,000 small businesses each year (FSA 2005a). This strategy is in line with previous recommendations made by the WHO report (1999) 'Consultation on strategies for implementing HACCP in small and/or less developed businesses' which recommended that government and regulators develop strategies to assist small businesses in the successful implementation of HACCP.

2.4.5 Food hygiene training

The Richmond Committee (see p.2) in their second report (Richmond et al. 1991) highlighted the importance of food hygiene training to all food handlers in the catering industry, but acknowledged the difficulties in providing training in an industry which was characterised by high staff turnover and part-time and casual staff. The authors suggested that a six hour basic course on food hygiene for all catering staff would have a beneficial effect on food safety standards. However, in comparison to a trained food handler, who is informed of the importance of food hygiene procedures and practices, a trained manager is informed and empowered to instigate change to ensure food safety standards are maintained. The Richmond Committee emphasised the importance of the role of managers and supervisors in maintaining food safety standards and recommended that:

> "Managers and supervisors must be properly trained as they need to understand the microbiologically important aspects of the processes for which they are responsible. We therefore recommend that management should take explicit responsibility for food safety training"
>
> (Richmond et al. 1990, p.112)

Regulations requiring food handlers to receive food hygiene training were then introduced in Regulation 4 (2) (a), Schedule 1, Chapter X of the Food Safety (General Food Hygiene) Regulations 1995, which states that the proprietor of a food business must ensure that food handlers are instructed, supervised and/or trained in food hygiene to a level appropriate for their work activity. Industry Guides accompanied the Regulations to provide good food hygiene practice and advice on appropriate levels of training and refresher training according to job titles; the Industry Guide to Good Hygiene Practice: Catering Guide was produced by the Food Safety and Hygiene Working Group (FSHWG) (1997) and remains the main reference document for Industry and enforcing officers on food hygiene training. The Guide recommends 3 levels of formal food hygiene training accredited by a range of professional environmental health and public health organisations:

Level1 – All food handlers who prepare food, managers and supervisors should receive this training which aims to develop an understanding of the basic principles of food hygiene including food poisoning micro organisms, premises and equipment, personal hygiene, cleaning and disinfection, common food hazards, preventing food contamination, safe food preparation, storage and cooking practices, pest control and legal responsibilities. This course lasts 6 hours and finishes with candidates taking a multiple choice test.

Level 2 – Managers and supervisors should also receive this intermediate level training, which deals with food hygiene principles in more detail and introduces food safety management and systems. The duration of this course is 12 – 24 hours.

Level 3 – As their career and responsibilities progress managers and supervisors can also receive additional more advanced food hygiene training which deals with the detail and application of food safety management systems as well as further detail on food hygiene principles. This advanced training takes 24 – 40 hours.

Although training itself is not mandatory, supervision and instruction of food handlers is, but, in contrast to training, there is limited guidance to businesses on achieving effective supervision and instruction of staff. The Industry Guide (FSHWG 1997) states that a greater degree of supervision is required for:

- New staff awaiting formal training
- Staff handling high risk foods
- Less experienced staff

FSHWG (1997) also suggests that training must be sufficient to allow work to be unsupervised, and implies that trained staff do not require supervision.

It is generally accepted that the provision of knowledge and understanding of food hygiene provided by training will not necessarily result in the implementation of good food safety practices and the reduction of foodborne disease particularly within the catering industry (Luby et al. 1993; Taylor 1996; Ehiri et al. 1997; Mitchell, Fraser and Bearon 2007). A study undertaken in the U.K. by Powell et al. (1997) to assess the level of food hygiene knowledge among staff and food safety standards in twelve food businesses in England found that there were no differences in food hygiene knowledge and the level of training received by staff and that the level of knowledge did not affect food safety standards. The authors argued that knowledge of food hygiene had less impact on food safety controls within food businesses than commercial pressures. Ehiri et al. (1997) investigated the effectiveness of a basic food hygiene training course in Scotland and found no improvement in food handlers knowledge of food safety after they had received training. They emphasised that the provision of information seldom translated into positive attitudes and behaviours in the workplace.

A number of studies which investigated the effectiveness of basic food hygiene training commented that it needed to be supported by commitment, motivation and effective supervision of management (Taylor 1996; Powell et al 1997; Worsfold, Griffith and Worsfold 2004). These observations, endorsed comments made in earlier U.S.A. studies on the effectiveness of food hygiene training programmes for managers of catering businesses (Palmer et al. 1975; Hennum et al. 1983; Wright and Feun 1986). Palmer et al. (1975) evaluated the effectiveness of a manager training programme on food hygiene practices in 31 restaurants which were part of a fast food restaurant chain and concluded that management training had the potential to improve food hygiene standards, but the degree of improvement was directly proportional to the amount of support given by restaurant owners and managers. Hennum et al. (1983) evaluated a foodborne illness training programme in catering businesses in the city of Moorhead, Minnesota and found an improvement in practices involved in temperature control of food, but also concluded that the effectiveness of the training was dependent on the manager's motivation to manage and control food hygiene. Wright and Feun's (1986) evaluation of management training showed that managers of restaurants in Oakland County, Michigan, displayed a general lack of commitment to undertaken food hygiene training. The authors acknowledged that this was also reflected in their own study, which had a low participation rate of 47%. This lack of commitment may, in part, be explained by recent work undertaken by Mitchell, Fraser and Bearon (2007) who found that food hygiene training based on scientific facts and specific competencies was unlikely to be successful if no attention was given to the factors that influence transfer of knowledge and skills from the learning environment to the workplace. The authors suggested that enabling factors: work pressure, safe working practices and equipment and reinforcing factors: management commitment to food safety, incentives, job stress and co-workers' attitudes to food safety also need to be considered to improve the effectiveness of food hygiene training.

2.4.6 Summary

All catering businesses operating in the U.K. are required to comply with the food safety controls outlined in the Food Hygiene (England) Regulations 2006 (SI. 2006 No.14) and Food Hygiene (Wales) Regulations 2006 (SI. 2006 No.31). Food hygiene inspections, undertaken by enforcing officers authorised by local authorities, assess compliance with the legislation. The frequency of inspections is determined a risk rating score given by the enforcing officer at the end of each primary inspection. Businesses with the highest scores are inspected more frequently in an effort to secure compliance and reduce risk to the consumer. There is no published evidence to confirm that the inspection rating system used in England and Wales identifies businesses that are more likely to be associated with a foodborne disease outbreak. Since 1995, there has been a move towards a more risk based approach to legislative food safety requirements. This includes the requirement that businesses adopt a HACCP approach to control and prevent food safety risks arising from their operations and that staff working in food businesses receive appropriate levels of food hygiene training. There is limited published evidence on the value of these requirements in improving food hygiene standards or reducing the occurrence of foodborne disease outbreaks.

3 SYSTEMATIC LITERATURE REVIEW OF MANAGEMENT FACTORS ASSOCIATED WITH FOODBORNE DISEASE OUTBREAKS

3.1 Introduction

This chapter reports the systematic literature review undertaken to identify studies on management factors associated with foodborne disease outbreaks. It includes the reason behind the review, the method used to identify relevant studies and the summary and synthesis of those studies identified

3.2 Background

The Cochran Centre for Reviews and Dissemination (2008) does not list any reviews of management factors associated with foodborne disease outbreaks and an extensive review of food safety literature did not identify any systematic investigation of management factors associated with foodborne disease outbreaks.

In the review of 'General outbreaks of infectious intestinal disease in England and Wales 1992 – 1994' (Djuretic et al. 1996) the authors discussed in detail food safety control failures that contributed to foodborne disease outbreaks, but only briefly commented on the possible impact of staff shortages and increased workloads on outbreaks. The most recent review of the epidemiology of foodborne disease outbreaks in England and Wales reported to the Communicable Disease Surveillance Centre between 1992 and 2003 (Hughes et al. 2007) only discussed the causative pathogens, morbidity and mortality, the outbreak setting and food vehicles associated with the outbreaks. Given the apparent limited evidence available on management factors associated with foodborne disease outbreaks a systematic review was undertaken. The aim was to:

- Identify, through a systematic review of peer-reviewed publication and grey literature, management and operational factors associated with foodborne disease outbreaks in the catering industry.

3.3 Search strategy and method

The following approach was adopted:

- Formulation of a search question;
- Development of a search strategy to find studies;
- Appraisal and selection of retrieved studies;
- Summary and synthesis of relevant studies;
- Determination of the applicability of results.

(Glasziou et al. 2001)

3.3.1 Formulation of a search question

The following question was used as the basis of the literature review:

"What management factors contribute to foodborne disease outbreaks in the catering industry?"

3.3.2 Development of a search strategy to find studies

The search strategy was developed by utilising the question components and information including subject headings and keywords from published articles known to contain relevant information. Table 13 outlines the subject headings and free text found to be most effective in identifying relevant papers. The information contained in Table 13 formed the basis of the search strategy outlined in Table 14. The search terms and strategy were designed to cover all topic areas that may possibly contain information on management risk factors, even where the focus of the paper related to another area.

Table 13: Question components: subject headings and free text

Food/catering (Population)	Management factors (Exposure)	Disease outbreak (Outcome)
SUBJECT HEADINGS: Food handling Food industry Food services Restaurants Food supply	SUBJECT HEADINGS: Food inspection Food control	SUBJECT HEADINGS: Foodborne disease Food poisoning *Salmonella* food poisoning Staphylococcal food poisoning
FREE TEXT: Catering Restaurant:	FREE TEXT: Food hygiene Contributory factory	FREE TEXT: Foodborne

Table 14: Terms used in the search strategy with respective search term reference

Search term reference	Search term
1	Food industry/or food handling/or food services/or restaurants/ food supply
2	Catering*.mp or restaurant*.mp
3	'1' AND '2'
4	Disease outbreaks/or food poisoning/or *Salmonella* food poisoning/or Staphylococcal food poisoning
5	Foodborne*.mp
6	'4' AND '5'
7	Food inspection/or food control
8	Food hygiene*.mp or contributory factors*.mp
9	'7' AND '8'
10	'3' OR '6' OR '9'

mp = title, original title, abstract, name of substance word, subject heading word.
All search terms were limited to the English language

Electronic searches of 10 online databases that covered a wide range of relevant and related disciplines were used, including those containing published and unpublished grey literature and conference papers (Table 15).

Table 15: Databases used to search for literature on 'What management factors contribute to foodborne disease outbreaks in the catering industry?'

Database	Gateway	Time period
Medline	OVID	1950 – February Week 3, 2008
EMBASE	OVID	1980 – 2008 Week 08
CINAHL	OVID	1982 – February Week 3, 2008
HMIC	OVID	1982 – January 2008
International bibliography of the social sciences	OVID	1951 – February, Week 3 2008
Medline in-process and other non-indexed citations	OVID	February 25, 2008
SIGHLE (System for information on grey literature in Europe)	OVID	1936 – 2005
Web of Science,	ISI web of Knowledge	1970 – present
ISI proceedings	ISI web of Knowledge	1990 – present
Web citation index	ISI web of Knowledge	1936 – 2005

3.3.3 Appraisal and selection of retrieved studies

Table 16 contains the results of the search strategy, 6,219 article titles were identified by the final search reference term '10'. The 6,219 article titles were reviewed in OVID web Gateway (2007), a research platform giving access to specialist medical, health, social science and grey literature databases (Anon 2003), applying the inclusion and exclusion criteria outlined in Table 17 and all duplicates were removed, leaving 228 articles. The remaining 228 articles were exported into ENDNOTE, an electronic bibliographic database (ENDNOTE 2002), where the abstracts were reviewed. Abstract screening removed a further 113 articles. The text of all remaining 113 articles and their cited references were manually reviewed. In total 27 articles were retrieved, one of which was retrieved from a cited reference.

Table 16: The number of references retrieved from the databases with each search term reference

Database	Search term reference									
	1	2	3	4	5	6	7	8	9	10
Medline	18,464	2,766	1,612	40,996	2,193	974	1,189	294	30	2,548
EMBASE	7,086	2,145	1258	22,664	1,396	448	1,515	205	19	1,684
CINAHL	3,684	491	238	6,399	219	154	0	134	134	510
HMIC	218	919	62	191	50	14	0	547	0	76
International bibliography of the social sciences	2,282	390	43	0	12	0	0	32	0	43
Medline in-process and other non-indexed citation	2	75	0	3	81	0	0	1	0	0
SIGHLE	3,318	450	35	49	36	1	85	74	1	37
Web of Science	2,145	2,907	47	8,159	3,603	481	32,104	2,983	519	1009
ISI proceedings	3,122	383	28	983	407	58	4,330	409	99	182
Web citation index	636	1,899	115	187	39	16	61	153	6	130

Table 17: Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
English language	Studies that focus on nutrition or food allergy
OECD countries (30)	Studies that either focused on improvement or review of public health systems used to detect or collate outbreak data.
01/01/1961 to 23/02/2008	Studies that focused on microbiological techniques
Viral or bacterial foodborne disease	Chemical or parasitic foodborne disease
Foodborne disease cases or outbreaks	Waterborne or person to person transmitted outbreaks

3.3.4 Summary and synthesis of relevant studies

Of the 27 articles that were identified as containing information on management risk factors associated with foodborne disease outbreaks only one contained a focused investigation on the differences in the management and operation of outbreak and non outbreak restaurants (Hedberg et al 2006). Another study, by Green and Selman (2005), although not in the context of specific outbreaks, investigated management and operational factors that related to unsafe food preparation practices. Of the remaining 25 articles, 19 were publications of individual outbreak investigations, 3 were reviews of foodborne outbreaks in different settings (schools, passenger ships and aircraft), 2 studies investigated the relationship between foodborne outbreaks and food hygiene inspection scores and one was a commentary on foodborne disease in restaurants in U.S.A. In these 25 articles information on management risk factors appeared as incidental to the main aim of the study and little detailed information was provided to further explain the statements made. The main features of these articles were identification of failures in food safety controls that contributed to the outbreak, the value of a multidisciplinary outbreak investigation team, a call for more effective guidelines on specific areas of food safety and microbiological methods.

With the exception of one review paper produced by the WHO, the papers were based on studies from the North America (17), Canada (4), U.K. (2), Spain (1), New Zealand (1) and Austria (1). The papers were published in the following journals:

• Epidemiology and Infection	4
• Journal of Food Protection	3
• Public Health Reports	3
• Canada Communicable Disease Report	2
• American Journal of Epidemiology	2
• Journal of the American Medical Association	2
• Clinical Infectious Disease	1
• Travel Medicine and Infectious Disease	1
• American Journal of Public Health	1
• Food Protection Trends	1
• Pediatric Infectious Disease Journal	1
• Journal of Public Health Management Practice	1
• Journal of American Geriatric Society	1
• Infection	1
• Canadian Journal of Public Health	1

- Australian and New Zealand Journal of Public Health 1
- Journal of Infectious Disease 1

A summary of the information on management risk factors was placed in one of three categories: business characteristics, staff employment and management and operational practices (Table 18).

Table 18: Management risk factors identified from retrieved articles

Specific management risk factor associated with foodborne disease outbreak	No. of papers	References
Business characteristics	**4**	
Business size Business type		Buchholz et al. (2002); Irwin et al. (1989); Jones and Angulo (2006). Hedberg et al. (2006).
Staff employment and management	**12**	
Staff supervision		Irwin et al. (1989); Roels et al. (1998)
High staff turnover Staff inexperience		Jones and Angulo (2006); McMullan et al. (2007); Roels et al. (1998); Gaulin et al. (2002); Hedberg et al. (1992b).
Sick leave policy		Daniels et al. (2000); Dunn el al (1995); Jones and Angulo (2006); Rooney et al. (2004); Schmid et al. (2007); Daniels et al. (2002); Hedberg et al. (2006).
Operational practices	**14**	
Catering in excess of capacity		Camps et al. (2005); Luby et al. (1993); Slaten et al. (1992); Hook, Jalaludian and Fitzsimmons (1996).
Customer demand impacted on practices		Currie et al. (2007); Evans et al. (1998); Hedberg et al. (1992a); Lin et al. (1988); Winquist et al. (2001); Honish et al. (2007); Green and Selman (2005).
Change in kitchen operations		Honish L. (2000); Mazurek et al. (2005); Seals et al. (1981).

Business characteristics: Business size was identified as being associated with foodborne disease outbreaks. Two studies found an association between restaurant size and foodborne disease outbreaks. Irwin et al. (1989) analysed the association between the routine inspections and foodborne outbreaks in restaurants in Seattle- King County, Washington, U.S.A. The main finding of this matched case-control study was that restaurants with poorer routine inspection scores were at an increased risk of foodborne outbreaks, but the authors also found that large restaurants (indicated by number of seats: ≥ 150 seats) were more likely to be associated with an outbreak. It was suggested that large restaurant size may only represent a risk factor because of the increased number of customers served, thus increasing the likelihood of finding two or more ill persons needed to identify an outbreak. However, they also pointed out that large restaurants may be more likely to have an outbreak because of poor control of food temperatures with greater food volume, more complex menus and less closely supervised food handlers.

In a similar study undertaken in 1997 in California, U.S.A., Buchholz et al. (2002) compared the inspection scores of restaurants that had been investigated by public health officials, following a customer complaint alleging foodborne illness, with restaurants that had not been associated with a complaint. They also found that restaurant size, indicated by seating capacity was associated with a foodborne incident. Restaurant size was categorised as small ≤ 60 seats, middle 61 – 150 seats and large > 150 seats; middle sized restaurants were 2.8 times more likely and large restaurants were 4.6 times more likely than small restaurants to be associated with a foodborne incident.

Authors concurred with Irwin's earlier work (Irwin et al. 1989) that the association could simply be a reflection of the higher number of customers served in large restaurants, and that differences in the number of meals served and complex menus increased the potential for cross contamination. They also suggested meals produced on site from multiple, fresh ingredients may play a role. Although data were not available in either study to pursue these explanations, Jones and Angulo (2006) suggested that, in comparison to smaller restaurants, even a momentary lapse in safe food handling practices or use of a contaminated product could have more dramatic consequences in high-volume establishments, leading to more illnesses and a greater likelihood of recognition.

In contrast to the work of Irwin et al. (1989) and Buchholz et al. (2002), Hedberg et al. (2006) compared food handling practices and characteristics in 22 outbreak restaurants and 347 non-outbreak restaurants in the U.S.A. between June 2002 and June 2003 to identify differences that may have implications for food safety. They found that outbreak and non-outbreak restaurants were similar in terms of corporate ownership and number of meals served, but outbreak restaurants were more likely to be sit-down restaurants and serve ethnic cuisine. No specific information was provided on business size based on seating capacity. With regard to the role of ethnic cuisine, Hedberg et al. (2006) commented that Chinese and Asian restaurants represented an identifiable feature of a restaurant that could bias the likelihood that an outbreak would be detected, reported or evaluated. Buchholz et al. (2002) identified cooking non American-style food as a risk factor for foodborne incidents but had insufficient detail on the type of cuisine and practices undertaken to draw conclusions.

Staff employment and management: Twelve articles reported factors relating to the employment and management of staff, including factors relating to staff supervision, turnover, inexperience and sick leave policies. In the U.S.A. Irwin et al. (1989) reported that food handlers were less closely supervised in larger restaurants and that this was a possible explanation for business size being associated with foodborne disease outbreaks, although no conclusive evidence was presented. Investigation of a foodborne outbreak of *Campylobacter* jejuni infection in a summer camp in U.S.A. affecting 79 people (Roels et al. 1998), suggested that deficiencies in food handling practices that led to the outbreak were the result of inexperienced and inadequately supervised food handlers. The food handlers were foreign students temporarily employed, with little or no experience in the food service industry and little knowledge of safe food handling and this was compounded by the lack of additional supervision from their managers. Similar circumstances were identified in a shigellosis outbreak associated with a commercial airline (Hedberg et al. 1992b). The authors highlighted the negative impact of high staff turnover on the effectiveness of food handler training and supervision and stated that failure in food hygiene training and supervision had led to the outbreak. Jones and Angulo (2006) commented that characteristics of the young catering workforce with high staff turnover and little background in food safety training presented an important barrier to the improvement of hygiene in the industry and the reduction in foodborne outbreaks.

Staff inexperience has also been identified as contributing to a number of outbreaks. Investigators of a *Bacillus* cereus outbreak affecting 25 people in Quebec, Canada found that the implicated banquet was prepared on site by employees and the owner of an established restaurant, but the meal was served away from the restaurant (Gaulin et al. 2002). The owner had little experience of catering for customers away from the premises. He was therefore unaware of the additional temperature control risks associated with this type of catering service and which led to the outbreak. In similar circumstances, a private part-time caterer was found to be responsible for an outbreak of *Clostridium* perfringens that affected 230 young people attending a youth camp of 820 participants (Hook Jalaludin and Fitzsimmons 1996). Investigators confirmed that the caterer assisted by 3 employees and some camp participants was inexperienced in handling large functions. McMullan et al. (2007) commented in their review of food poisoning and commercial air travel and the introduction of HACCP to in-flight catering that, irrespective of age or inexperience, food handlers did not tend to have a history of recording what they did. Therefore the introduction of any documented recording system, such as that required by HACCP, presented a culture change to the kitchen environment.

Another factor that was identified was that the catering industry does not tend to offer food handlers sick leave benefits, particularly in relation to gastrointestinal disease (Jones and Angulo, 2006; Hedberg et al. 2006). Consequently workers do not get paid if they do not work, and so will often work whilst suffering illness. However, Hedberg et al. (2006) found that outbreak and non outbreak restaurants were similar in respect to policies providing sick leave benefits to food workers, requiring workers to report illness to a manager, and placing restrictions on food workers who are ill. This finding is in contrast to other studies. In 1992, investigation of an outbreak of *Shigella* flexineri associated with consumption of salad found that the source of contamination was likely to be three salad preparers who reported diarrhoeal illness before the outbreak and continued working while ill (Dunn et al. 1992). The study suggested that sick employees were not encouraged to report illness, were not offered alternative low risk work while ill, and were not offered any paid sick leave. A review of foodborne outbreaks associated with passenger ships (Rooney et al. 2004) highlighted that, in an outbreak of Norovirus, crew had been reluctant to report illness because of concern about job security. The review concluded that it was important not to penalize crew members for reporting illness to management. Fear of job security was also identified as the reason for a food handler working while suffering with sickness and diarrhoea in an outbreak of foodborne Norovirus in Austria (Schmid et al. 2007). The infected kitchen assistant was identified as the source of contamination having prepared salad manually while suffering with symptoms of gastroenteritis. Investigation of an outbreak of Norwalk-like virus affecting 125 students in a Texas University indicated that the source of contamination was a food handler, who denied illness but also chose to surrender her job rather than give a stool sample. She had also cared for her sick child who had watery diarrhoea 2 days before she prepared the food items implicated in the outbreak (Daniels et al. 2000). The authors suggested that adoption of a work policy that included paid leave for food handlers with gastroenteritis would increase compliance with illness related work exclusion policies. This recommendation was again endorsed 2 years later in a review of foodborne disease outbreaks associated with schools in the U.S.A. where 57% of outbreaks were found to be attributed to likely contamination by an infected food-handler (Daniels et al. 2002).

Operational practices: Management factors relating to the operation of the kitchen fell into two categories; those where there had been a change to the routine operation or practice undertaken in the kitchen and exceeding the capability of the kitchen through increased volume.

In 2002, a *Salmonella* Enteritidis outbreak associated with the consumption of a vanilla cream pastry consumed during a holiday festival in Catalonia, Spain resulted in 1,435 cases (Camps et al. 2005). The investigation confirmed that the outbreak was due to the over-production of the vanilla cream in a facility not designed for this use, with cross contamination identified as the most probable contributory factor. Investigators of a Salmonellosis outbreak in U.S.A. affecting 824 people judged that the kitchen of the restaurant was too small to prepare over 500 meals safely (Luby et al. 1993). They commented that whilst the kitchen was adequate to prepare 200 – 300 meals per day required for routine business, during the weekend of the outbreak the kitchen was used to prepare an additional 7, 000 meals over a 30 hour period creating a high risk environment for cross contamination. The authors also commented that a competitive bidding process inadvertently rewarded catering businesses with smaller kitchens and less equipment and staff, and therefore less overheads and costs. An outbreak of *Bacillus* cereus involving 55 people also emphasised the danger that exists when inadequate facilities are used for large scale food preparation (Slaten et al. 1992). This outbreak was associated with a restaurant that had a seating capacity of 29 but at the time of the outbreak the kitchen was used to prepare food for nearly 300 people on the same day at two separate locations. Investigators confirmed that the kitchen size and facilities were inadequate to deal with the increased number of customers and prepare food safely. Similarly, investigators of an outbreak of *Campylobacter* affecting 16 people confirmed that the implicated meal served to 70 people was much larger than the kitchen staff was accustomed to preparing (Winquist et al. 2001). Because of the large volume of food prepared usual food handling practices were not followed, creating the potential for cross contamination.

A number of studies have made comments on the impact of increased customer demand on food preparation practices that contribute to foodborne outbreaks. In 2006, investigators of an *E.* coli O157:H7 outbreak associated with the consumption of beef donairs in Edmonton, Canada suggested that the likely reason for the undercooking was increased customer volume (Honish et al, 2007). Post hockey game celebrations near the implicated restaurant resulted in a reduction in the length of time that donair beef was cooked on the rotisserie in response to the increased customer demand.

These circumstances were mirrored in another outbreak of *E.* coli O157:H7 that occurred two years earlier. Forty three people were affected following consumption of beef donairs in a restaurant in Calgary, Canada (Currie et al. 2007). High customer volume was again identified as a contributory factor. Similar circumstances were also identified in an outbreak of *Campylobacter* in Cardiff, Wales associated with a 'Hawaiian' theme restaurant specialising in stir-fry foods (Evans et al. 1998). At peak periods, the wok measuring 1.5 metres in diameter was of adequate size to allow 8 meals to be stir-fried by two chefs, but investigators suggested that cooking time was compromised by the need to prepare food promptly for a large party of customers. Increased customer demand was also reported as a contributory factor in a multi-state outbreak of 130 cases of *Salmonella* javiana and 11 cases of *Salmonella* oranienburg associated with the consumption of mozzarella cheese (Hedberg et al. 1992a). The investigation revealed that production workers had reported that the manager had placed emphasis on increased production which they felt led to insufficient time to clean and disinfect of food preparation equipment thoroughly.

Managing peaks and troughs in customer demand has been implicated in outbreaks. Investigators of a *Salmonella* enteritidis outbreak with 71 cases associated with the consumption of eggs from a restaurant highlighted poor management of scrambled eggs served from the hot display bar (Lin et al. 1988). Scrambled eggs were intentionally undercooked because the display unit would continue to cook them. Fully cooked eggs would therefore dry out too quickly and be thrown away. During slow periods of customer demand the display bar temperature would be turned down to avoid continued cooking and drying out. A study by Green and Selman (2005) recorded food workers self-reported food safety practices and beliefs about factors that affected their ability to prepare food safely. High volume of business or inadequate staffing were the most commonly reported reasons identified by food handlers that prevented them washing their hands, changing their gloves, cleaning, checking temperatures of cooked or held food and cooling and reheating food properly.

A deviation from the normal operation of the kitchen has also been reported as contributing to foodborne disease outbreaks. Honish (2000) reported that deviation from a standard recipe for ice cream pie contributed to an outbreak of *Salmonella* typhimurium phage type 1 affecting 27 people. The recipe required pasteurised egg products, but on this occasion whole shell eggs were used, although no reason was given for the change in recipe. Similarly, assigning different food handlers to roles they are unfamiliar with has also been reported as contributing to foodborne disease outbreaks. In Ohio, U.S.A. an outbreak of *Salmonella* Enteritidis associated with consumption of coconut meringue pie resulted in 11 cases of illness (Mazurek et al. 2005). Investigators found that a new worker was responsible for making the meringue and baking the pies in place of the regular worker who went on holiday. It was reported that, although this worker was experienced, he could have made changes to the baking process resulting in undercooking of the pies. It was concluded that the meringue was not heated to a temperature that would have killed Salmonella. In a restaurant outbreak of type A botulism affecting 7 people, potato salad was the implicated food vehicle (Seals et al. 1981). Investigation revealed that a basic recipe existed for the preparation of potato salad but the method tended to vary at the discretion of the person preparing the product. Three different batches of potato salad were prepared during the time of exposure and only the last batch was prepared to the standard recipe. The earlier two batches, of which the second was found to be the implicated food vehicle, were prepared by different chefs (one from a different restaurant and the other, responsible for the implicated batch, had only been employed at the restaurant for a week). This article also provides an indication of the potential complexity of managing relatively simple catering operations.

3.3.5 Determination of the applicability of results

The review reported above, though systematic, revealed very few publications that addressed management level risk factors. Selection bias of publication was minimised by using specific search terms with clear inclusion and exclusion criteria and electronic searches of all peer reviewed and grey literature. The method also included manually searching the references of each of the 113 papers to identify papers not previously retrieved.

The results of this literature review indicated that business characteristics (business size, cuisine type), staff employment and management (staff supervision, high staff turnover, inexperience and unpaid sick leave policies) and operational practices (catering in excess of capacity, customer demand and changes to the routine operation of the kitchen) may have contributed to individual foodborne disease outbreaks. No paper, however, presented data that could quantify the relevant contribution of these factors in the occurrence of outbreaks. With the exception of one paper (Hedberg et al. 2006) the management information was incidental to the main aim, and was either offered as an explanation for failures in food safety controls or had insufficient information collected on the management related variable to offer a conclusive explanation.

As limited information was identified an epidemiological study could be undertaken to investigate the role of management level factors associated with foodborne disease outbreaks in the catering industry.

4 METHOD

4.1 Introduction

A matched case control study was considered to be the most appropriate epidemiological study design to test the hypothesis that "management risk factors are associated with foodborne disease outbreaks", because it is the most efficient method to study rare events such as foodborne outbreaks, and it allows for the investigation of a large number of potential risk factors (Irwin et al 1989; Cruz et al 2001; Hedberg et al 2006). The matched design was chosen for three reasons. Firstly, matching by SME status was necessary to balance the numbers of SME businesses and larger businesses in the control group to that of the case group, since there are many more SME catering businesses in England and Wales than larger businesses. Random sampling from catering registers would lead to a marked disparity between the case and control groups. SME status is also known to be strongly associated with some management factors (IGD 2005). For example large businesses such as national chains often offer the same menu throughout the country and chefs in these outlets will manage their kitchen and menu to standardised procedures produced by head office. In contrast, a chef from an independent SME is likely to have more control and flexibility over the way he/she manages his/her staff and menu. Matching for SME status therefore enabled the author to investigate types of management factors that may be associated with foodborne disease rather than the size of the business and its association with an outbreak. Secondly, matching by local authority controlled for the possible confounding effects of variations between local authorities in their interpretation and application of risk assessment protocols under the

Food Safety Act 1990 which might lead them to differ systematically in the risk rating scores applied to catering businesses. Thirdly, matching by local authority was convenient in terms of ease and consistency in selecting control businesses. All food catering businesses are legally required to register with the local authority in whose area they operate (SI 2006, No.14; European Union 2004). In comparison to national telephone directories and membership to catering organisations, this public register is the most complete and up to date list of catering businesses operating at any given time. As the author was already in contact with the local authority regarding the case business it proved more efficient to utilise their services to identify a control business.

Ascertainment, recruitment and data collection methods were tested in a pilot study.

4.2 <u>The study population</u>

Estimated numbers of outbreaks available to study were based on the number of foodborne disease outbreaks officially reported to the Health Protection Agency. The most recently available published data at the time of study design was for the period 1995 - 1998 when 2,698 general outbreaks of infectious intestinal disease were reported to the national outbreak surveillance scheme in England and Wales (Djuretic et al. 1996). Removal of outbreaks not associated with catering operations reduced this number to 707 outbreaks, an average of 176 per year. Due to the intrusive nature of this study, a participation rate of 50% was anticipated and a target of 88 outbreaks over one year was set for the main study.

4.3 Study definitions

4.3.1 Case definition

A *case business* was defined as:

a catering business located in England and Wales that was confirmed as the place of a general outbreak of bacterial or viral foodborne disease between 1st December 2002 and 31st December 2003.

A *catering business* was defined as:

a commercial or voluntary organisation that prepares, serves and sells food to the final consumer. It included restaurants, public houses, cafes, takeaways, hotels, guesthouses, and caterers. It did not include private houses, mobile retailers, armed services camps, retailers, manufacturers and suppliers. Hospitals, residential institutions, schools, universities, colleges and places of work were included when the outbreak was 'point source' and confirmed to be the result of foodborne transmission only.

'Confirmed as the place' was defined as:

environmental, epidemiological or microbiological evidence collected during the local authority outbreak or project team investigation.

An outbreak of bacterial or viral foodborne disease was defined as:

three or more persons from more than one household who were thought to have a common exposure to a proven infection.

In the UK, the national surveillance scheme for outbreaks (O'Brien et al 2002; Hughes et al 2007) use the Department of Health definition of a general outbreak which is "two or more people from more than one household" (D.o.H Working 1994), (Ch. 2.1). In this FSA funded study a more stringent definition was used to minimise the introduction of selection bias that could result from inclusion of viral outbreaks that were the result of a wider person to person spread community outbreak rather than from foodborne transmission associated with a catering business.

Catering businesses reported to be associated with viral foodborne disease outbreaks were also reviewed against an additional set of criteria to ensure that only those viral outbreaks where transmission was predominantly foodborne were included:

- It was defined as a point source outbreak by local investigators.
- A common food exposure was identified by local investigators – meal, buffet, lunch, wedding breakfast.
- Foodborne transmission was the only or predominant transmission pathway identified by investigators.
- The cases did not have any other common exposure that could explain the outbreak apart from the consumption of food.
- The outbreak was not known to be the result of a guest or member of staff vomiting in a public area.

4.3.2 Control definition

The following control definition was applied to the study:

a catering business located in England and Wales which had not been reported as a source of a general outbreak of bacterial or viral food poisoning between 1st December 2002 and 31st December 2003.

4.4 Case ascertainment

Incident cases were sought from two sources:

1. The foodborne disease surveillance scheme managed nationally at the Health Protection Agency: Information on all general gastrointestinal outbreaks associated with all businesses and organisations operating or thought to be operating as a catering service was received electronically on a monthly basis from the national surveillance system (Djuretic et al 1996; O'Brien et al 2002; O'Brien et al 2006; Hughes et al 2007). This information was used to identity the location of the outbreak and the relevant local authority. The national surveillance scheme was also manually interrogated at the Colindale site in north-west London on two occasions during data collection to ensure that possible cases were not missed.

2. A network system of national catering and hotel chains, trade contacts and environmental health officers (EHOs), developed and maintained for the duration of the research: There is good evidence (Wheeler et al 1999; Adak, Long and O'Brien 2002; Hughes et al 2007) of a general under ascertainment of foodborne disease in England and Wales reported to the national surveillance scheme. To minimise selection bias unofficial reports of

outbreaks were selected from environmental health and industry contacts. This network of contacts was established during preparation of the study and during the pilot.

EHO network: An article was placed in the Chartered Institute of Environmental Health (CIEH) weekly magazine Environmental Health News, informing the profession of the study and a letter was sent to all local authorities in England and Wales requesting information on foodborne outbreaks through EHCnet, a secure national intranet site used by the profession to exchange information on current and emerging environmental health issues. This was supported by 12 presentations to local food safety liaison groups which each comprised between 7 and 10 local environmental health departments. Information was also sent to the chairperson of other liaison groups.

Industry network: Customer complaint procedures operated by a national food safety consultancy, which had an extensive client base of national catering chains, including hotels, restaurants, public houses, coffee houses and retail and leisure outlets. This client base was used to set up a monthly reporting system to the author of allegations of foodborne illness. Information on the study was also published in the British Hospitality Association journal and trade journals including the Caterer.

To encourage regular reporting of outbreaks, network participants were sent quarterly newsletters of the progress of the study (Appendix 1).

When local authorities had completed all formal investigations into the outbreak, the following case business details were released:

- Name, address and telephone number of the catering business.
- Name of the owner/manager of the catering business, preferably the person who was involved in the routine operation of the kitchen.
- Total risk rating and confidence in management score of the business at the time of the outbreak.

4.5 Control ascertainment

The sampling frame for this study utilised the public food premises register of the local authority where the outbreak occurred (SI 2006, No.14; European Union 2004; Little et al 2008). To ensure that each catering business on the public register had an equal chance of being selected the local authority environmental health department was asked to select the control using a set of simple guidelines that could be applied to either a computer or paper register:

- Go to the case business on the food register.
- Count five businesses down from the case business.
- If the fifth business is a catering business and has the same SME status, select this one.
- If the fifth business is not a catering business or not the same SME status, go to the business below, and so on until a match is found.

4.6 Recruitment of case and control businesses

Personalised letters were sent to both case and control businesses requesting their participation. A standard template was used for both case and control businesses (Appendix 2), but in order to maximise participation rates, letters were tailored to the particular circumstances of the business. For example, letters to cases were frequently sympathetic to their circumstances, focused on confidentiality and emphasised that the interviewers were from industry and independent of the enforcing local authority. In contrast, control businesses were advised that their contribution was invaluable 'as a business that managed to operate successfully in a competitive market without being associated with a foodborne disease outbreak'.

The letter was followed by a telephone call to the case and control business with the view to arranging an appointment with the person most familiar with the daily operation of the business, usually the owner, the general or kitchen manager or the head chef. Telephone calls were also used to build up a rapport with the business and to reiterate the value of their participation. This helped to develop trust in the project team and encourage open communication during the forthcoming interview.

Frequently, local authorities undertook a formal investigation of the outbreak and took or considered a prosecution against the business proprietor. The pilot study confirmed that in these circumstances, the process took many months to complete, so, in the main study, control business details were released to the project in advance to avoid undue delay in interviewing control businesses.

4.7 Risk factors to be tested

The risk factors to be tested were based on evidence from the:

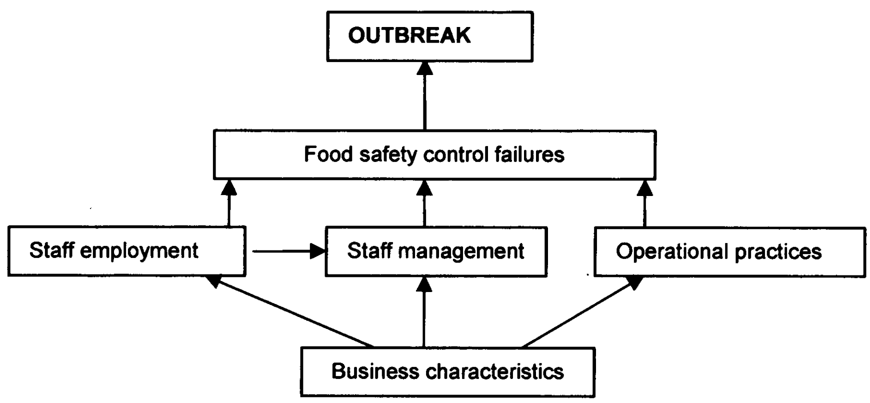
1. Systematic literature review into management risk factors associated with foodborne disease (Chapter 3).
2. Public enquiries (Report of the Committee of Inquiry 1986; Pennington Group 1997) and Government reports (Richmond et al 1990; Richmond et al 1991; Agriculture Committee 1998; FSA 2001a) into foodborne disease outbreaks and food safety standards in England and Wales.

These variables were classified into one of four hypotheses groups related to a hypothesised causal pathway:

- Characteristics of the catering business
- The method of staff employment
- The way staff were managed
- The operational practices employed by the business

The hypotheses groups were developed into a pre-defined hypothesised causal pathway which formed the basis for data analysis - foodborne disease outbreaks are the result of food safety control failures that were determined by how staff are employed and managed and by the operating practices used by the business. These features in turn are determined by the characteristics of the catering business (Figure 4).

Figure 4: Hypothesised causal pathway leading to a hierarchy of risk factors



It was hypothesised that foodborne disease outbreaks were more likely to occur in businesses employing casual staff and relief managers, and these practices were more likely in larger businesses such as hotels. In contrast, it was hypothesised that outbreaks were less likely to occur when businesses employed full-time staff and operated a closely supervised kitchen, determined by either a reduced number of staff requiring supervision (micro SME) or by a kitchen supervisor with a vested interest in the business (owner/manager working in the kitchen). It was also hypothesized that foodborne disease outbreaks were less likely to occur in businesses in which staff had formal food hygiene training qualifications, and were more likely to occur in businesses where foods known to have relatively high levels of food pathogens such as poultry were prepared from raw, or where food was served from a hot display (Kessel et al 2001; European Food Safety Authority 2006). Table 19 identifies all variables to be tested with variable definitions.

Table 19: Variable definitions

[N.B. Further detailed commentary on variables can be found in Table 20, p. 89]

HYPOTHESIS: The business characteristics of catering businesses associated with foodborne disease outbreaks was different to those of non outbreak businesses.	
Variable	Definition
Hotel	Includes bed and breakfast establishments and residential pubs
Restaurant	Includes takeaways
Other catering businesses	Includes canteens in workplaces, universities and colleges, residential care homes, caterers, schools, clubs, shop caterers and cafes.
Family business	A business which is owned and operated by members of the same family, applicable to any size of business
Small independent	A business employing less than 250 employees which operates from one site.
Small independent > 1	A business employing less than 250 employees which operates from more than one site.
Large independent	A business employing greater than 250 employees which operates from one site.
National chain	A business employing greater than 250 employees which operates from multiple sites throughout the country.
Voluntary organisation	An organisation whose members are not paid for their work and that

	does not make a profit. Includes registered charities, church groups, luncheon clubs and community groups.
SME	Small medium sized enterprise employing less than 250 staff, includes micro, small and small medium SMEs (European Union 2003)
Micro SME	Small medium sized enterprise employing less than 11 staff (European Union 2003)
Small SME	Small medium sized enterprise employing between 11 – 49 staff (European Union 2003)
Small medium SME	Small medium sized enterprise employing between 50 and 249 staff (European Union 2003)
Lunch	Meal served at midday
Dinner	Meal served in the evening/night
HYPOTHESIS: Staff employment in catering businesses associated with foodborne disease outbreaks is different to those of non outbreak businesses.	
Variable	Definition
Casual staff	Staff employed by a business on an infrequent and irregular basis. Casual staff are taken on from time to time for a short period of time to fulfil a specific requirement e.g. work in a hotel over the Easter holidays. Casual staff are not defined by the number of hours they work during that period of employment.
Full-time staff	A full-time member of staff works 35 hours or more per week
Part-time staff	A part-time member of staff works less than 35 hours per week
Salaried	Staff receive a weekly or monthly wage and are not paid by the hour.
Food and beverage	Food and beverage, which includes front of house/customer areas
Tier 1	Manager and deputy, applies to either kitchen or F and B
Tier 2	Tier below Manager and Deputy can comprise of chefs, bar supervisors, team leaders, restaurant supervisors
Tier 3	Tier below tier 2 comprising of kitchen assistants, kitchen porters, bar staff, waiters
Team	Staff other than the manager or deputy of the kitchen or F and B
Kitchen manager	The person in charge of the kitchen usually known as the head chef, executive chef, kitchen manager, catering manager
Food and beverage manager	The person in charge of those areas where customers are served usually the dining area and bar usually know as F and B manager, Restaurant manager, head waiter, beverages manager
HYPOTHESIS: Management of staff in catering businesses associated with foodborne outbreaks is different to those of non outbreak businesses.	
Variable	Definition
Induction training	Formal or informal training undertaken by the employer at the start of employment
Basic training	Stage 3, level 1 food hygiene training, nationally recognised, accredited qualification of generally 6 hours duration (FSHWG 1997).
Intermediate training	Stage 3, level 2 food hygiene training, nationally recognised accredited qualification usually of 12 to 24 hours duration (FSHWG 1997).
Advanced training	Stage 3, level 3 food hygiene training, nationally recognised accredited qualification for managers usually of 24 to 40 hours duration (FSHWG 1997).
Professional training	Training in the profession in which the person works with Institute, Association, trade, graduate qualifications
Tier 1	Manager and Deputy of either kitchen or F and B
Tier 2	Generally chefs/head waiters or head bar man
Tier 3	Generally kitchen assistant, kitchen porters, waiters, bar staff
Leave	Authorised absence from work
Sick leave	Absence from work due to sickness and/or diarrhoea, symptoms of gastroenteritis
Sick at work	Vomited or experienced diarrhoea while working at the catering business

Family with Diarrhoea and vomiting	A close member of the family i.e. a person living in the same household whose has sickness and/or diarrhoea, symptoms of gastroenteritis
Staff incentives	Includes bonus schemes, meals paid for, accommodation provided, tips, staff discounts
Internal pressures	Includes wage percentage, GP, undertaking of additional roles, cutting corners
External pressures	Includes increased utility costs, high or change in rent/lease agreement, contractual issues
d-dverb	Informal verbal communication
Meeting	Any formal meeting, including shift briefs
Notices	Includes notice board, signs, booklets, written procedures
Training	Includes formal certified training and on the job training
Diary	Includes function sheets
Checks/audits	Includes inspections, monitoring undertaken either internally or externally
HYPOTHESIS: Operational practices in catering businesses associated with foodborne disease outbreaks are different to those of non outbreak businesses.	
Variable	Definition
Menu specifications	Written documents outlining the preparation, cooking and presentation of food, includes recipes
Bulk preparation	The preparation of menu items for more than two people in advance of ordering. These items can be either hot or cold. Preparation can include cooking.
Food regenerated on site	Food products that simply require reheating to be ready for human consumption can either be frozen or fresh products. Branded ready made meals come within this category.
Totally made	Food items which come into the kitchen in a raw state and require full preparation and cooking before service e.g. a raw whole chicken.
Partially prepared	Food items which come into the kitchen partially prepared but still require preparation or cooking e.g. precooked lasagne, frozen chips.
Served only	Food items which come into the kitchen ready to eat with no further preparation required, apart from wrapper removal e.g. fresh cakes, fruit, cooked sliced ham
Cook to order	Menu item which is ordered by a customer and then cooked from raw for immediate service.
Reheat to order	Menu item which is ordered by a customer and only requires reheating before service as the product has been cooked sometime in advance.
Freezer to Fryer	Frozen food put directly from the freezer into the fryer before serve to the customer e.g. scampi, chips, battered fish.
Small Function 1 (SMALL FUNCTION)	A party/function of less than 20 persons
Large Function 2 (LARGE FUNCTION)	A party/function of more than 20 persons
Hot display buffet	Hot food displayed on hot plates, hot trolley, heated display unit for service either directly by the customer or by staff.
Cold display buffet	Cold food displayed on a refridgerated display unit for service either directly by the customer or by staff.
Ambient display buffet	Food displayed at room temperature for service either directly by the customer or by staff.
Poultry	Includes chicken and duck
Red meat	Includes beef, lamb and pork
Local supplier	A food supplier who operates within the local community extending to no greater than one county,
Regional supplier	A food supplier who operates within one to seven counties.
National supplier	A food supplier who operates throughout the country of England and Wales or both.
HACCP	Hazard Analysis Critical Control Point

Written HACCP	A documented system of HACCP either developed by the business or bought as a product.
Verbal HACCP	Business follows the key principles of HACCP but did not have any system recorded. Business has shown some understanding of HACCP.
Unusual events or circumstances variables	
Variable	Definition
Food preparation equipment	Any equipment involved in the receipt, storage, handling, preparing, cooking, holding, reheating, serving of food.
Change in menu preparation	The method in which a menu item is prepared for service. This may not necessarily mean that there has been a change in menu.
Temporary or alternative equipment	Equipment not routinely used by the catering business, used either to replace a piece of equipment or as an addition.
Disturbance to water supply	Provision or quality of the water supply is abnormal, intermittent, ceases
Relief manager	A manager employed on a temporary basis to fill in for an absent manager of either the whole business or part thereof.
Other incident/unusual occurrence	Includes increased water rates, rent, and tax, additional expenditure, extreme weather of incidents outside the normal business routine which affected the operation in some way.
Exploratory variables	
Meal for 2 <£21	The cost of a meal for 2 persons excluding alcohol (cheaper meals).
Opening hours	Hours the business is open to the public for the service of food and/or drink
Covers	Number of meals or servings made and sold to customers

4.8 Data collection

4.8.1 Face to face interviews

Exposure to management and operational variables in case and control businesses were measured by conducting face to face interviews using structured interview protocols which included all variables outlined in Table 19. In comparison to telephone and postal questionnaires, evidence suggests that face to face interviews are the most appropriate means of data collection for this type of investigation (Irwin et al 1989; Lee et al 2004; Green and Selman 2005; Hedberg et al 2006) and particularly for this study because the intrusive nature of the investigation meant that it would be difficult to encourage commercial catering business to participate in the study and answer all the questions in the protocol if either postal questionnaires or telephone interviews had been used. Face to face interviews enabled the interviewer to observe circumstances present during the interview and adapt the interview approach and dialogue to suit different situations. For example, once the interviewer had arrived at the business he or she could observe the initial body language of the interviewee and where necessary begin dialogue by expressing an interest in the business rather than immediately focusing on the interview. This improved the rapport between the business and the investigator and encouraged more open discussion on the way the business was operated.

An inspection of the business was not undertaken at the time of the interview as it would not provide any useful information regarding events and practices that occurred during the specific time period. Also, case businesses may have been required by enforcing officers to change food preparation practices or renew of food preparation equipment following the outbreak.

Interviews were conducted at the business address at a time convenient to the interviewee. This tended to be either before or after serving hours and was always between 9.00am and 10.30pm.

4.8.2 Choice and training of interviewers

Interviews were conducted by one of four regional investigators including the author. All investigators were professionally qualified in the field of environmental health with backgrounds in catering and food safety.

To ensure that there was a consistent approach to data collection investigators received regular project training. This included a full day's training at the beginning of the pilot study and three half day training sessions throughout the period of data collection (one during the pilot study, another at the beginning of the main study and the remaining session halfway through data collection in the main study). This was supported by regular telephone calls between each of the investigators and the author.

The first training session involved discussions on the approach to be used during the interview with emphasis on the need for consistency when interviewing both case and control businesses. An explanation of the questions included within the protocol was provided and interviewers were advised on the correct recording of information given by the interviewee. Administrative procedures were also outlined. The remaining three half day sessions provided the opportunity to reinforce the techniques that should be used when conducting interviews and to discuss issues raised by the investigators during the interviews that they had undertaken. This was important during the pilot study when the appropriateness of the interview protocol was being tested as investigators identified that the questionnaire did not reflect the order of discussion with the business. The format of the questionnaire was reorganised for the main study.

The telephone calls between the author and investigators helped support the continuity of data collection and provided motivation to the investigators.

Case control studies can be affected by exposure suspicion bias; that is, knowledge of the disease status of the business may influence the intensity of questioning for exposure to the possible cause. Knowledge of the disease status of the businesses could not be avoided, and Palmer (1989) has suggested that in these circumstances the only safeguards are professionalism in the techniques of interviewing and the rigorous application of a structured questionnaire. With the exception of the author the investigators were not aware of the hypotheses being tested.

4.8.3 Minimising recall bias

Exposure to risk factors related to the time of the outbreak and the 14 days before this occurrence. As the date of interview was frequently some months after this event, 'trigger events' were used during interviews to help businesses, particularly controls recall practices and operations over the specified time period. Trigger events were identified as a useful recall tool during the pilot study and the most effective trigger events were found to be school and national holidays, extremes in weather, calendar events, religious festivals and significant local and national news and sporting events.

The pilot study highlighted the length of time between the date of the outbreak and date of interview (mean -174 days; median - 153 days; range – 52 and 670 days). This time period differed marginally for cases (mean - 172 days; median - 152 days; range - 52 and 623 days) and controls (mean - 173 days; median - 155 days; range - 54 and 670 days). To reduce this time period and minimise the impact of recall bias the following procedures were introduced for the main study:

- Where local authorities did not return telephone and e-mail requests for outbreak information or case and control business detail within 48 hours of the original enquiry, the author would contact the local authority again rather than wait for the call to be returned.
- Business managers or owners were not always available when the author telephoned the business to arrange interview appointments. To avoid undue delay the author requested mobile telephone numbers to try and make immediate contact with the person concerned or identify when the owner or manager was usually available at the business. If telephone messages were not returned within 24 hours the business was contacted again rather than wait for the call to be returned.
- Local authorities agreed to send control details in advance of case information where formal action was being considered or taken.

Throughout the pilot and main study, interviewees were also encouraged to use their business and booking diaries to recall events and validate their responses, an approach also suggested by Palmer (1989).

4.9 Data preparation

Completed interview protocols were carbonised. The original was sent by first class post to the University where the data was securely stored. The investigator retained the copy until confirmation of receipt was received, and then the copy was either destroyed or returned to the University.

A password protected database was created using Microsoft ACCESS 2003 (Microsoft ACCESS 2003) into which all information recorded on the interview protocols were entered by the author. Data was then exported into SPSS 12 for Windows (SPSS Inc. 2008) which is a data management and analysis package that performs a range of statistical analyses required by the methods used in epidemiological case control studies.

Data was cleaned and edited before analysis to ensure accuracy, consistency and completeness of data. Data cleaning involved visually checking the data against the paper entries for errors, undertaken independently by two members of the project team, and corrections were made by the author. Distribution and frequency checks were used to check the consistency and completeness of data; for example, mutually exclusive variables were compared. Other checks looked for similar discrepancies; for example, comparing the management structure variables within SME businesses and large businesses since certain management structures were only found in SME businesses and others only in large businesses.

Data editing identified variables that were poorly defined. For example the 'kitchen porter's wages' variable was found to include wages of similar job titles including catering assistant and kitchen assistant, and in the 'staff sickness' variable, symptoms and dates of illness or sick leave could not always be confirmed by documentation. These variables were therefore removed from the dataset. Table 20 identifies the variable and reasons for its removal.

Distribution and frequency checks identified a number of variables which contained only a small number of values, such as variables relating to the employment of staff and managers, variables relating to changes in the use to equipment and menu preparation and variables which contained similar information such as foods served from a hot display buffet. Rothman, Greenland and Lash (2008) advise that in these circumstances variables can be 'collapsed' together which means that data from more than one variable can be combined to produce a single variable containing more data. However, the authors warn that this process of data editing can only be undertaken where the data within the variables is similar. Table 21 outlines the variables which have been combined.

Table 20: Variables removed from analysis

Variable	Reason
Cheaper meals	A meal for 2 (excluding drinks) < £21. It was intended that this variable would indicate the complexity of the menu, that is the cheaper the meal the less complex the menu and therefore the less opportunity for food safety control failures to occur. Whilst this is relevant to products such as pizza and fish and chips, it does not apply to sandwiches or salads made on site and Sunday lunch offers. Further, very few businesses prepare only complex or simple menu items.
Snacks	Too ambiguous, a food served as a snack can also be served as a meal, for example sandwiches, chips, slices of pizza.
Unusual events	Interviewees were asked to recall any event that was considered to be 'unusual' or 'unexpected' which they feel may have affected the running of their business. This was too subjective, for example extremes in weather were quoted by cases but as they were matched by region the control businesses were also exposed to the same weather conditions. Also cases, unlike controls will by nature search longer and harder for a reason for being involved in an outbreak.
Kitchen porter's wages	Catering and kitchen assistants were sometimes included within the job title of a kitchen porter. This is incorrect as the role of kitchen porter is different to that to that of a catering or kitchen assistant.
Staff sickness	Accurate data collection proved difficult, onset dates were sometimes difficult to confirm, information was often not verified and was frequently given second hand. The data is therefore likely to contain false positives. Staff could have been victims rather than the cause.
F and B staff professional training/Recruit F and B staff with professional qualifications	Poorly defined. During data collection interviewers were concerned about credibility of professional qualifications given, also the possibility of that social acceptability bias was introduced.
Staff interviews	Section 5 asked questions of both the manager/owner and food workers, this information was subjective. Investigators frequently commented that the interviewee guessed or were reluctant to give information. The information was considered inaccurate and unlikely to add anything to the understanding of the data
Dairy/dairy suppliers	This variable repeated information contained in more specific variables i.e. egg suppliers and poultry suppliers
Time site in operation	Confusing as although site had operated as a food business for a specified period of time, it was frequently bought and sold to different companies in that time period, catering operations therefore differed. Times given were frequently estimates
Duration that interviewee was in business	The GM or head chef were not always interviewed and sometimes this position had been employed on site by different companies adopting different procedures.

Table 21: Variables where data were combined

Variables collapsed	Name of combined variable
Kitchen managers employed full-time Kitchen staff employed full-time F and B managers employed full-time F and B staff employed full-time	Full-time staff employed
Temporary or alternative equipment used at the time of outbreak Change in menu preparation at the time of outbreak New practice or procedure used at time of outbreak	Change in kitchen practices
Vegetables served from a hot display buffet Fish served from a hot display buffet Shellfish served from a hot display buffet Poultry served from a hot display buffet Red meat served from a hot display buffet Eggs served from a hot display buffet Rice/pasta served from a hot display buffet Sauce served from a hot display buffet	Food served from a hot display buffet

4.10 Data analysis

The strength of association between variables and the case and control status of each business was assessed using the odds ratios (OR), 95% confidence intervals and p values for all foodborne disease outbreaks. Sub analyses of outbreaks associated with SME businesses and large businesses and outbreaks due to *Salmonella* species and viruses were also undertaken.

4.10.1 Univariate analysis

Unmatched analysis: The frequency of exposure in case businesses was compared to that of control businesses firstly by unmatched analyses using SPSS 12 for Windows. Dichotomous categorical variables (yes/no answers) relating to the four hypotheses groups were compared in 2x2 tables by calculating ORs and 95% confidence intervals (Schlesselman 1982;

Rodrigues and Kirkwood 1990). P values were calculated using the chi square statistic.

Matched analysis: The data were then analysed in matched case control sets within the four hypothesis groups by calculation of Mantel Haenszel matched odds ratios using STATA (Stata Corporation, 1997). The case control pairing was retained during analysis which means that the application of the 2 x 2 tables differs from that of the unmatched case control study. Figure 5 outlines the application of the 2 x 2 table.

Figure 5: 2 x 2 table for matched analysis

		Control		Total
		+	-	
Case	+	A	B	A + B
	-	C	D	C + D
Total		A + C	B + D	N

Where exposed (+), non exposed (-)

(Schlesselman 1982)

The discordant pairs (B represents the number of discordant pairs where the case possesses the risk factor and C represents the discordant pairs where the control has the risk factor) give information regarding the differential exposure to the study factor. It is accepted that inference is made on the difference in proportions derived from the matched pairs of B and C and the maximum likelihood estimate of the odds ratio is conditional on the number of discordant pairs B + C (Schlesselman 1982). The Mantel-Haenszel estimated summary odds ratio only depends on the discordant pair, as A and D are concordant pairs that are not relevant to the OR calculation and are therefore eliminated from the analysis (Selvin, 2004).

The same statistical methods, confidence intervals and p values, were used to evaluate the observed differences with the discordant pairs. Here, the p value determines whether the frequency of the risk factor in B and C differ by chance alone and the test statistic applied is the McNemar's test, which has an approximate chi-square distribution of 1 degree of freedom; this test improves accuracy particularly in small sample sizes (Selvin 2004) and is interpreted in the same was as unmatched analysis.

4.10.2 Multivariate analysis

Variables that were significant at the 10% level in matched univariate analysis were considered for multivariate analysis. Some variables were significant at the 10% level but were not taken forward because of insufficient numbers or because they duplicated information already provided by other significant variables.

Conditional logistic regression is the most common type of multivariate analysis used for matched case control studies and was undertaken on all the foodborne disease outbreaks dataset by following the pre-defined hypothetical causal pathways to identify variables independently associated with foodborne outbreaks. Conditional logistic regression analysis was used to adjust for confounding; a variable may be significantly associated with case status in univariate analysis even though it is not causally linked. Logistic regression analysis estimates the strength of association between an explanatory variable and the case-control status of a business independently of the effect of other variables in the model (Rothman 2002). The model looks for the 'goodness of fit' indicated by the log likelihood statistic which is interpreted as the chi square statistic and a p value indicates whether adding the terms significantly improves the goodness of fit.

In this analysis, each of the four hypothesis groups (business characteristics, staff employment, staff management or operational practices) formed a conditional logistic regression model. Significant variables were adjusted for potential confounders within their hypothesis group. Business characteristic, staff employment and staff management variables that remained independently significant at the 5% level were then placed in a staff management practices model and adjusted for each other. The operational practices variables comprised different practices; food preparation methods included the preparation of foods from raw, foods where no further preparation was required, food service methods e.g. cook to order, reheat to order and foods served from a hot display. These variables were adjusted within their specific preparation types and variables significant at the 5% level were then placed in a food preparation methods model. The food supplier variables were placed in another model and those remaining independently significant operational practices were then placed in a final model with the remaining independently significant staff management variables. The analysis was repeated for subsets of the data: SMEs and non SMEs, and outbreaks caused by *Salmonella*s and viruses.

This method of analysis was chosen in preference to the stepwise approach, where variables in a model are either subtracted or added to the model in successive stages according to their statistical significance (Rothman, 2002), because the stepwise approach does not taken into account causal pathways. Rothman (1986) warns that the stepwise approach is inappropriate for most epidemiological analyses which focus on the effect of specific factors rather than using statistical significance to assess the adequacy of the model. The primary objective of employing a multivariate model in epidemiology is to make a judgement on the need to control confounding for specific factors on the basis of the extent of confounding involved. The stepwise approach negates this advantage.

5 RESULTS

5.1 Pilot study

5.1.1 Pilot study: Recruitment of outbreak businesses

From 1st November 2001 to 31st October 2002, there were 186 outbreak businesses identified, of which 70 (38%) met the case definition, and of these, 60 agreed to participate in the study; a response rate of 86%. Forty seven (78%) of the outbreaks were identified by the HPA (Table 22). Sixty (93%) out of 64 control businesses were recruited.

Table 22: Pilot study: reporting source

Reporting source	Number of outbreaks (%)
Industry network	6 (10%)
EHO network	7 12%)
HPA national surveillance scheme	47 (78%)
Total	60 (100%)

There were 10 non-participant case businesses (Table 23) and 4 non-participant control businesses (Table 24). The case businesses had outbreaks due to *S.* Enteritidis (n = 6), *S.* Typhimurium (n = 1), and Norovirus (n = 3).

Seven of the 10 case businesses that had declined to participate were SMEs, six were restaurants, two were hotels, one was a commercial caterer and one a takeaway. All four control businesses that declined were SME catering businesses.

Table 23: Pilot study: Comparison of participating and non-participating case businesses

Business characteristic	Study businesses (%)	Non participating businesses (%)
Restaurant	17/60 (28%)	6/10 (60%)
Commercial caterer	5/60 (18%)	1/10 (10%)
Hotel	17/60 (28%)	2/10 (20%)
Takeaway	0/60 (0%)	1/10 (10%)
Large business	20/60 (33%)	3/10 (30%)
SME	40/60 (67%)	7/10 (70%)
Causative pathogen	**Study businesses (%)**	**Non participating businesses (%)**
S. Enteritidis	17/60 (28%)	6/10 (60%)
S. typhimurium	1/60 (2%)	1/10 (10%)
Norovirus	28/60 (34%)	3/10 (30%)

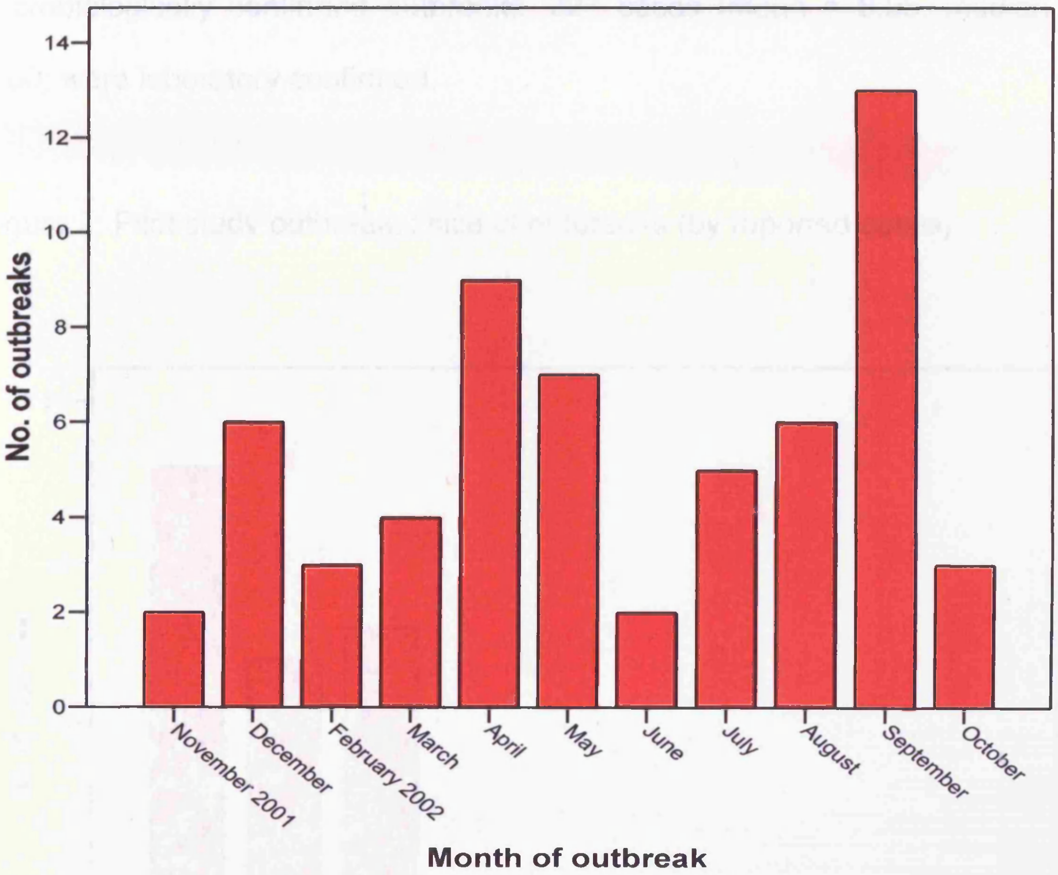
Table 24: Pilot study: Comparison of participating and non participating control businesses

Business characteristic	Study businesses (%)	Non participating businesses (%)
Restaurant	24/60 (40%)	2/4 (50%)
Cafe	5/60 (18%)	1/4 (25%)
Hotel	10/60 (17%)	1/4 (25%)
Large businesses	20/60 (33%)	0/4 (0%)
SME	40/60 (67%)	4/4 (100%)

5.1.2 Pilot study: Outbreak details

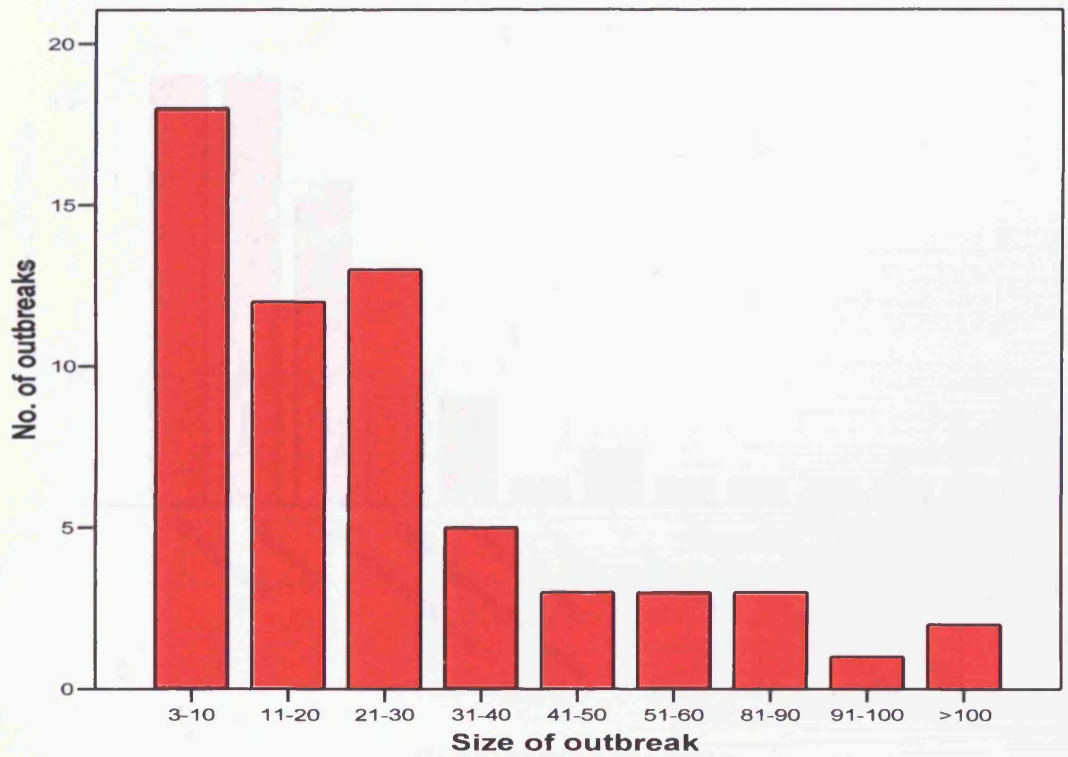
Outbreaks occurred throughout the year but there was a definite seasonal pattern. Twenty seven (45%) outbreaks occurred between July and October 2002 (Figure 6) and 13 (22%) occurred in September. The lowest number of outbreaks occurred in June (2, 3%) and November 2001 (2, 3%) and no outbreaks were recorded in January 2002.

Figure 6: Pilot study outbreaks: Temporal distribution



In the 60 outbreaks there were reported to be 1,972 people affected (mean = 32.9, median = 20.5). Outbreaks ranged in size from 3 to 296 cases (Figure 7). Small outbreaks occurred with greatest frequency; 43 (72%) outbreaks had between 3 and 30 cases and 18 (30%) outbreaks had between 3 and 10 cases. Only 2 outbreaks (3%) had more than 100 cases. Of the 47 (78%) microbiologically confirmed outbreaks, 327 cases (mean = 6.96, median = 4.00) were laboratory confirmed.

Figure 7: Pilot study outbreaks: size of outbreaks (by reported cases)



There were 31 (52%) bacterial outbreaks of which 21 (68%) were due to *Salmonella* species, including 17 (81%) due to *S.* Enteritidis. Five (16%) outbreaks were associated with *Campylobacter*, and 3 (10%) associated with

Clostridium perfringens (Figure 8). Three outbreaks were associated with more than one causative pathogen: these were *Clostridium* perfringens and *Staphylococcus* aureus, *Campylobacter* and Norovirus, and *Salmonella* Branderup and *Salmonella* Enteritidis PT4. There were 28 (47%) presumptive Norovirus outbreaks, of which 16 (57%) were microbiologically confirmed (Figure 8). The remaining pilot study outbreak was due to Scombrotoxin poisoning.

Figure 8: Pilot study outbreaks: Causative pathogens

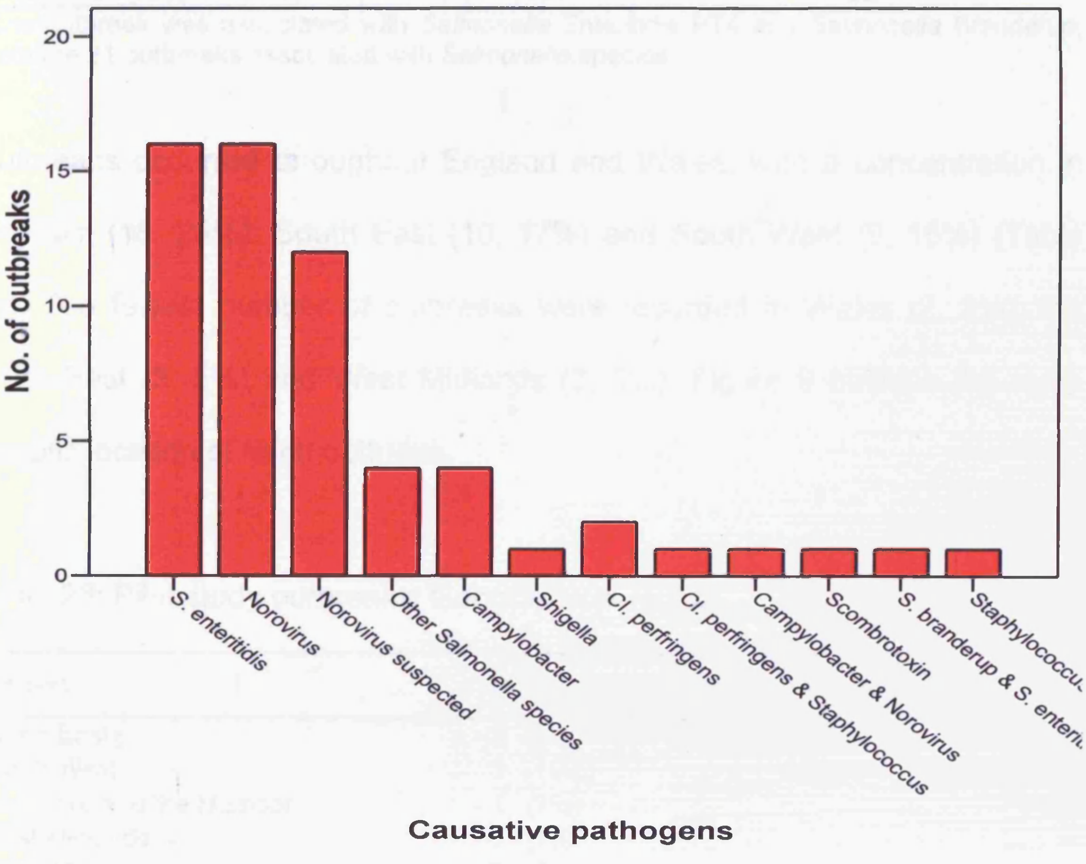


Table 25 outlines the number of outbreaks associated with *Salmonella* serotypes and *S.* Enteritidis phage types. Of the *S.* Enteritidis outbreaks, PT4 accounted for 8 (50%).

Table 25: Pilot study outbreaks: Species of *Salmonella* and *Salmonella* Enteritidis serotypes.

Salmonella	Number of outbreaks	*Salmonella*	Number of outbreaks
Enteritidis PT4*	8	Enteritidis PT57	1
Enteritidis PT3	2	Enteritidis PT6	1
Enteritidis PT1	1	Hadar	1
Enteritidis PT21b	1	Typhimurium DT104	1
Enteritidis PT21	1	Branderup*	2
Enteritidis PT24	1	Brandenburg	1
Enteritidis PT34	1	Total	22

*One outbreak was associated with *Salmonella* Enteritidis PT4 and *Salmonella* Branderup, therefore 21 outbreaks associated with *Salmonella* species

Outbreaks occurred throughout England and Wales, with a concentration in the East (15, 25%), South East (10, 17%) and South West (9, 15%) (Table 26). The fewest number of outbreaks were recorded in Wales (2, 3%), the North East (3, 5%) and West Midlands (3, 5%). Figure 9 outlines the more specific location of each outbreak.

Table 26: Pilot study outbreaks: Geographical region

Region	Number of Outbreaks (%)
North East	3 (5%)
North West	6 (10%)
Yorkshire and the Humber	4 (7%)
East Midlands	4 (7%)
West Midlands	3 (5%)
South West	9 (15%)
London	5 (8%)
South East	11 (18%)
East	13 (22%)
Wales	2 (3%)
TOTAL	60 (100%)*

Figure 9: Pilot study outbreaks: Geographical distribution

5.1.3 Pilot study: Case businesses by type of business

Restaurants (17, 28%) and hotels (17, 28%) were the commonest type of case business, followed by pub/bars (8, 13%), (Figure 10). Other catering businesses (18, 30%) included workplace canteens (2, 3%), residential care homes (3, 5%), halls/caterers (5, 8%), educational establishments (1, 2%), clubs/centres (4, 7%) and cafes (3, 5%), (Figure 11).

Figure 10: Pilot study outbreaks: Business category

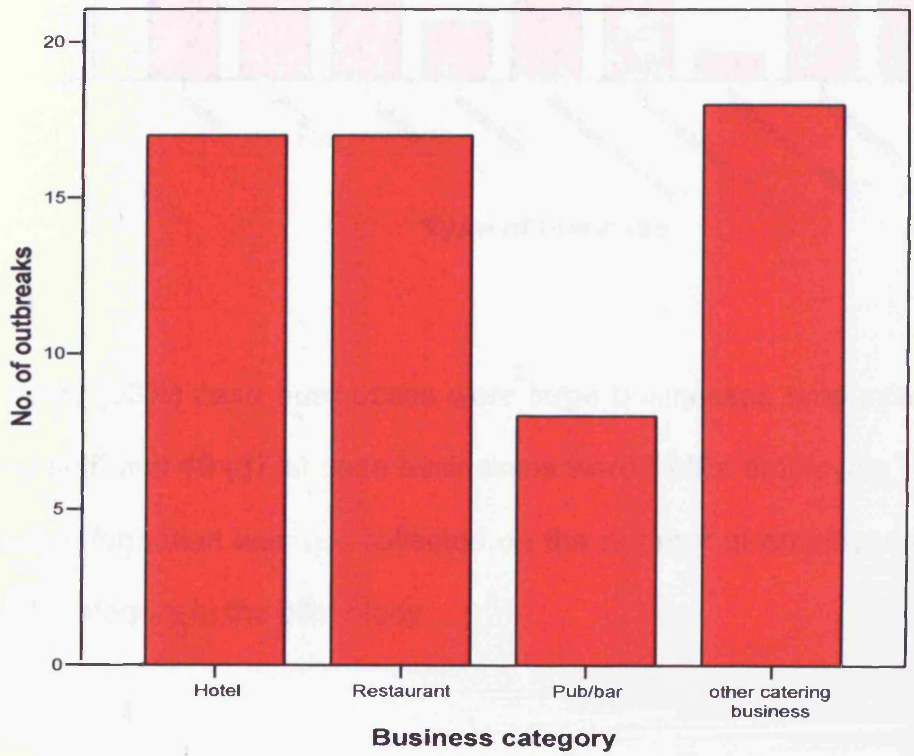
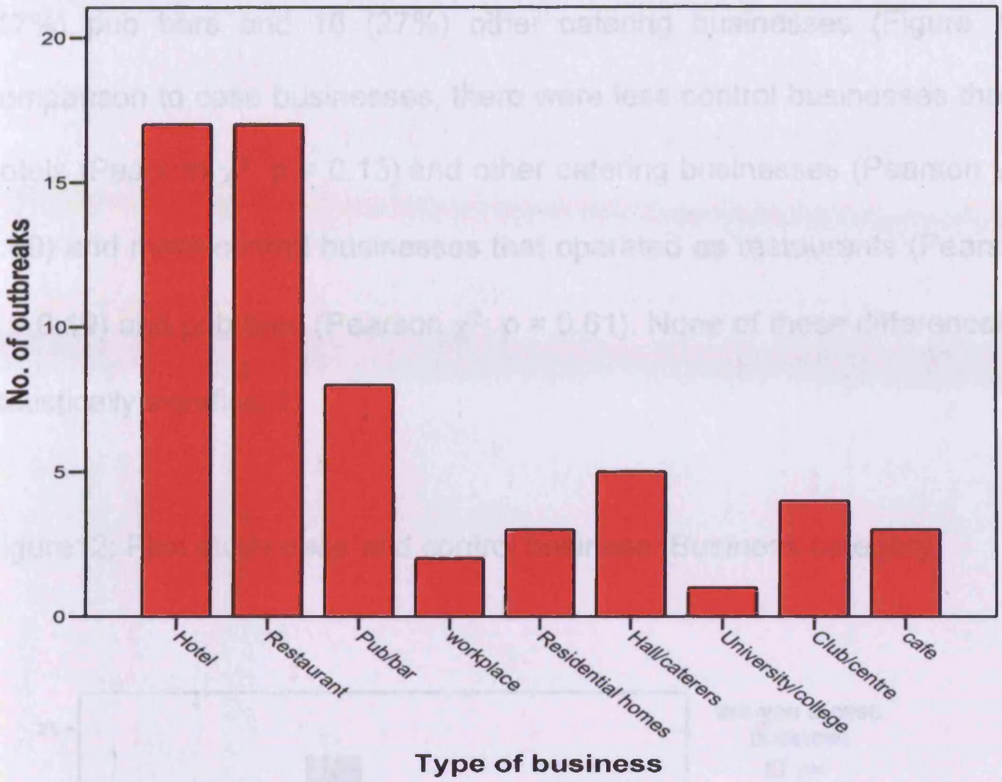


Figure 11: Pilot study outbreaks: Type of business

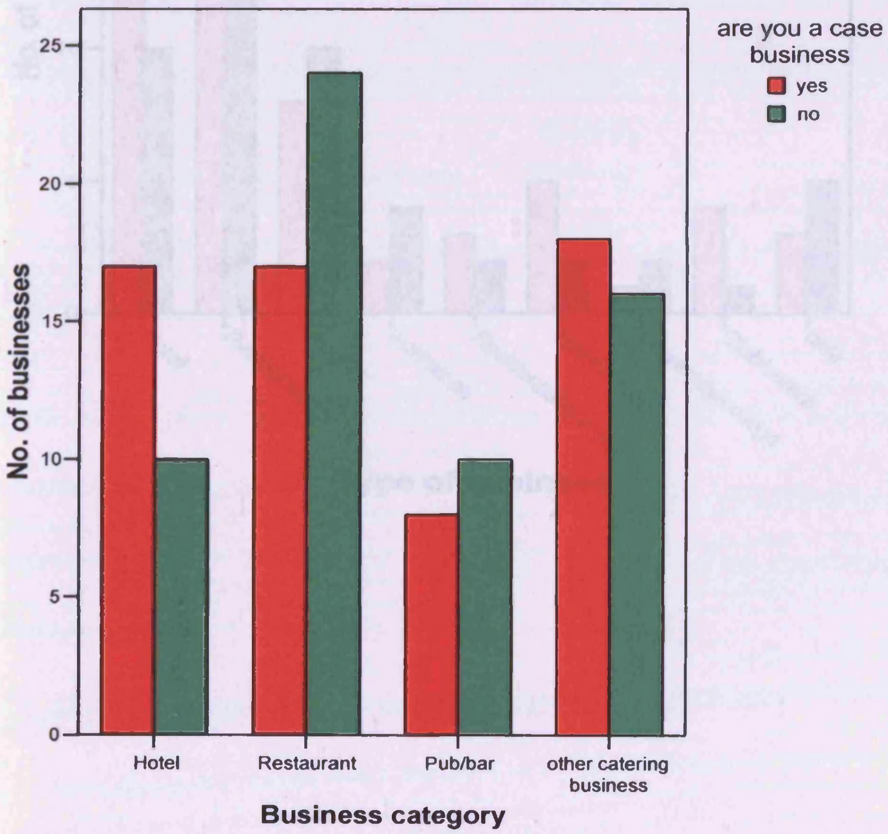


Twenty (33%) case businesses were large businesses employing more than 250 staff and 40 (67%) case businesses were SMEs employing less than 250 staff. Information was not collected on the number of employees within each SME category in the pilot study.

5.1.4 Pilot study: Control businesses by type of business

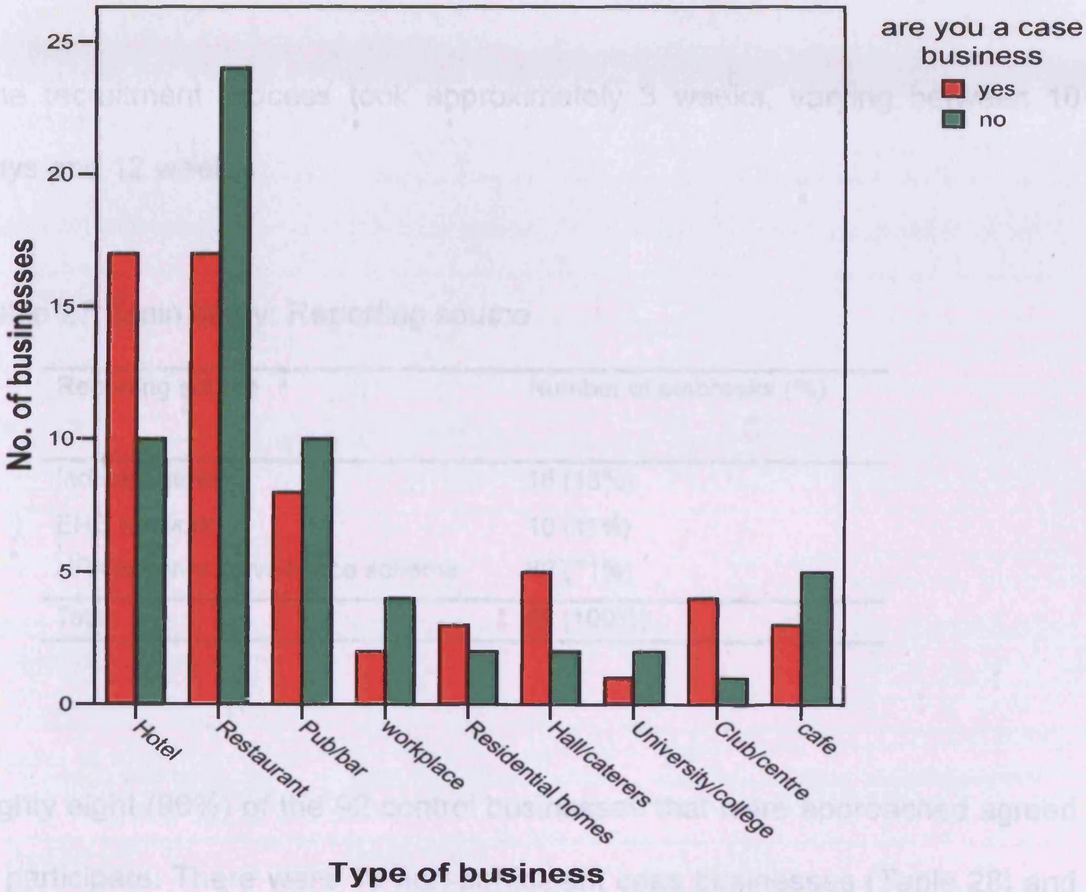
Of the 60 control businesses, 10 (17%) were hotels, 24 (40%) restaurants, 10 (17%) pub bars and 16 (27%) other catering businesses (Figure 12). In comparison to case businesses, there were less control businesses that were hotels (Pearson χ^2: p = 0.13) and other catering businesses (Pearson χ^2: p = 0.69) and more control businesses that operated as restaurants (Pearson χ^2: p = 0.19) and pub bars (Pearson χ^2: p = 0.61). None of these differences were statistically significant.

Figure12: Pilot study case and control business: Business category



The 16 other control catering businesses comprised 5 (31%) cafes, 4 (25%) workplace canteens, 2 (13%) hall/caterers, 2 (13%) universities/colleges, 2 (13%) residential care homes and 1 (6%) club/centre (Figure 13).

Figure 13: Pilot study case and control businesses: Type of business



5.2 Main study

5.2.1 Main study: Recruitment of outbreak businesses

From 1st December 2002 to 31st December 2003, 180 suspected outbreaks were identified. Of these, 98 (54%) came within the case definition and 88 (90%) participated in this study. Sixty two (71%) of the outbreaks were identified by the HPA national surveillance scheme (Table 27).

The recruitment process took approximately 3 weeks, varying between 10 days and 12 weeks.

Table 27: Main study: Reporting source

Reporting source	Number of outbreaks (%)
Industry network	16 (18%)
EHO network	10 (11%)
HPA national surveillance scheme	62 (71%)
Total	88 (100%)

Eighty eight (96%) of the 92 control businesses that were approached agreed to participate. There were 10 non-participant case businesses (Table 28) and 4 non-participant control businesses (Table 29). The case businesses had outbreaks due to *S.* Enteritidis (n = 6), *S.* Typhimurium (n = 1), VTEC O157 (n = 1), *Shigella* sonnei (n = 1) and Norovirus (n = 1).

Nine of the 10 case businesses that had declined to participate were SMEs, six were restaurants, two were commercial caterers and one was a nursing home. Of the four control businesses that declined only 1 operated as a SME catering business.

Table 28: Main study: Comparison of participating and non-participating case businesses

Business characteristic	Study businesses (%)	Non participating businesses (%)
Commercial caterer	5/88 (6%)	3/10 (30%)
Restaurant	36/88 (41%)	6/10 (60%)
Nursing Home	7/88 (8%)	1/10 (10%)
Large business	28/88 (32%)	1/10 (10%)
SME	60/88 (68%)	9/10 (90%)
Causative pathogen	**Study businesses (%)**	**Non participating businesses (%)**
S. Enteritidis	44/88 (50%)	6/10 (60%)
S. typhimurium	3/88 (3%)	1/10 (10%)
Shigella sonnei	0/88 (0%)	1/10 (10%)
VTEC 0157	0/88 (0%)	1/10 (10%)
Norovirus	30/88 (34%)	1/10 (10%)

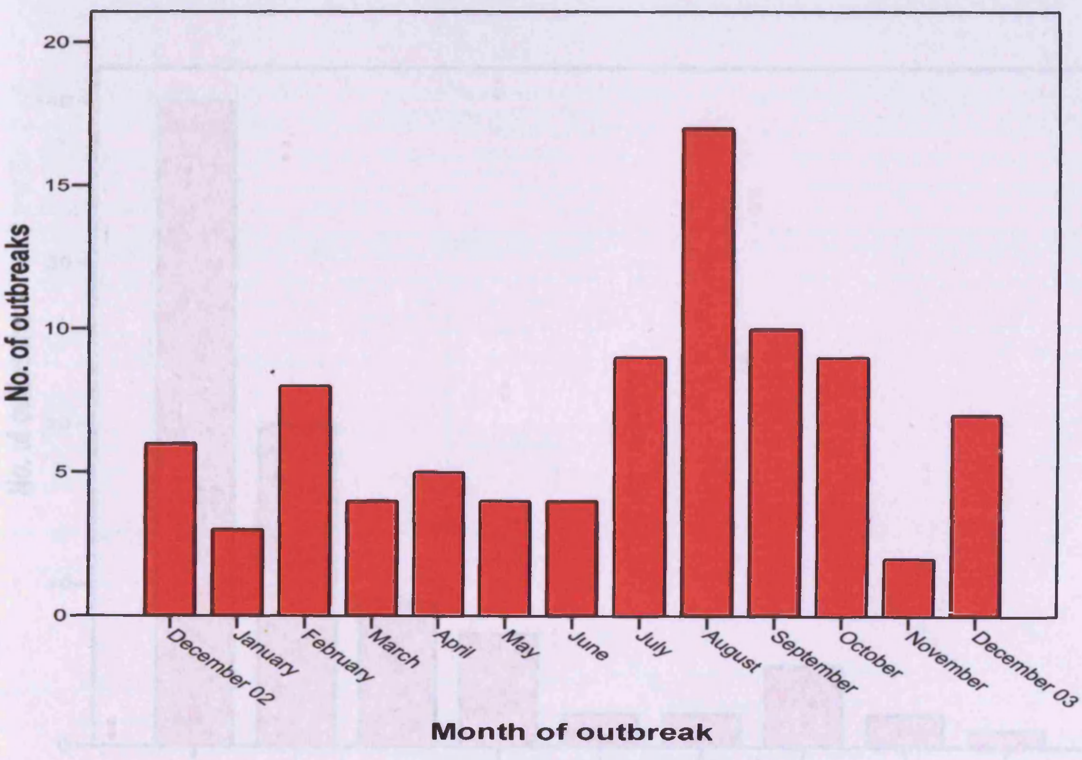
Table 29: Main study: Comparison of participating and non participating control businesses

Business characteristic	Study businesses (%)	Non participating businesses (%)
Restaurant	34/88 (39%)	1/4 (25%)
Cafes	10/88 (11%)	1/4 (25%)
Pub/bar	18/88 (25%)	1/4 (25%)
Bingo Hall	0/88 (0%)	1/4 (25%)
Large businesses	28/88 (32%)	3/4 (75%)
SME	60/88 (68%)	1/4 (25%)

5.2.2 Main study: Outbreak details

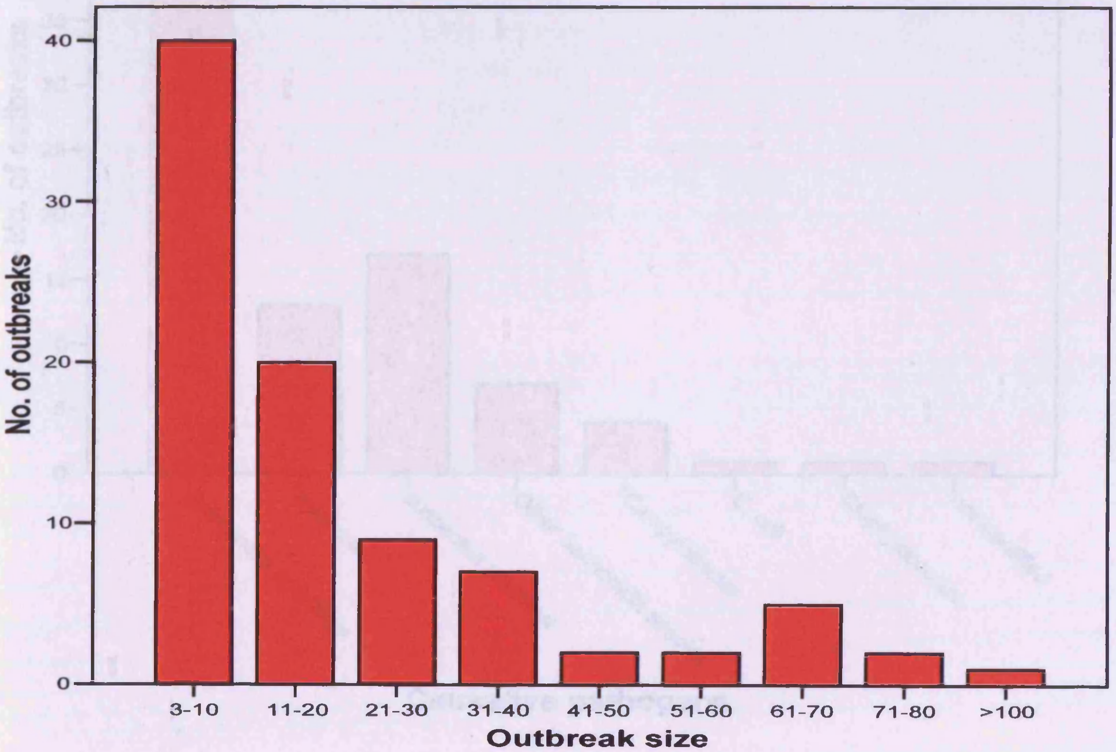
Outbreaks occurred throughout the year but there was a definite seasonal pattern. Forty five (51%) occurred between July and October (Figure 14) and 17 (19%) occurred in August. The lowest number of outbreaks occurred in January (3, 3%) and November 2003 (2, 2%).

Figure 14: Main study outbreaks: Temporal distribution



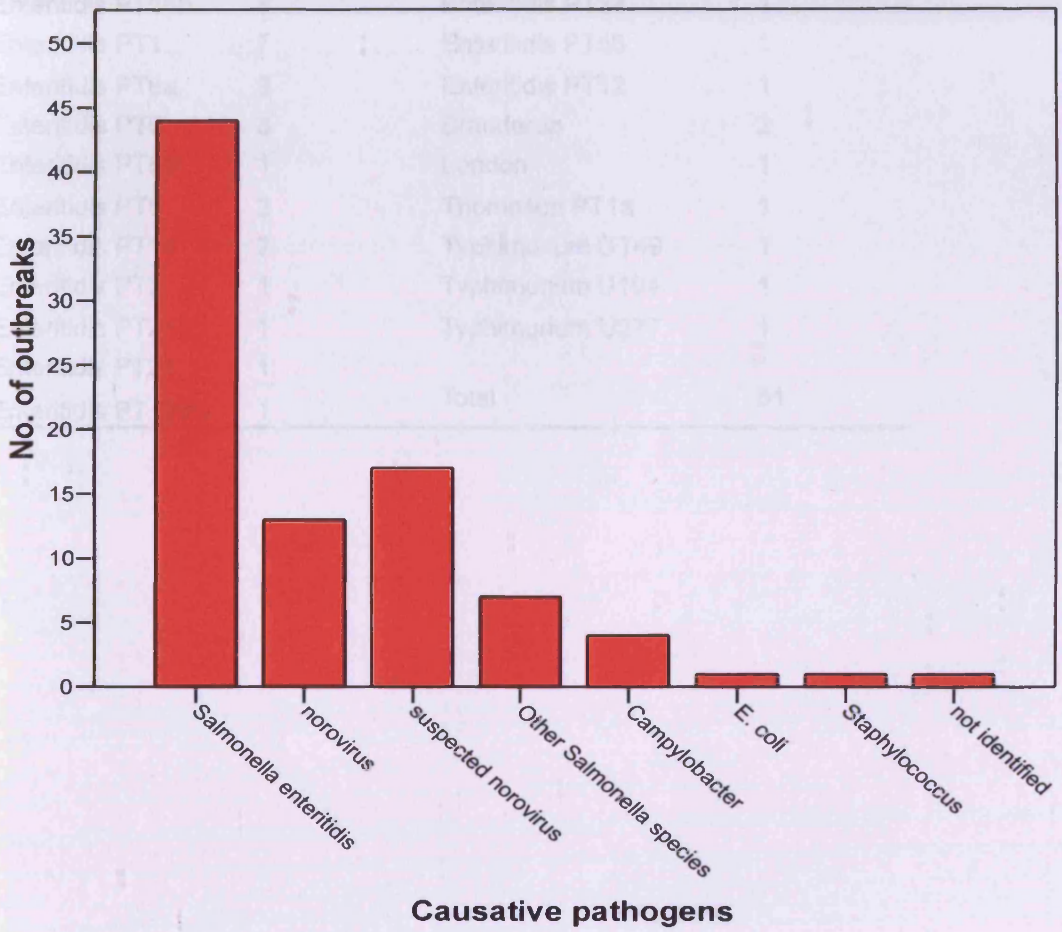
In the 88 outbreaks that took part in the main study there were reported to be 1,851 cases (mean = 21.0, median 12.0) and outbreaks ranged in size from 3 to 142 cases (Figure 15). Small outbreaks occurred with greatest frequency; 69 (78%) outbreaks had between 3 and 30 cases and 40 (45%) outbreaks had between 3 and 10 cases. Only 1 outbreak (1%) had more than 100 cases. Of the 70 (80%) microbiologically confirmed outbreaks 706 cases (mean = 10.1, median = 5.0) were laboratory confirmed.

Figure 15: Main study outbreaks: Size of outbreaks (by reported cases)



There were 58 (66%) bacterial outbreaks, of which 51 were due to *Salmonella* species, including 44 due to *S.* Enteritidis, and 4 due to *Campylobacter* (Figure 16). There were 30 presumptive Norovirus outbreaks, of which 13 (43%) were microbiologically confirmed (Figure 16).

Figure 16: Main study outbreaks: Causative pathogen



S. Enteritidis PT4 accounted for 10 (23%) of the 51 *Salmonella outbreaks* (Table 30).

Table 30: Main study outbreaks: Species of *Salmonella* and *Salmonella* Enteritidis serotypes.

Salmonella	Number of outbreaks	*Salmonella*	Number of outbreaks
Enteritidis PT4	10	Enteritidis PT1c	1
Enteritidis PT14b	8	Enteritidis PT24	1
Enteritidis PT1	7	Enteritidis PT56	1
Enteritidis PT6a	3	Enteritidis PT12	1
Enteritidis PT6	3	Branderup	2
Enteritidis PT6d	1	London	1
Enteritidis PT8	2	Thompson PT1a	1
Enteritidis PT1e	2	Typhimurium DT49	1
Enteritidis PT2	1	Typhimurium U104	1
Enteritidis PT21b	1	Typhimurium U277	1
Enteritidis PT21	1		
Enteritidis PT O9G	1	Total	51

Outbreaks occurred throughout England and Wales with a concentration in the South East (14, 16%), East (16, 16%), South West (12, 14%) and Yorkshire and Humber areas (11, 13%), (Table 31). The fewest number of outbreaks were recorded in the East Midlands (3, 3%) and Wales (5, 7%) (Figure 17).

Table 31: Main study outbreaks: Geographical region

Region	Number of Outbreaks
North East	9 (10%)
North West	4 (5%)
Yorkshire and the Humber	11 (13%)
East Midlands	3 (3%)
West Midlands	7 (8%)
South West	12 (14%)
London	7 (8%)
South East	14 (16%)
East	16 (18%)
Wales	5 (7%)
TOTAL	88 (100%)

Figure 17: Main study: outbreaks: Geographical distribution

5.2.3 Main study: Case businesses by type of business

Restaurants were the commonest type of case business with 36 cases (41%), followed by hotels with 19 (22%), other catering businesses (23, 26%) and pub bars (10, 11%), (Figure 18). The 23 other catering businesses included 6 (26%) residential care homes, 5 (22%) hall/caterers, 3 (13%) shop caterers whose secondary income was catering (that is, they made and sold food products/meals on site e.g. bakers and butchers), 3 (13%) club/centres, 2 (9%) cafes, 1 (4%) workplace, 1 (4%) hospital, 1 (4%) university/college and 1 (4%) school (Figure 19).

Figure 18: Main study outbreaks: Business category

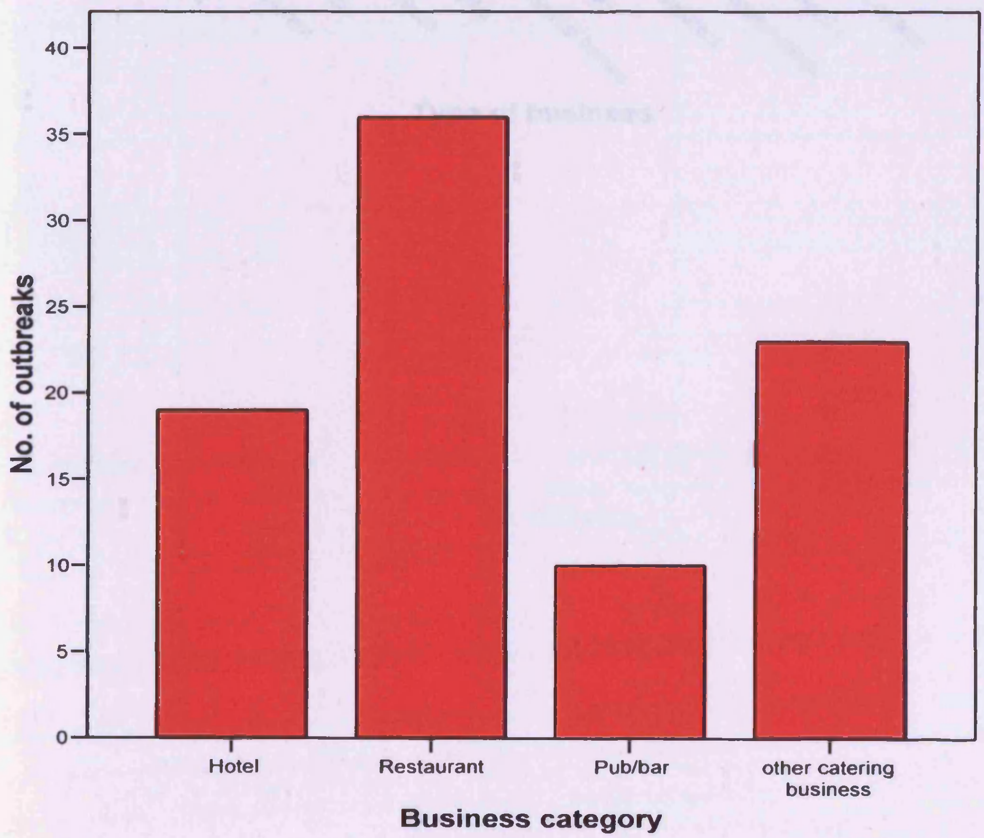
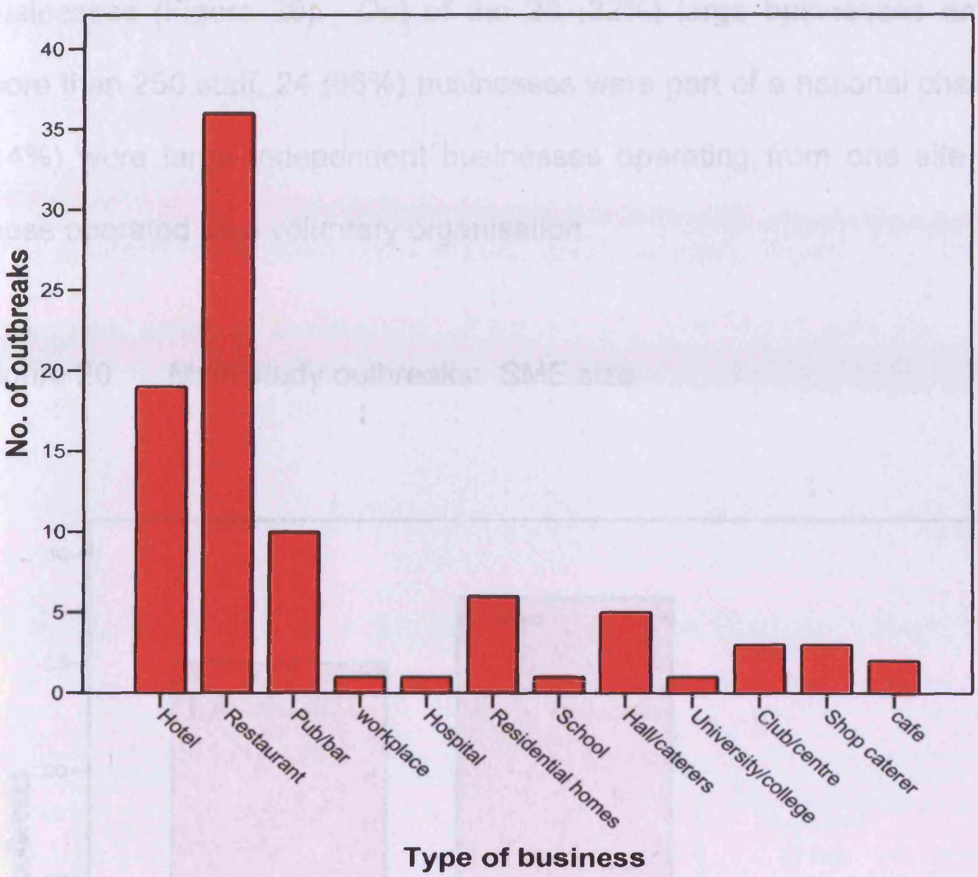
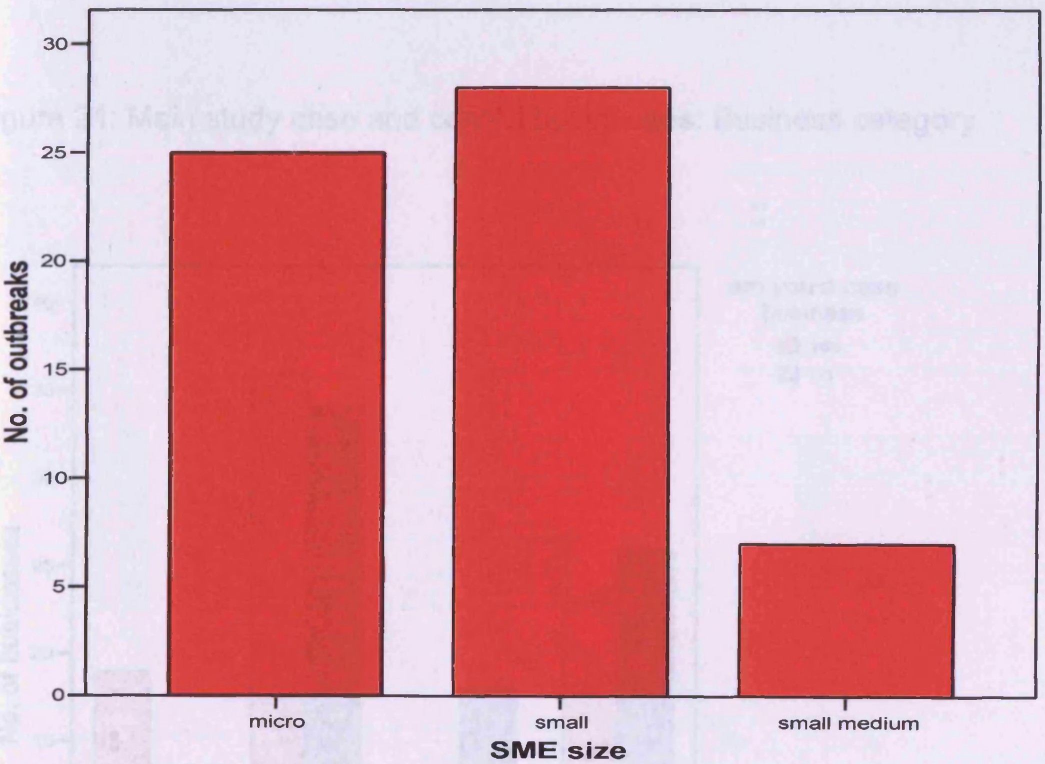


Figure 19: Main study outbreaks: Type of business



Sixty (68%) case businesses were SMEs, of which 25 (42%) were micro businesses, 28 (47%) were small businesses and 7 (11%) were small-medium businesses (Figure 20). Out of the 28 (32%) large businesses employing more than 250 staff, 24 (86%) businesses were part of a national chain and 4 (14%) were large independent businesses operating from one site, one of these operated as a voluntary organisation.

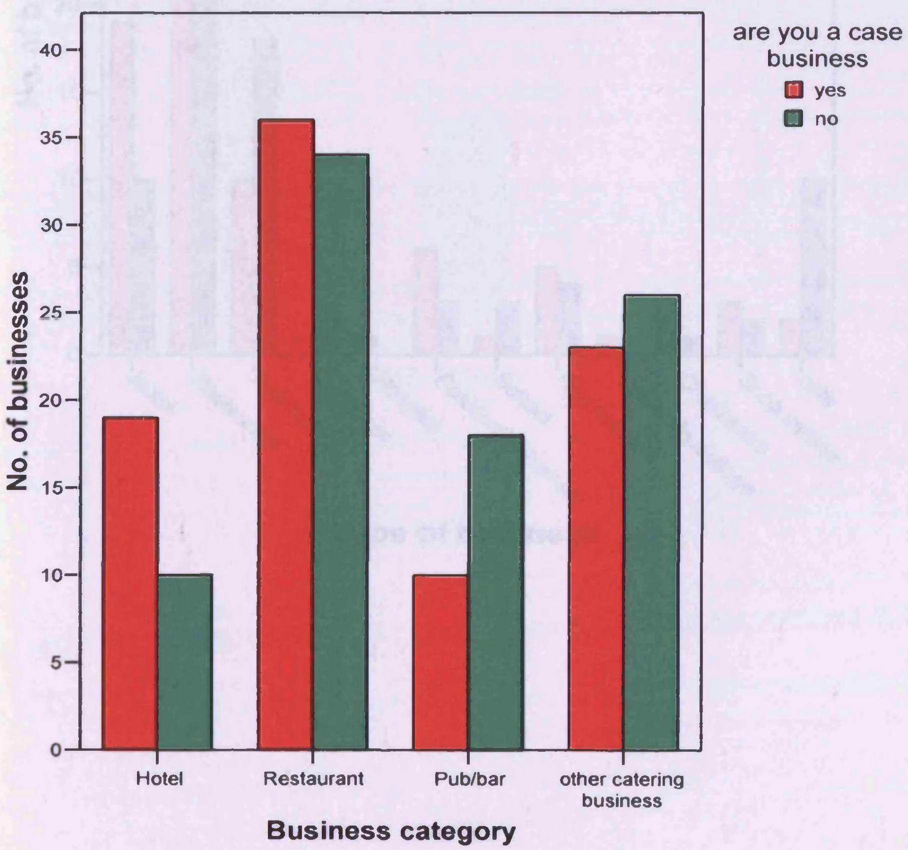
Figure 20 Main study outbreaks: SME size



5.2.4 Main study: Control businesses by type of business

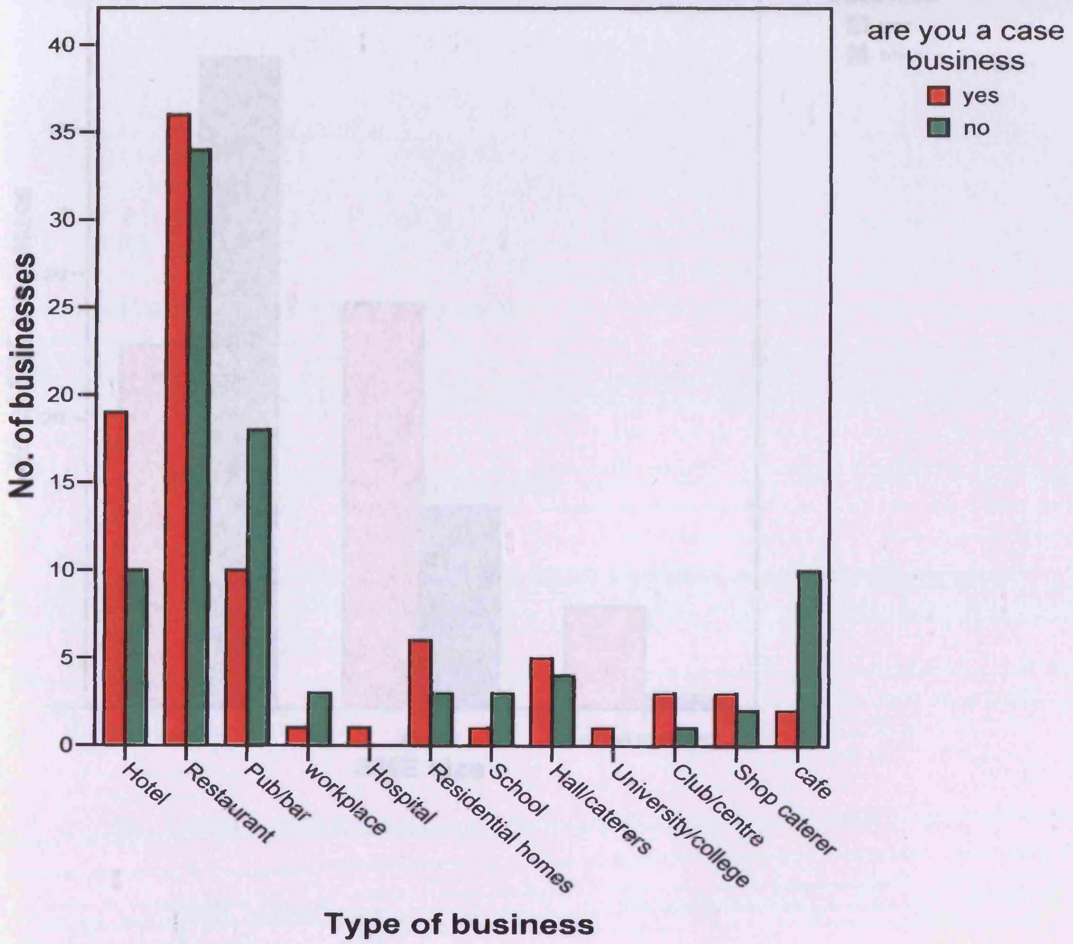
Of the 88 control businesses, 10 (11%) were hotels, 34 (39%) were restaurants, 18 (20%) were pub bars and 26 (30%) other catering businesses (Figure 21). In comparison to case businesses, there were less control businesses operating as hotels (Pearson χ^2: p = 0.07), similar numbers of case and control businesses operating as restaurants (Pearson χ^2: p = 0.76) and other catering businesses (Pearson χ^2: p = 0.61) and more control businesses operating as pub bars (Pearson χ^2: p = 0.10).

Figure 21: Main study case and control businesses: Business category



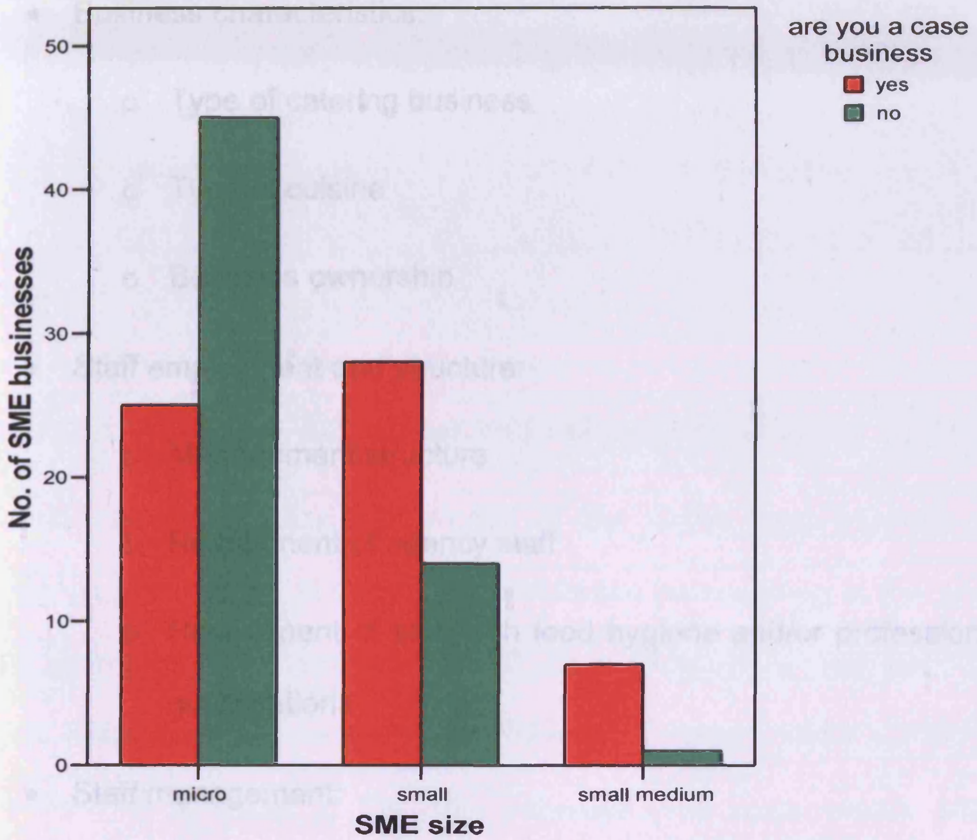
The 26 other control catering businesses comprised 10 (38%) cafes, 4 (15%) halls/caterers, 3 (12%) schools, 3 (12%) residential care homes, 3 (12%) workplace canteens, 2 (8%) shop caterers and 1 (4%) club/centre. There were no control catering businesses in universities or hospitals (Figure 22).

Figure 22: Main study case and control businesses: Type of business



Within the SME businesses there were significantly more control businesses that were micro SMEs (45, 73%, Pearson χ^2: p = 0.002) and significantly less small SMEs (14, 23%, Pearson χ^2: p = 0.01) and small medium SMEs (1, 2%, Pearson χ^2: p = 0.06) (Figure 23).

Figure 23: Main study case and control businesses: SME size



5.3 Pooling of pilot and main study data

The preceding descriptive analysis indicated that the characteristics of the pilot and main study populations were similar, therefore, where variables from the pilot and main study were identical, data from both studies were combined. Data were pooled for the following variables:

- Business characteristics:
  - Type of catering business
  - Type of cuisine
  - Business ownership
- Staff employment and structure:
  - Management structure
  - Recruitment of agency staff
  - Recruitment of staff with food hygiene and/or professional qualifications
- Staff management:
  - Communication
  - Staff incentives
- Operational practices:
  - Menu specifications
  - HACCP

The total number of cases and controls therefore varied depending on which study population had been analysed (Table 32).

Table 32: Study populations

No. of cases and controls	**Study population**
148 cases and 148 controls	Pooled data from pilot and main study
88 cases and 88 controls	Data from the main study
72 cases and 72 controls	Data from *Salmonella* outbreaks
58 cases and 58 controls	Data from viral outbreaks
100 cases and 100 controls	SME businesses from pooled data
48 cases and 48 controls	Larger businesses from pooled data

5.3.1 Interview time differences between case and control businesses

There was no significant difference in the mean days between date of outbreak and date of interview for businesses participating in the pilot study and main study (174 days versus 157 days, independent sample t test, p = 0.11). There was also no significant difference between cases and controls for the date of outbreak to the date interview (165 days versus 163 days, independent t test, p = 0.85) for all foodborne disease outbreaks.

5.4 <u>All foodborne disease outbreaks</u>

5.4.1 Univariate analysis: All foodborne disease outbreaks (n = 148)

Case businesses were significantly more likely to be a small or small medium SME rather than a micro SME, to operate as a hotel or serve Chinese cuisine and were significantly less likely to be pub bars (Table 33). Case businesses were also significantly more likely to serve dinner or be open for 10 hours. No other business characteristic variables were significantly associated with all foodborne disease outbreaks.

Table 33: All foodborne disease outbreaks: Univariate analysis of business characteristics

Variable		Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Hotel		**36/148 (24%)**	**20/148 (14%)**	**2.06 (1.13 – 3.76) p = 0.02**	**3.29 (1.41 – 7.66) p = 0.004**
Restaurant		53/148 (36%)	58/148 (39%)	0.87 (0.54 – 1.37) p = 0.55	0.83 (0.49 – 1.42) p = 0.50
Pub bar		**18/148 (12%)**	**28/148 (19%)**	**0.59 (0.31 – 1.13) p = 0.11**	**0.41 (0.17 – 0.99) p = 0.04**
Other catering business		41/148 (28%)	42/148 (28%)	0.97 (0.58 – 1.61) p = 0.90	0.96 (0.53 – 1.72) p = 0.88
Chinese cuisine		**23/148 (16%)**	**7/148 (5%)**	**3.71 (1.54 – 8.93) p = 0.002**	**5.00 (1.71 – 14.63) p = 0.001**
British cuisine		107/148 (72%)	113/148 (76%)	0.81 (0.48 – 1.36) p = 0.43	0.75 (0.41 – 1.38) p = 0.35
Indian cuisine		7/148 (5%)	11/148 (7%)	0.62 (0.23 – 1.64) p = 0.33	0.56 (0.19 – 1.66) p = 0.29
Other cuisine		11/148 (7%)	17/148 (11%)	0.62 (0.28 – 1.37) p = 0.23	0.63 (0.28 – 1.38) p = 0.24
Family business		40/148 (27%)	49/148 (33%)	0.75 (0.45 – 1.23) p = 0.25	0.61 (0.31 – 1.18) p = 0.14
Small independent business		40/148 (27%)	41/148 (28%)	0.97 (0.58 – 1.61) p = 0.90	0.95 (0.52 – 1.74) p = 0.88
Small independent business > 1 site		17/148 (11%)	9/148 (6%)	2.00 (0.86 – 4.65) p = 0.10	1.89 (0.84 – 4.24) p = 0.12
Large independent business		6/148 (4%)	3/148 (2%)	2.04 (0.50 – 1.55) p = 0.50*	- p = 0.08#
Part of a national chain		42/148 (28%)	44/148 (30%)	0.69 (0.57 – 1.55) p = 0.80	0.33 (0.03 – 3.20) p = 0.32
Voluntary organisation		3/148 (2%)	2/148 (1%)	1.51 (0.25 – 9.17) p = 1.00	2.00 (0.18 – 22.06) p = 0.56
	Micro	**25/88 (28%)**	**45/88 (51%)**	**0.38 (0.20 – 0.71) p = 0.02**	**Reference**
SME size**	**Small**	**28/88 (32%)**	**14/88 (16%)**	**2.47 (1.19 – 5.10) p = 0.01**	**9.61 (2.23 – 41.35) p = 0.002**
	Small medium	**7/88 (11%)**	**1/88 (1%)**	**7.59 (0.91 – 62.45) p = 0.06**	**33.82 (2.71 – 422.31) p = 0.006**
Breakfast		37/88 (42%)	31/88 (35%)	1.33 (0.73 – 2.45) p = 0.35	1.46 (0.72 – 2.96) p = 0.29
Lunch		79/88 (90%)	72/88 (82%)	1.95 (0.81 – 4.69) p = 0.13	2.16 (0.82 – 5.70) p = 0.11
Dinner		**79/88 (90%)**	**67/88 (76%)**	**2.75 (1.18 – 6.41) p = 0.02**	**3.00 (1.19 – 7.56) p = 0.01**
Room service[a]		18/88 (20%)	5/88 (6%)	4.27 (1.51 – 12.08) p = 0.004	5.33 (1.55 – 18.30) p = 0.003
Functions for < 20 persons		32/88 (36%)	31/88 (35%)	1.05 (0.57 – 1.95) p = 0.88	1.06 (0.54 – 2.10) p = 0.86
Functions for > 20 persons		39/88 (44%)	30/88 (34%)	1.54 (0.84 – 2.83) p = 0.17	1.56 (0.83 – 2.93) p = 0.16
Open 10 hrs continuously		**50/88 (57%)**	**37/88 (42%)**	**1.81 (1.00 – 3.30) p = 0.05**	**2.18 (1.07 – 4.45) p = 0.03**

Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.

* Fisher's exact test used as 2 cells have expected count of less than 5

Insufficient strata formed in analysis to calculate MOR

**SME size is a categorical variable where micro = 1, small = 2 and small medium = 3. Micro SME is the reference category, 2 MORs are calculated for small and small medium SMEs. These should be interpreted relative to Micro SMEs

[a] Variable is exclusive to the 'Hotel' variable and therefore not taken forward for conditional logistic regression

Case businesses were significantly more likely to have 2 tiers of management between the site manager or owner and the kitchen manager or head chef, to employ casual staff or to pay head chefs above the national average wage or employ head chefs on a salary (Table 34). Case businesses were significantly less likely to have the owner or manager working in the kitchen or employ full-time staff. There were no significant differences in the reporting of problems recruiting or retaining staff.

Table 34: All foodborne disease outbreaks: Univariate analysis of staff employment

Variable	Proportion of case exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.) p value	Matched odds ratio (95% C.I.), p value
Owner/manager work in the kitchen	**28/148 (19%)**	**51/148 (34%)**	**0.44 (0.26 – 0.76) p = 0.003**	**0.34 (0.18 – 0.66) p <0.001**
2 tiers of management before the kitchen manager/head chef	**29/148 (20%)**	**17/148 (11%)**	**1.88 (0.98 – 3.59) p = 0.05**	**2.10 (1.02 – 4.49) p = 0.04**
1 tier of management before the kitchen manager/head chef	51/148 (34%)	47/148 (32%)	1.13 (0.70 – 1.83) p = 0.62	1.19 (0.70 - 2.02) p = 0.51
3 tiers of management before the kitchen manager/ head chef	2/148 (1%)	0/148 (0%)	- p = 0.50*	- p = 0.16#
Area manager and 2 tiers of management before the kitchen manager~	21/148 (14%)	13/148 (9%)	1.72 (0.83 – 3.57) p = 0.15	2.14 (0.89 – 5.26) p = 0.09
Area manager and no tiers of management before the kitchen manager	1/148 (1%)	4/148 (4%)	0.25 (0.03 – 2.22) p = 0.37	0.25 (0.03 – 2.23) p = 0.18
Problem recruiting staff	29/88 (33%)	33/88 (38%)	0.82 (0.44 – 1.52) p = 0.53	0.80 (0.41 – 1.54) p = 0.50
Problem retaining staff	15/88 (17%)	16/88 (18%)	0.93 (0.43 – 2.01) p = 0.84	0.93 (0.44 – 1.98) p = 0.85
Recruit agency staff (kitchen)	29/148 (20%)	26/148 (18%)	1.14 (0.64 – 2.06) p = 0.65	1.19 (0.61 – 2.31) p = 0.61
Recruit staff with professional qualifications (kitchen)	38/148 (26%)	29/148 (20%)	1.42 (0.82 – 2.45) p = 0.21	1.56 (0.83 – 2.93) p = 0.16
Recruit staff with food hygiene qualifications (kitchen)	48/148 (32%)	41/148 (28%)	1.25 (0.76 – 2.06) p = 0.38	1.33 (0.76 – 2.35) p = 0.32
Recruit agency staff (F and B)	29/148 (20%)	20/148 (14%)	1.56 (0.84 – 2.91) p = 0.16	1.82 (0.87 – 3.79) p = 0.11
Recruit staff with food hygiene qualifications (F and B)	14/148 (9%)	16/148 (11%)	0.86 (0.41 – 1.84) p = 0.70	0.80 (0.38 – 1.89) p = 0.68
Casual staff employed	**33/88 (38%)**	**20/88 (23%)**	**2.04 (1.06 – 3.95) p = 0.03**	**2.08 (1.05 – 1.15) p = 0.03**
Full-time staff employed	**83/88 (94%)**	**87/88 (98%)**	**0.19 (0.02 – 1.67) p = 0.21**	**0.20 (0.02 – 1.71) p = 0.10**
All kitchen staff salaried	20/88 (23%)	14/87 (16%)	1.53 (0.72 – 3.28) p = 0.27	1.75 (0.73 – 4.17) p = 0.20
Only chefs salaried	**17/88 (19%)**	**9/87 (10%)**	**2.08 (0.87 – 4.95) p = 0.10**	**2.33 (0.90 – 6.07) p = 0.07**
Only kitchen managers salaried	12/88 (14%)	16/87 (18%)	0.70 (0.31 – 1.58) p = 0.39	0.71 (0.32 – 1.61) p = 0.41
No kitchen staff salaried	33/88 (38%)	33/87 (38%)	0.98 (0.53 – 1.81) p = 0.95	0.94 (0.48 – 1.86) p = 0.86

Head chef wages above the national average wage	**48/88 (55%)**	**30/88 (34%)**	**2.32 (1.26 – 4.26) p = 0.006**	**2.38 (1.25 – 4.56) p = 0.007**
Head chef wages below the national average~	11/88 (13%)	20/88 (23%)	0.49 (0.22 – 1.09) p = 0.08	0.50 (0.22 – 1.11) p = 0.08
Head chef wages same as the national average wage	11/88 (13%)	12/88 (14%)	0.91 (0.38 – 2.18) p = 0.82	0.91 (0.38 – 2.14) p = 0.83
All F and B staff salaried	13/87 (15%)	8/87 (9%)	1.74 (0.68 – 4.42) p = 0.25	2.67 (0.71 – 10.05) p = 0.13
Only F and B manager salaried	21/87 (24%)	13/87 (15%)	1.81 (0.84 – 3.91) p = 0.13	1.89 (0.84 – 4.23) p = 0.12
No F and B staff salaried	37/87 (43%)	39/87 (45%)	0.91 (0.50 – 1.66) p = 0.76	0.91 (0.50 – 1.67) p = 0.76

Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.

~ Variables provide duplicate or alternative information to other significant variable

* Fisher's exact test used as 2 cells have expected count of less than 5, OR could not be calculated as no controls were exposed to this variable

Insufficient strata formed in analysis to calculate MOR

Case businesses were significantly more likely to provide staff accommodation, offer staff incentives and employ staff with formal food hygiene training (Table 35). Case businesses were significantly less likely to communicate verbally on a daily basis. There were no other staff management variables significantly associated with all foodborne disease outbreaks.

Table 35: All foodborne disease outbreaks: Univariate analysis of staff management

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Pay staff for first 3 days of sick leave	41/88 (47%)	33/88 (38%)	1.45 (0.80 – 2.65) p = 0.22	1.53 (0.80 – 2.94) p = 0.19
Designated staff toilets	66/88 (75%)	61/88 (69%)	1.33 (0.69 – 2.57) p = 0.40	1.36 (0.68 – 2.71) p = 0.38
Staff use customer toilets	**47/88 (53%)**	**35/88 (40%)**	**1.74 (0.96 – 3.16) p = 0.07**	**1.75 (0.95 – 3.23) p = 0.07**
Provide staff accommodation	**27/88 (31%)**	**12/88 (14%)**	**2.80 (1.31 – 5.99) p = 0.006**	**4.00 (1.50 – 10.66) p = 0.003**
Incentives to maintain hygiene standards	48/148 (32%)	48/148 (32%)	1.00 (0.62 – 1.63) p = 1.00	1.00 (0.59 – 1.69) p = 1.00
Disincentives to maintain hygiene standards	14/148 (9%)	14/148 (9%)	1.00 (0.46 – 2.18) p = 1.00	1.00 (0.45 – 2.23) p = 1.00
Support to maintain hygiene standards	135/148 (91%)	140/148 (95%)	0.59 (0.24 – 1.48) p = 0.26	0.62 (0.26 – 1.48) p = 0.28
Good communication between front and back of house	133/148 (90%)	128/148 (86%)	1.39 (0.68 – 2.82) p = 0.37	1.42 (0.68 – 2.97) p = 0.35
Staff incentives	**62/148 (42%)**	**43/148 (29%)**	**1.76 (1.09 – 2.85) p = 0.02**	**2.12 (1.19 – 3.77) p = 0.009**
TRAINING				
Kitchen manager: induction FH training	46/88 (52%)	37/88 (42%)	1.51 (0.83 – 2.74) p = 0.17	1.75 (0.86 – 3.56) p = 0.12
Kitchen manager: basic FH training	78/88 (89%)	77/88 (88%)	1.11 (0.45 – 2.78) p = 0.82	1.13 (0.43 – 2.92) p = 0.81
Kitchen manager: intermediate FH training	**22/88 (25%)**	**8/88 (9%)**	**3.33 (1.39 – 7.98) p = 0.005**	**3.80 (1.42 – 10.18) p = 0.004**
Kitchen manager: advanced FH training	8/88 (9%)	4/88 (5%)	2.10 (0.61 – 7.25) p = 0.23	2.33 (0.60 – 9.02) p = 0.21
Kitchen manager: professional training	38/88 (43%)	29/88 (33%)	1.55 (0.84 – 2.85) p = 0.16	1.82 (0.87 – 3.79) p = 0.11
Kitchen staff: induction FH training	**46/88 (52%)**	**33/88 (38%)**	**1.83 (1.00 – 3.33) p = 0.05**	**2.18 (1.07 – 4.45) p = 0.03**
Kitchen staff: basic FH training	**59/88 (67%)**	**49/88 (56%)**	**1.62 (0.88 – 2.99) p = 0.12**	**1.91 (0.92 – 3.96) p = 0.08**
Kitchen staff: intermediate FH training	12/88 (14%)	9/88 (10%)	1.39 (0.55 – 3.48) p = 0.49	1.50 (0.53 – 4.21) p = 0.44
Kitchen staff: advanced FH training	0/88 (0%)	2/88 (2%)	- p = 0.50*	- p = 0.16#
Kitchen staff: professional training	22/88 (25%)	19/88 (22%)	1.21 (0.60 – 2.44) p = 0.59	1.25 (0.59 – 2.67) p = 0.56
F and B manager: induction FH training	30/88 (34%)	26/88 (30%)	1.23 (0.65 – 2.33) p = 0.52	1.27 (0.64 – 2.49) p = 0.49
F and B manager: basic FH training	44/88 (50%)	38/88 (43%)	1.32 (0.73 – 2.38) p = 0.36	1.38 (0.72 – 2.62) p = 0.33

F and B manager: intermediate FH training	8/88 (9%)	6/88 (7%)	1.37 (0.45 – 4.12) p = 0.58	1.40 (0.44 – 4.41) p = 0.56
F and B manager: advanced FH training	2/88 (2%)	4/88 (5%)	0.49 (0.09 – 2.74) p = 0.68	0.50 (0.09 – 2.73) p = 0.41
F and B staff: induction FH training	25/88 (28%)	23/88 (26%)	1.12 (0.58 – 2.18) p = 0.74	1.14 (0.56 – 2.34) p = 0.72
F and B staff: basic FH training	**30/88 (34%)**	**18/88 (20%)**	**2.01 (1.02 – 2.97) p = 0.04**	**2.50 (1.10 – 5.68) p = 0.02**
F and B staff: intermediate FH training	1/88 (1%)	1/88 (1%)	1.00 (0.06 – 16.24) p = 1.00*	1.00 (0.06 – 15.99) p = 1.00
F and B staff: advanced FH training	0/88 (0%)	0/88 (0%)	-	-
BUSINESS ISSUES COMMUNICATED				
Daily verbally	**52/148 (35%)**	**70/148 (47%)**	**0.60 (0.38 – 0.96) p = 0.03**	**0.58 (0.36 – 0.95) p = 0.03**
Meetings	59/148 (40%)	47/148 (32%)	1.43 (0.88 – 2.30) p = 0.15	1.56 (0.90 – 2.64) p = 0.11
Notices	22/148 (15%)	21/148 (14%)	1.06 (0.55 – 2.01) p = 0.87	1.09 (0.48 – 2.47) p = 0.83
Training	0/148 (0%)	1/148 (1%)	- p = 1.00*	- p = 0.32#
Diary	29/148 (20%)	27/148 (18%)	1.09 (0.61 – 1.96) p = 0.88	1.10 (0.59 – 2.06) p = 0.75
Not given	24/148 (16%)	22/148 (15%)	1.11 (0.59 – 2.08) p = 0.75	1.13 (0.57 – 2.21) p = 0.73
FOOD HYGIENE COMMUNICATED				
Daily verbally	75/141 (53%)	77/147 (53%)	1.03 (0.65 – 1.64) p = 0.89	1.13 (0.65 – 1.95) p = 0.67
Meetings	26/141 (18%)	26/147 (53%)	1.05 (0.58 – 1.92) p = 0.87	1.00 (0.48 – 2.10) p = 1.00
Notices	36/141 (26%)	41/147 (28%)	0.89 (0.53 – 1.50) p = 0.65	0.84 (0.47 – 1.50) p = 0.74
Training	22/141 (16%)	25/147 (17%)	0.90 (0.48 – 1.69) p = 0.75	0.89 (0.47 – 1.72) p = 0.74
Diary	3/141 (2%)	3/147 (2%)	1.04 (0.21 – 5.26) p = 1.00	1.00 (0.20 – 4.95) p = 1.00
Checks/audits	22/141 (16%)	18/147 (12%)	1.33 (0.68 – 2.59) p = 0.41	1.33 (0.63 – 2.82) p = 0.45
Not done	9/141 (6%)	11/147 (7%)	0.84 (0.34 – 2.10) p = 0.71	0.89 (0.34 – 2.30) p = 0.81

Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.
* Fisher's exact test used as 2 cells have expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR

Case businesses were significantly more likely to have prepared poultry dishes from a raw state, cook shellfish to order, reheat rice or pasta to order, or serve ice cream, red meat, vegetables and ice cream dishes prepared from raw ingredients were of borderline significance (Table 36). Case businesses were also significantly less likely to serve poultry dishes that were not prepared from raw or serve fish from a cold display, more likely to serve food from a hot display buffet and use regional suppliers rather than national or local suppliers for red meat, poultry and eggs. There were no significant differences between case and control businesses for the presence of HACCP, temperature control records, cleaning schedules or staff training records.

Table 36: All foodborne disease outbreaks: Univariate analysis of operational practices

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Menu specifications used	71/148 (48%)	64/148 (43%)	1.21 (0.77 – 1.91) p = 0.41	1.27 (0.76 – 2.12) p = 0.36
BREAD/CAKES:				
Made from raw	20/88 (23%)	15/88 (17%)	1.43 (0.68 – 3.02) p = 0.35	1.56 (0.67 – 3.59) p = 0.30
Partially prepared	22/88 (25%)	28/88 (32%)	0.71 (0.37 – 1.38) p = 0.32	0.63 (0.28 – 1.38) p = 0.24
Served	72/88 (82%)	78/88 (89%)	0.58 (0.25 – 1.35) p = 0.20	0.57 (0.24 – 1.36) p = 0.20
Cook to order	13/88 (15%)	13/88 (15%)	1.00 (0.44 – 2.30) p = 1.00	1.00 (0.43 – 2.31) p = 1.00
Cold display buffet	4/88 (5%)	1/88 (1%)	4.14 (0.45 – 37.83) p = 0.37	4.00 (0.45 – 35.79) p = 0.18
Hot display buffet	2/88 (2%)	4/88 (5%)	0.49 (0.09 – 2.74) p = 0.68	0.50 (0.09 – 2.73) p = 0.41
Ambient display buffet	36/88 (41%)	31/88 (35%)	1.27 (0.69 – 2.34) p = 0.44	1.36 (0.68 – 2.71) p = 0.38
FRUIT				
Made from raw	9/88 (10%)	8/88 (9%)	1.14 (0.42 – 3.10) p = 0.80	1.13 (0.43 – 2.92) p = 0.81
Partially prepared	39/88 (44%)	40/88 (45%)	0.96 (0.53 – 1.73) p = 0.88	0.95 (0.52 – 1.74) p = 0.88
Served	75/88 (85%)	69/88 (78%)	1.59 (0.73 – 3.46) p = 0.24	1.75 (0.73 – 4.17) p = 0.20
Cook to order	8/88 (9%)	8/88 (9%)	1.00 (0.36 – 2.80) p = 1.00	1.00 (0.32 – 3.10) p = 1.00
Cold display buffet	10/88 (11%)	6/88 (7%)	1.75 (0.61 – 5.05) p = 0.29	2.00 (0.60 – 6.64) p = 0.24
Ambient display buffet	25/88 (28%)	21/88 (24%)	1.27 (0.65 – 2.49) p = 0.49	1.40 (0.62 – 3.15) p = 0.41
VEGETABLES				
Made from raw	**27/88 (31%)**	**18/88 (20%)**	**1.72 (0.87 – 3.43) p = 0.12**	**2.50 (0.97 – 6.44) p = 0.05**
Partially prepared	61/88 (69%)	68/88 (77%)	0.66 (0.34 – 1.30) p = 0.23	0.53 (0.23 – 1.26) p = 0.14
Served	84/88 (95%)	85/88 (77%)	0.74 (0.16 – 3.41) p = 1.00*	0.75 (0.17 – 3.35) p = 0.71
Cook to order	54/88 (61%)	49/88 (56%)	1.26 (0.69 – 2.31) p = 0.59	1.26 (0.69 – 2.31) p = 0.45
Reheat to order	18/88 (20%)	21/88 (24%)	0.82 (0.40 – 1.67) p = 0.59	0.81 (0.39 – 1.69) p = 0.58
Freezer to fryer	62/88 (70%)	57/88 (65%)	1.30 (0.69 – 2.44) p = 0.42	1.38 (0.68 – 2.83) p = 0.37

Cold display buffet	1/88 (1%)	3/88 (3%)	0.33 (0.03 – 3.19) p = 0.62*	0.33 (0.03 – 3.20) p = 0.32
Hot display buffet##	36/88 (41%)	26/88 (30%)	1.65 (0.88 – 3.08) p = 0.12	2.11 (0.95 – 4.67) p = 0.06
Ambient display buffet	9/88 (10%)	7/88 (8%)	1.32 (0.47 – 3.71) p = 0.60	1.40 (0.44 – 4.41) p = 0.56
FISH				
Made from raw	40/88 (45%)	38/88 (43%)	1.10 (0.61 – 1.99) p = 0.76	1.15 (0.55 – 2.42) p = 0.71
Partially prepared	54/88 (61%)	54/88 (61%)	1.05 (0.57 – 1.92) p = 0.88	1.07 (0.53 – 2.16) p = 0.86
Served	75/88 (85%)	77/88 (88%)	0.82 (0.35 – 1.96) p = 0.66	0.78 (0.29 – 2.08) p = 0.61
Cook to order	60/88 (68%)	59/88 (67%)	1.05 (0.56 – 1.98) p = 0.87	1.06 (0.55 – 2.05) p = 0.87
Reheat to order	3/88 (3%)	6/88 (7%)	0.48 (0.12 – 1.99) p = 0.50*	0.50 (0.13 – 2.00) p = 0.32
Freezer to fryer	33/88 (38%)	34/88 (39%)	0.95 (0.52 – 1.75) p = 0.88	0.94 (0.46 – 1.89) p = 0.86
Cold display buffet	**3/88 (3%)**	**8/88 (9%)**	**0.35 (0.09 – 1.38) p = 0.12**	**0.29 (0.06 – 1.38) p = 0.10**
Hot display buffet##	30/88 (34%)	23/88 (26%)	1.46 (0.76 – 2.80) p = 0.25	2.00 (0.81 – 4.96) p = 0.13
Ambient display buffet	7/88 (8%)	5/88 (6%)	1.44 (0.44 – 4.71) p = 0.55	1.40 (0.44 – 4.41) p = 0.56
SHELLFISH				
Made from raw	26/88 (30%)	20/88 (23%)	1.43 (0.73 – 2.81) p = 0.30	1.60 (0.73 – 3.53) p = 0.24
Partially prepared	48/88 (55%)	50/88 (57%)	0.91 (0.50 – 1.65) p = 0.76	0.89 (0.47 – 1.72) p = 0.73
Served	69/88 (78%)	64/88 (73%)	1.36 (0.68 – 22.72) p = 0.38	1.42 (0.68 – 2.97) p = 0.35
Cook to order	**54/88 (61%)**	**43/88 (49%)**	**1.66 (0.91 – 3.03) p = 0.10**	**1.85 (0.94 – 3.63) p = 0.07**
Freezer to fryer	12/88 (14%)	10/88 (11%)	1.23 (0.50 – 3.02) p = 0.65	1.25 (0.49 – 3.17) p = 0.64
Cold display buffet	4/88 (5%)	5/88 (6%)	0.79 (0.21 – 3.05) p = 1.00*	0.75 (0.17 – 3.35) p = 0.71
Hot display buffet##	21/88 (24%)	8/88 (9%)	3.13 (1.30 – 7.53) p = 0.008	7.50 (1.72 – 32.80) p = 0.002
Ambient display buffet	7/88 (8%)	7/88 (8%)	1.00 (0.34 – 2.98) p = 1.00	1.00 (0.32 – 3.10) p = 1.00
POULTRY				
Made from raw	**58/88 (66%)**	**41/88 (47%)**	**2.22 (1.21 – 4.07) p = 0.01**	**3.13 (1.41 – 6.93) p = 0.003**
Partially prepared	54/88 (61%)	55/88 (63%)	0.95 (0.52 – 1.75) p = 0.88	0.93 (0.44 – 1.98) p = 0.85
Served**	**86/88 (98%)**	**78/88 (89%)**	**5.51 (1.17 – 25.94) p = 0.02**	**5.00 (1.10 – 22.82) p = 0.02**
Cook to order	54/88 (61%)	46/88 (52%)	1.45 (0.80 – 2.64) p = 0.22	1.50 (0.80 – 2.82) p = 0.21

Reheat to order	36/88 (41%)	33/88 (38%)	0.64 (1.15 – 0.63) p = 0.64	1.21 (0.60 – 2.46) p = 0.59
Freezer to fryer	12/88 (14%)	10/88 (11%)	1.23 (0.50 – 3.02) p = 0.65	1.29 (0.48 – 3.45) p = 0.62
Cold display buffet	3/88 (3%)	4/88 (5%)	0.74 (0.16 – 3.41) p = 1.00	0.67 (0.11 – 3.99) p = 0.65
Hot display buffet##	39/88 (44%)	24/88 (27%)	2.12 (1.13 – 3.99) p = 0.02	3.50 (1.41 – 8.67) p = 0.004
Ambient display buffet	12/88 (14%)	11/88 (13%)	1.11 (0.46 – 2.66) p = 0.82	1.11 (0.45 – 2.73) p = 0.82
RED MEAT				
Made from raw	**58/88 (66%)**	**48/88 (55%)**	**1.61 (0.88 – 2.96) p = 0.12**	**2.25 (0.98 – 5.17) p = 0.05**
Partially prepared	55/88 (63%)	47/88 (53%)	1.45 (0.80 – 2.65) p = 0.22	1.73 (0.82 – 3.63) p = 0.14
Served	83/88 (94%)	80/88 (91%)	1.66 (0.52 – 5.29) p = 0.39	1.75 (0.51 – 5.98) p = 0.37
Cook to order	62/88 (70%)	60/88 (68%)	1.11 (0.59 – 2.11) p = 0.74	1.14 (0.56 – 2.34) p = 0.72
Reheat to order	33/88 (38%)	35/88 (40%)	0.91 (0.50 – 1.67) p = 0.76	0.89 (0.45 – 1.74) p = 0.73
Cold display buffet	3/88 (3%)	2/88 (2%)	1.52 (0.25 – 9.31) p = 1.00	1.50 (0.25 – 8.98) p = 0.65
Hot display buffet##	39/88 (44%)	24/88 (27%)	2.12 (1.13 – 3.99) p = 0.02	3.50 (1.41 – 8.67) p = 0.004
Ambient display buffet	7/88 (8%)	7/88 (8%)	1.00 (0.34 – 2.98) p = 1.00	1.00 (0.35 – 2.85) p = 1.00
COOKED MEAT				
Made from raw	14/88 (16%)	9/88 (10%)	1.66 (0.68 – 4.07) p = 0.26	1.56 (0.67 – 3.59) p = 0.30
Partially prepared	27/88 (31%)	28/88 (32%)	0.95 (0.50 – 1.79) p = 0.87	0.95 (0.50 – 1.81) p = 0.87
Served	61/88 (69%)	61/88 (69%)	1.00 (0.53 – 1.90) p = 1.00	1.00 (0.45 – 2.23) p = 1.00
Prepare to order	11/88 (13%)	12/88 (14%)	0.91 (0.38 – 2.18) p = 0.82	0.83 (0.25 – 2.73) p = 0.76
Reheat to order	3/88 (3%)	3/88 (3%)	1.00 (0.20 – 5.10) p = 1.00	1.00 (0.20 – 4.95) p = 1.00
Cold display buffet	10/88 (11%)	12/88 (14%)	0.81 (0.33 – 1.99) p = 0.65	0.80 (0.32 – 2.03) p = 0.64
Ambient display buffet	25/88 (28%)	27/88 (31%)	0.90 (0.47 – 1.71) p = 0.74	0.87 (0.41 – 1.82) p = 0.71
PATE				
Made from raw	18/88 (14%)	12/88 (14%)	1.20 (0.52 – 2.76) p = 0.67	1.18 (0.53 – 2.64) p = 0.68
Partially prepared	8/88 (9%)	7/88 (8%)	1.16 (0.40 – 3.34) p = 0.79	1.14 (0.41 – 3.15) p = 0.80
Served	35/88 (40%)	32/88 (32%)	1.16 (0.63 – 2.13) p = 0.64	1.15 (0.63 – 2.09) p = 0.65
Prepare to order	3/88 (3%)	2/88 (2%)	1.52 (0.25 – 9.31) p = 1.00	1.50 (0.25 – 8.97) p = 0.65

Cold display buffet	5/88 (6%)	6/88 (7%)	0.82 (0.24 – 2.80) p = 0.76	0.80 (0.21 – 9.98) p = 0.74
Ambient display buffet	14/88 (16%)	10/88 (11%)	1.48 (0.62 – 3.53) p = 0.38	1.67 (0.61 – 4.59) p = 0.32
SALADS				
Made from raw	50/88 (57%)	53/88 (60%)	0.87 (0.48 – 1.58) p = 0.65	0.86 (0.46 – 1.61) p = 0.63
Partially prepared	28/88 (32%)	26/88 (30%)	1.11 (0.59 – 2.11) p = 0.74	1.13 (0.57 – 2.27) p = 0.72
Served	75/88 (85%)	76/88 (86%)	0.91 (0.39 – 2.13) p = 0.83	0.91 (0.39 – 2.14) p = 0.83
Prepare to order	23/88 (26%)	22/88 (25%)	1.06 (0.54 – 2.09) p = 0.86	1.07 (0.53 – 2.16) p = 0.86
Cold display buffet	15/88 (17%)	14/88 (16%)	1.09 (0.49 – 2.41) p = 0.84	1.11 (0.45 – 2.73) p = 0.82
Ambient display buffet	28/88 (32%)	28/88 (32%)	1.00 (0.53 – 1.89) p = 1.00	1.00 (0.53 – 1.89) p = 1.00
EGGS				
Made from raw	59/88 (67%)	53/88 (60%)	1.34 (0.73 – 2.49) p = 0.35	1.55 (0.72 – 3.30) p = 0.26
Partially prepared	38/88 (43%)	39/88 (44%)	0.96 (0.53 – 1.73) p = 0.88	0.94 (0.48 – 1.86) p = 0.86
Served	85/88 (96%)	82/88 (93%)	2.07 (0.50 – 8.57) p = 0.50*	2.00 (0.50 – 8.00) p = 0.32
Cook to order	52/88 (59%)	50/88 (57%)	1.10 (0.60 – 2.00) p = 0.76	1.11 (0.59 – 2.10) p = 0.75
Reheat to order	5/88 (6%)	2/88 (2%)	2.59 (0.49 – 13.72) p = 0.44	2.50 (0.49 – 12.89) p = 0.41
Cold display buffet	7/88 (8%)	10/88 (11%)	0.67 (0.24 – 1.86) p = 0.44	0.63 (0.20 – 1.91) p = 0.41
Hot display buffet##	25/88 (28%)	14/88 (16%)	2.10 (1.01 – 4.38) p = 0.05	3.75 (1.24 – 11.30) p = 0.01
Ambient display buffet	20/88 (23%)	18/88 (20%)	1.14 (0.56 – 2.35) p = 0.71	1.20 (0.52 – 2.78) p = 0.67
RICE/PASTA				
Made from raw	44/88 (50%)	42/88 (48%)	1.10 (0.61 – 1.98) p = 0.76	1.13 (0.57 – 2.27) p = 0.72
Partially prepared	48/88 (55%)	42/88 (48%)	1.31 (0.73 – 2.38) p = 0.37	1.40 (0.72 – 2.72) p = 0.32
Served	80/88 (91%)	77/88 (88%)	1.43 (0.55 – 3.74) p = 0.47	1.50 (0.53 – 4.21) p = 0.44
Cook to order	41/88 (47%)	39/88 (44%)	1.10 (0.61 – 1.98) p = 0.76	1.11 (0.59 – 2.06) p = 0.75
Reheat to order	**28/88 (32%)**	**16/88 (18%)**	**2.10 (1.04 – 4.24) p = 0.04**	**2.71 (1.14 – 6.46) p = 0.02**
Cold display buffet	3/88 (3%)	5/88 (6%)	0.59 (0.14 – 2.53) p = 0.72*	0.60 (0.14 – 2.51) p = 0.48
Hot display buffet##	35/88 (40%)	22/88 (25%)	1.98 (1.04 – 3.77) p = 0.04	2.86 (1.21 – 6.76) p = 0.01
Ambient display buffet	7/88 (8%)	9/88 (10%)	0.76 (0.27 – 2.14) p = 0.60	0.71 (0.23 – 2.25) p = 0.56

DESSERTS				
Made from raw	37/88 (42%)	33/88 (38%)	1.21 (0.66 – 2.21) p = 0.54	1.21 (0.66 – 2.22) p = 0.54
Partially prepared	33/88 (38%)	23/88 (26%)	1.70 (0.89 – 3.22) p = 0.11	1.63 (0.87 – 3.03) p = 0.12
Served	80/88 (91%)	75/88 (85%)	1.73 (0.68 – 4.42) p = 0.25	1.71 (0.67 – 4.35) p = 0.25
Cook to order	21/88 (24%)	16/88 (18%)	1.41 (0.68 – 2.93) p = 0.36	1.42 (0.68 – 2.97) p = 0.35
Reheat to order	2/88 (2%)	3/88 (3%)	0.66 (0.11 – 4.04) p = 1.00	0.50 (0.05 – 5.51) p = 0.56
Cold display buffet	13/88 (15%)	12/88 (14%)	1.10 (0.47 – 2.56) p = 0.83	1.11 (0.45 – 2.73) p = 0.82
Hot display buffet##	11/88 (13%)	11/88 (13%)	1.00 (0.41 – 2.44) p = 1.00	1.00 (0.35 – 2.85) p = 1.00
Ambient display buffet	25/88 (28%)	21/88 (24%)	1.27 (0.65 – 2.49) p = 0.49	1.33 (0.63 – 2.63) p = 0.45
ICE CREAM				
Made from raw	**5/88 (6%)**	**1/88 (1%)**	**5.24 (0.60 – 45.81) p = 0.21***	**5.00 (0.58 – 42.80) p = 0.10**
Partially prepared	8/88 (9%)	10/88 (11%)	0.78 (0.29 – 2.08) p = 0.62	0.71 (0.23 – 2.25) p = 0.56
Served**	**80/88 (91%)**	**66/88 (75%)**	**3.33 (1.39 – 7.98) p = 0.005**	**4.50 (1.52 – 13.30) p = 0.003**
Prepare to order	4/88 (5%)	6/88 (7%)	0.65 (0.18 – 2.39) p = 0.52	0.67 (0.19 – 2.36) p = 0.53
SAUCE				
Made from raw	38/88 (43%)	31/88 (35%)	1.40 (0.76 – 2.57) p = 0.28	1.41 (0.76 – 2.63) p = 0.27
Partially prepared	24/88 (27%)	19/88 (22%)	1.36 (0.68 – 2.72) p = 0.38	1.56 (0.67 – 3.59) p = 0.30
Served	74/88 (84%)	70/88 (80%)	1.36 (0.63 – 2.94) p = 0.43	1.36 (0.63 – 2.97) p = 0.43
Cook to order	21/88 (24%)	14/88 (16%)	1.66 (0.78 – 3.52) p = 0.19	1.78 (0.79 – 4.02) p = 0.16
Reheat to order	9/88 (10%)	9/88 (10%)	1.00 (0.38 – 2.65) p = 1.00	1.00 (0.35 – 2.85) p = 1.00
Cold display buffet	4/88 (5%)	2/88 (2%)	2.05 (0.37 – 11.48) p = 0.68*	2.00 (0.37 – 10.92) p = 0.41
Hot display buffet##	23/88 (26%)	12/88 (14%)	2.24 (1.04 – 4.85) p = 0.04	2.83 (1.12 – 7.19) p = 0.02
Ambient display buffet	4/88 (5%)	8/88 (9%)	0.48 (0.14 – 1.64) p = 0.23	0.50 (0.15 – 1.66) p = 0.25
READY MADE MEALS				
Partially Made	21/88 (24%)	24/88 (27%)	0.84 (0.42 – 1.65) p = 0.60	0.75 (0.32 – 1.78) p = 0.51
Served	25/88 (28%)	28/88 (32%)	0.85 (0.45 – 1.62) p = 0.62	0.75 (0.32 – 1.78) p = 0.51
Cook to order	14/88 (16%)	12/88 (32%)	1.20 (0.52 – 2.76) p = 0.67	1.29 (0.48 – 3.45) p = 0.62

Reheat to order	9/88 (10%)	10/88 (10%)	0.89 (0.34 – 2.31) p = 0.81	0.75 (0.17 – 3.35) p = 0.71
Freezer to fryer	1/88 (1%)	1/88 (1%)	1.00 (0.06 – 16.24) p = 1.00*	1.00 (0.06 – 15.99) p = 1.00
Cold display buffet	0/88 (0%)	0/88 (0%)	-	-
Hot display buffet	1/88 (1%)	5/88 (6%)	0.19 (0.02 – 1.67) p = 0.10*	0.20 (0.02 – 1.71) p = 0.10
Ambient display buffet	1/88 (1%)	3/88 (3%)	0.33 (0.03 – 3.19) p = 0.62*	0.33 (0.03 – 3.20) p = 0.32
MILK				
Serve	**84/88 (95%)**	**77/88 (88%)**	**3.00 (0.92 – 9.82) p = 0.06**	**3.33 (0.92 – 12.11) p = 0.05**
Cold display buffet	3/88 (3%)	6/88 (7%)	0.48 (0.12 – 1.99) p = 0.31*	0.50 (0.13 – 2.00) p = 0.32
Ambient display buffet	8/88 (9%)	9/88 (10%)	0.88 (0.32 – 2.39) p = 0.80	0.89 (0.34 – 2.30) p = 0.81
DAIRY PRODUCTS				
Made from raw	3/88 (3%)	1/88 (1%)	3.07 (0.31 – 30.11) p = 0.62*	3.00 (0.31 – 28.84) p = 0.32
Partially prepared	21/88 (24%)	18/88 (20%)	1.22 (0.60 – 2.49) p = 0.59	1.27 (0.58 – 2.80) p = 0.55
Serve	80/88 (91%)	76/88 (86%)	1.58 (0.61 – 4.07) p = 0.34	1.57 (0.67 – 4.05) p = 0.35
Prepare to order	5/88 (6%)	5/88 (6%)	1.00 (0.28 – 3.58) p = 1.00	1.00 (0.29 – 3.45) p = 1.00
Cold display buffet	8/88 (9%)	11/88 (13%)	0.70 (0.27 – 1.83) p = 0.47	0.67 (0.24 – 1.87) p = 0.44
Ambient display buffet	20/88 (23%)	14/88 (16%)	1.56 (0.73 – 3.32) p = 0.25	1.55 (0.72 – 3.30) p = 0.26
Food served from a hot display buffet	**39/88 (44%)**	**27/88 (31%)**	**1.80 (0.97 – 3.34) p = 0.06**	**2.50 (1.10 – 5.68) p = 0.02**
Poultry served only	**28/88 (32%)**	**37/88 (42%)**	**0.75 (0.46 – 1.24) p = 0.16**	**0.44 (0.18 – 1.06) p = 0.06**
Ice cream served only	**75/88 (85%)**	**65/88 (74%)**	**1.15 (0.83 – 1.61) p = 0.06**	**2.43 (1.01 – 5.86) p = 0.04**
SUPPLIERS				
Food collected from supplier~	20/88 (23%)	35/88 (40%)	0.45 (0.23 – 0.86) p = 0.02	0.38 (0.17 – 0.80) p = 0.009
NATIONAL SUPPLIERS				
Bread/cakes	43/69 (62%)	43/77 (56%)	1.31 (0.67 – 2.54) p = 0.43	1.50 (0.61 – 3.67) p = 0.37
Fruit	33/75 (44%)	29/70 (41%)	1.11 (0.58 – 2.15) p = 0.75	0.92 (0.42 – 2.02) p = 0.84
Vegetables	30/83 (36%)	36/86 (42%)	0.79 (0.42 – 1.46) p = 0.45	0.67 (0.32 – 1.38) p = 0.27
Fish	42/77 (55%)	39/77 (51%)	1.17 (0.62 – 2.20) p = 0.63	1.18 (0.53 – 2.64) p = 0.68
Shellfish	40/69 (58%)	30/64 (47%)	1.56 (0.79 – 3.10) p = 0.20	2.17 (0.82 – 5.70) p = 0.11

Poultry	35/85 (41%)	41/79 (52%)	0.65 (0.35 – 1.20) p = 0.17	0.43 (0.16 – 1.12) p = 0.07
Red meat	33/83 (40%)	35/80 (44%)	0.85 (0.46 – 1.58) p = 0.61	0.67 (0.27 – 1.63) p = 0.37
Cooked meats	32/55 (58%)	35/58 (60%)	0.91 (0.43 – 1.94) p = 0.85	0.83 (0.25 – 2.73) p = 0.76
Pate	21/27 (78%)	14/25 (56%)	2.75 (0.83 – 9.16) p = 0.09	0.83 (0.25 – 2.73) p = 0.56
Salads	29/57 (51%)	24/51 (47%)	1.17 (0.55 – 2.48) p = 0.69	1.00 (0.25 – 3.99) p = 1.00
Eggs	29/84 (35%)	37/82 (45%)	0.64 (0.34 – 1.20) p = 0.16	0.43 (0.16 – 1.12) p = 0.07
Desserts	41/69 (59%)	40/62 (65%)	0.81 (0.40 – 1.65) p = 0.55	0.67 (0.24 – 1.87) p = 0.44
Ice cream	49/76 (64%)	44/64 (69%)	0.83 (0.41 – 1.67) p = 0.59	0.77 (0.34 – 1.75) p = 0.53
Sauce	39/56 (70%)	33/48 (69%)	1.04 (0.45 – 2.40) p = 1.00	0.83 (0.25 – 2.73) p = 0.73
Ready made meals	22/25 (88%)	23/28 (82%)	1.59 (0.34 – 7.48) p = 0.71	- p = 0.32#
Milk	45/84 (54%)	46/77 (60%)	0.78 (0.42 – 1.45) p = 0.43	0.62 (0.26 – 1.48) p = 0.27
REGIONAL SUPPLIERS				
Bread/cakes	8/69 (12%)	11/77 (14%)	0.79 (0.30 – 2.09) p = 0.63	0.86 (0.29 – 2.55) p = 0.32
Fruit	9/75 (12%)	9/70 (13%)	0.92 (0.34 – 2.48) p = 0.88	1.00 (0.35 – 2.85) p = 0.78
Vegetables	17/83 (20%)	13/86 (15%)	1.45 (0.65 – 3.20) p = 0.36	1.56 (0.67 – 3.59) p = 0.30
Fish	14/77 (18%)	14/77 (18%)	1.00 (0.44 – 2.67) p = 1.00	1.00 (0.32 – 3.10) p = 0.78
Shellfish	16/69 (23%)	16/64 (47%)	0.91 (0.41 – 2.01) p = 0.81	1.00 (0.32 – 3.10) p = 1.00
Poultry	**21/85 (36%)**	**6/79 (8%)**	**3.99 (1.52 – 10.50) p = 0.003**	**4.67 (1.34 – 16.24) p = 0.008**
Red meat	**19/83 (23%)**	**7/80 (9%)**	**3.10 (1.22 – 7.84) p = 0.01**	**6.00 (1.34 – 26.81) p = 0.008**
Cooked meats	6/55 (11%)	4/58 (7%)	1.65 (0.44 – 6.21) p = 0.45	2.00 (0.37 – 10.91) p = 1.00
Pate	2/27 (7%)	1/25 (4%)	1.92 (0.16 – 22.58) p = 1.00*	- p = 1.00#
Salads	8/57 (14%)	6/51 (12%)	1.22 (0.39 – 3.80) p = 0.73	2.00 (0.50 – 8.00) p = 0.41
Eggs	**25/84 (30%)**	**7/82 (9%)**	**4.54 (1.84 – 11.22) p = 0.001**	**4.00 (1.50 – 10.66) p = 0.003**
Desserts	15/69 (22%)	9/62 (15%)	1.64 (0.66 – 4.06) p = 0.29	1.67 (0.61 – 4.59) p = 0.32
Ice cream	16/76 (21%)	12/64 (19%)	1.16 (0.50 – 2.67) p = 0.73	1.80 (0.60 – 5.37) p = 0.32
Sauce	9/56 (16%)	8/48 (17%)	0.96 (0.34 – 2.71) p = 1.00	1.34 (0.30 – 5.96) p = 0.32
Ready made meals	2/25 (8%)	1/28 (4%)	2.35 (0.20 – 27.59) p = 0.60*	-, p = 0.29#

Milk	10/84 (12%)	5/77 (6%)	1.95 (0.63 – 5.97) p = 0.24	2.00 (0.68 – 5.85) p = 0.20
LOCAL SUPPLIERS				
Bread/cakes	23/69 (35%)	28/77 (36%)	0.88 (0.44 – 1.73) p = 0.70	0.86 (0.40 – 1.85) p = 0.70
Fruit	33/75 (44%)	33/70 (47%)	0.88 (0.46 – 1.70) p = 0.70	1.00 (0.43 – 2.31) p = 1.00
Vegetables	37/83 (45)	40/86 (47%)	0.93 (0.51 – 1.70) p = 0.80	0.94 (0.49 – 1.83) p = 0.87
Fish	25/77 (32%)	26/77 (34%)	0.94 (0.48 – 1.85) p = 0.86	0.87 (0.41 – 1.82) p = 0.71
Shellfish	17/69 (25%)	20/64 (31%)	0.72 (0.34 – 1.54) p = 0.40	0.58 (0.23 – 1.48) p = 0.25
Poultry	31/85 (36%)	37/79 (47%)	0.65 (0.35 – 1.22) p = 0.18	0.60 (0.26 – 1.37) p = 0.22
Red meat	34/83 (41%)	41/80 (51%)	0.66 (0.36 – 1.23) p = 0.19	0.53 (0.23 – 1.26) p = 0.14
Cooked meats	19/55 (35%)	21/58 (36%)	0.93 (0.43 – 2.01) p = 0.85	1.00 (0.32 – 3.10) p = 1.00
Pate	5/27 (19%)	10/25 (40%)	0.34 (0.10 – 1.20) p = 0.09	0.33 (0.03 – 3.20) p = 0.32
Salads	23/57 (40%)	22/51 (43%)	0.89 (0.41 – 1.92) p = 0.77	0.86 (0.29 – 2.55) p = 0.78
Eggs	30/84 (36%)	38/82 (46%)	0.64 (0.35 – 1.20) p = 0.16	0.56 (0.25 – 1.27) p = 0.16
Desserts	15/69 (22%)	16/62 (26%)	0.80 (0.36 – 1.79) p = 0.58	0.75 (0.26 – 2.16) p = 0.59
Ice cream	12/76 (16%)	9/64 (14%)	1.15 (0.45 – 2.92) p = 0.78	0.86 (0.29 – 2.55) p = 0.78
Sauce	9/56 (16%)	10/48 (21%)	0.73 (0.27 – 1.97) p = 0.53	- p = 0.32#
Ready made meals	2/25 (8%)	4/28 (14%)	0.52 (0.09 – 3.13) p = 0.67	- p = 0.32#
Milk	30/84 (36%)	27/77 (35%)	1.03 (0.54 – 1.96) p = 0.93	1.00 (0.38 – 2.66) p = 1.00
FOOD SAFETY				
HACCP verbal	21/148 (14%)	25/148 (17%)	0.81 (0.43 – 1.53) p = 0.52	1.39 (0.82 – 2.36) p = 0.22
HACCP written	83/148 (56%)	73/148 (49%)	1.31 (0.83 – 2.07) p = 0.24	0.81 (0.43 – 1.53) p = 0.51
Temperature control records	68/88 (77%)	65/88 (74%)	1.20 (0.60 – 2.40) p = 0.60	1.38 (0.55 – 3.42) p = 0.49
Cleaning schedule records	57/88 (65%)	54/88 (61%)	1.16 (0.63 – 2.14) p = 0.64	1.21 (0.60 – 2.46) p = 0.59
Staff training records	55/88 (63%)	59/88 (67%)	0.82 (0.44 – 1.52) p = 0.53	0.75 (0.35 – 1.59) p = 0.45

Denominators vary depending on the number of cases and controls that used the food or supplier
Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.

~ Variable provide alternative information to other significant variables
* Fisher's exact test where 2 cells have expected count of less than 5
# insufficient strata within the analysis to calculate MOR
##Variables collapsed into a single variable 'food served from a hot display'
** Variable was refined to 'serve only'

Case businesses were significantly more likely to have a relief manager on duty at the time of the outbreak or have reported a change in kitchen practices (Table 37).

Table 37: All foodborne disease outbreaks: Univariate analysis of unusual events

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Short staffed	17/148 (11%)	12/148 (8%)	1.47 (0.68 – 3.20) p = 0.33	1.50 (0.67 – 3.34) p = 0.32
Relief manager on duty~~	**19/148 (13%)**	**2/148 (1%)**	**10.75 (2.46 – 47.05) p <0.001**	**18.00 (2.40 – 134.83) p <0.001**
Recently installed food preparation equipment used	4/148 (3%)	3/148 (2%)	1.34 (0.30 – 6.11) p = 1.00*	1.33 (0.30 – 5.96) p = 0.71
Food preparation equipment due a service	3/148 (2%)	4/148 (3%)	0.75 (0.16 – 3.39) p = 1.00*	0.75 (0.17 – 3.35) p = 0.71
Food preparation equipment not working properly	9/148 (6%)	4/148 (3%)	2.33 (0.70 – 7.74) p = 0.16	2.25 (0.69 – 7.31) p = 0.17
Food preparation equipment breakdown	9/148 (6%)	5/148 (3%)	1.85 (0.61 – 5.66) p = 0.27	2.00 (0.60 – 6.64) p = 0.25
Change to kitchen practices~~	**23/148 (16%)**	**4/148 (4%)**	**6.62 (2.23 – 19.67) p < 0.001**	**19.00 (2.54 – 141.93) p< 0.001**
Change or new menu	12/148 (8%)	12/148 (8%)	1.00 (0.43 – 2.30) p = 1.00	1.00 (0.42 – 2.40) p = 1.00
Promotions on offer	11/148 (7%)	7/148 (5%)	1.62 (0.61 – 4.29) p = 0.33	1.57 (0.61 – 4.05) p = 0.35
Power cut	0/148 (0%)	4/148 (3%)	- p = 0.12*	- p = 0.05#
Water disturbance	2/148 (1%)	2/148 (1%)	1.00 (0.14 – 7.20) p = 1.00*	1.00 (0.14 – 7.10) p = 1.00

Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.
*Fisher's exact test used as 2 cells have an expected count less than 5
Insufficient strata within the analysis to calculate MOR
~~ Variable was placed in the most appropriate management hypothesis group for conditional logistic regression: Relief manager in staff employment and changes in kitchen practices in operational practices.

There were no significant differences between case and control businesses for any of the exploratory variables (Table 38).

Table 38: All foodborne disease outbreaks: Univariate analysis of exploratory variables

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Bookings taken	69/88 (74%)	64/88 (73%)	1.36 (0.68 – 2.72) p = 0.38	1.38 (0.68 – 2.83) p = 0.37
Catering main business	66/88 (75%)	68/88 (77%)	0.88 (0.44 – 1.77) p = 0.72	0.83 (0.36 – 1.93) p = 0.67
Independent consultants used	23/88 (26%)	21/88 (24%)	1.13 (0.57 – 2.24) p = 0.73	1.22 (0.51 – 2.95) p = 0.65
Premises on mains water supply	88/88 (100%)	86/88 (98%)	- p = 0.50*	- p = 0.16#
Good relationship with EHO	77/88 (88%)	84/88 (95%)	0.33 (0.10 – 1.09) p = 0.06	0.36 (0.12 – 1.14) p = 0.07
Opening hours different at time of outbreak	2/88 (2%)	7/88 (8%)	0.27 (0.05 – 1.33) p = 0.17*	0.29 (0.06 – 1.38) p = 0.10

*Fisher's exact test used as 2 cells have an expected count less than 5
Insufficient strata within the analysis to calculate MOR

5.4.2 Multivariate analysis: All foodborne disease outbreaks

Variables that were significant at the 10% level and did not provide duplicate or alternative information to another significant variable and did not comprise small numbers of cases and control were taken forward for multivariate analysis.

Significant variables were adjusted for potential confounders within their hypothesis group. Business characteristic, staff employment and staff management variables that remained independently significant at the 5% level were then placed in a staff management practices model and adjusted for each other. The operational practices variables were first adjusted within their specific preparation types and variables significant at the 5% level were then placed in a food preparation methods model. The food supplier variables were placed in supplier model and all remaining independently significant operational practices were then placed in a final model with the remaining independently significant staff management variables.

The same method of multivariate analysis was repeated for subsets of the data: outbreaks associated SME businesses and outbreaks associated with larger businesses, and outbreaks caused by *Salmonella*s and viruses.

Business characteristics

Six significant business characteristic variables: hotel, pub bar, Chinese cuisine, SME size, dinner and open for 10 hours or more continuously were placed in a conditional logistic regression model. SME size was the only risk factor that remained independently significant (Table 39).

Table 39: All foodborne disease outbreaks: Conditional logistic regression analysis of business characteristics

Variable		Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Hotel		3.29 (1.41 – 7.66) p = 0.004	2.55 (0.72 – 9.11) p = 0.15
Pub bar		0.41 (0.17 – 0.99) p = 0.04	0.44 (0.11 – 1.85) p = 0.27
Chinese cuisine		5.00 (1.71 – 14.63) p = 0.001	2.43 (0.67 – 8.87) p = 0.18
	Micro	**Reference**	**Reference**
SME size	**Small**	**9.61 (2.23 – 41.35) p = 0.002**	**8.59 (1.73 – 42.53) p = 0.008**
	Small medium	**33.82 (2.71 – 422.31) p = 0.006**	**24.41(1.59 – 375.57) p = 0.02**
Dinner		3.00 (1.19 – 7.56) p = 0.01	1.79 (0.60 – 5.32) p = 0.30
Open 10 hrs continuously		2.18 (1.07 – 4.45) p = 0.03	0.99 (0.39 – 2.50) p = 0.99

Bold variables are significant at the 5% level when adjusted within their hypothesis group

Staff employment

There were 7 significant staff employment variables entered into a logistic regression model: Owner or manager working in the kitchen, 2 tiers of management before the head chef, a relief manager on duty at the time of the outbreak, employing full-time staff, causal staff, providing the chefs with a salary and paying the head chef wages above the national average. Employing casual staff and having the owner or manager working in the kitchen were the only staff employment risk factors that remained independently significant in conditional logistic regression (Table 40).

Table 40: All foodborne disease outbreaks: Conditional logistic regression analysis of staff employment

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Owner/manager working in the kitchen	**0.34 (0.18 – 0.66) p <0.001**	**0.30 (0.10 – 0.91) p = 0.03**
2 tiers of management before head chef	2.10 (1.02 – 4.29) p = 0.04	0.66 (0.15 – 2.85) p = 0.58
Relief manager on duty	18.00 (2.40 – 134.83) p <0.001	6.50 (0.66 – 63.74) p = 0.11
Full-time staff employed	0.20 (0.02 – 1.71) p = 0.10	0.19 (0.02 – 1.86) p = 0.15
Casual staff employed	**2.08 (1.05 – 1.15) p = 0.03**	**2.34 (1.01 – 5.41) p = 0.05**
Only chefs salaried	2.33 (0.90 – 6.07) p = 0.07	2.18 (0.67 – 7.11) p = 0.20
Head chefs wages above national average wage	2.38 (1.25 – 4.56) p = 0.007	1.83 (0.80 – 4.19) p = 0.15

Bold variables are significant at the 5% level when adjusted within their hypothesis group

Staff management

Eight significant variables were placed in the staff management model: Staff incentives, daily verbal communication, provision of staff accommodation, staff use of customer toilets, the kitchen manager with intermediate food hygiene training, kitchen staff received induction training, kitchen staff and food and beverage (F&B) staff received basic food hygiene. The provision of staff accommodation and the presence of a kitchen manager trained to intermediate level in food hygiene remained independently significant risk factors (Table 41).

Table 41: All foodborne disease outbreaks: Conditional logistic regression analysis of staff management

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Staff incentives given	2.12 (1.19 – 3.77) p = 0.009	1.34 (0.55 – 3.24) p = 0.52
Daily verbal communication	0.58 (0.36 – 0.95) p = 0.03	0.77 (0.36 – 1.65) p = 0.51
Provision of staff accommodation	**4.00 (1.50 – 10.66) p = 0.003**	**3.45 (1.08 – 11.00) p = 0.04**
Staff use customer toilets	1.75 (0.95 – 3.23) p = 0.07	1.96 (0.93 – 4.13) p = 0.08
Kitchen manager received intermediate food hygiene training	**3.80 (1.42 – 10.18) p = 0.004**	**3.92 (1.15 – 13.35) p = 0.03**
Kitchen staff received induction training	2.18 (1.07 – 4.45) p = 0.03	1.92 (0.74 – 4.96) p = 0.18
Kitchen staff received basic food hygiene training	1.91 (0.92 – 3.96) p = 0.08	1.81 (0.74 – 4.42) p = 0.19
F and B staff received basic food hygiene training	2.50 (1.10 – 5.68) p = 0.02	2.49 (0.94 – 6.57) p = 0.07

Bold variables are significant at the 5% level when adjusted within their hypothesis group

Combined model of independently significant staff management practices

The five independently significant variables were placed in the final combined model: SME size, casual staff, owner or manager working in the kitchen, provision of staff accommodation and kitchen manager with intermediate food hygiene training. SME size and the provision of staff accommodation remained independently significant risk factors (Table 42).

Table 42: All foodborne disease outbreaks: Conditional logistic regression analysis of independently significant staff management practices

Variable		AOR within hypothesis group
	Micro	**Reference**
SME size	**Small**	**6.70 (1.31 – 34.11) p = 0.02**
	Small medium	**14.77 (1.01 – 215.27) p = 0.05**
Casual staff		1.82 (0.83 – 4.00) p = 0.13
Owner or manager working in the kitchen		0.68 (0.22 – 2.18) p = 0.05
Provision of staff accommodation		**3.27 (1.01 – 10.63) p = 0.05**
Kitchen manager trained to intermediate food hygiene		2.13 (0.72 – 6.31) p = 0.17

Bold variables are significant at the 5% level when adjusted within their hypothesis group.

Operational practices

Vegetables, poultry, red meat and ice cream prepared from a raw state were placed in a logistic regression model and poultry dishes prepared from raw remained independently significant (Table 43). In a model of foods that were not prepared from raw: poultry, milk and ice cream, none remained significantly independent and in a model of fish served from a cold display, shellfish cooked to order and rice or pasta reheated to order, only rice or pasta reheated to order remained significantly independent (Table 43). Changes in kitchen practices and foods served from a hot display were then placed in the food preparation methods model with the independently significant variables: poultry prepared from raw, rice or pasta reheated to order. Poultry made from raw, rice or pasta reheated to order and foods served from a hot display remained independently significant (Table 43).

In the food supplier model of regional eggs supplier, regional red meat supplier and poultry supplier, regional egg supplier remained independently significant (Table 43).

Table 43: All foodborne disease outbreaks: Conditional logistic regression analysis of operational practices

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group	AOR within food preparation methods
FOOD PREPARATION METHODS			
Vegetables made from raw	2.50 (0.97 – 6.44) p = 0.05	2.25 (0.74 – 6.81) p = 0.15	
Poultry made from raw	**3.13 (1.41 – 6.93) p = 0.003**	**11.55 (1.32 – 101.11) p = 0.03**	**3.36 (1.01 – 5.49) p = 0.05**
Red meat made from raw	2.25 (0.98 – 5.17) p = 0.05	0.17 (0.02 – 1.74) p = 0.14	
Ice cream made from raw	5.00 (0.58 – 42.80) p = 0.10	3.26 (0.35 – 30.24) p = 0.30	
Milk served	0.33 (0.92 – 12.11) p = 0.05	2.22 (0.57 – 8.72) p = 0.25	
Ice cream served only	4.50 (1.52 – 13.30) p = 0.003	2.11 (0.82 – 5.41) p = 0.12	
Poultry served only	5.00 (1.10 – 22.82) p = 0.02	0.44 (0.18 – 1.11) p = 0.08	
Fish served from a cold display	0.29 (0.06 1.38) p = 0.10	0.28 (0.06 – 1.41) p = 0.12	
Shellfish cooked to order	1.85 (0.94 – 3.63) p = 0.07	1.46 (0.71 – 2.97) p = 0.30	
Rice/pasta reheated to order	**2.71 (1.41 – 6.46) p = 0.02**	**2.64 (1.08 – 6.46) p = 0.03**	**2.99 (1.09 – 8.18) p = 0.03**
Food served from a hot display	**2.50 (1.10 – 5.68) p = 0.02**	**-**	**2.74 (1.05 – 7.10) p = 0.04**
Change in kitchen practices	19.00 (2.54 – 141.93) p < 0.001	-	3.38e+07, p = 0.99#
SUPPLIERS			
Regional red meat supplier	6.00 (1.34 – 26.81) p = 0.008	0.56 (0.03 – 9.96) p = 0.70	
Regional poultry supplier	4.67 (1.34 – 16.24) p = 0.008	4.61 (0.47 – 45.63) p = 0.19	
Regional egg supplier	**4.00 (1.50 – 10.66) p = 0.003**	**3.07 (1.03 – 9.09) p = 0.04**	

Bold variables are significant at the 5% level when adjusted within their hypothesis group
Too few outbreaks available to examine the independent effect of this risk factor in conditional logistic regression

Final model of independently significant operational practices

SME size, regional egg supplier, food served from a hot display, rice or pasta reheated to order and poultry prepared and cooked from raw were placed in the final conditional logistic regression model. SME size was the only risk factor independently associated with foodborne disease outbreaks (Table 44).

Table 44: All foodborne disease outbreaks: Conditional logistic regression analysis of independently significant operational practices.

Variable		AOR within hypothesis group
	Micro	**Reference**
SME size	**Small**	**4.73 (0.90 – 24.96) p = 0.07**
	Small medium	**15.13 (1.16 – 197.04) p = 0.04**
Regional egg supplier		2.90 (0.96 – 8.74) p = 0.06
Food served from a hot display		2.12 (0.59 – 7.62) p = 0.25
Rice/pasta reheated to order		2.36 (0.79 – 7.06) p = 0.12
Poultry prepared and cooked from raw		2.29 (0.87 – 6.01) p = 0.09

5.5 Outbreaks associated with SME businesses

5.5.1 Univariate analysis: Outbreaks associated with SME businesses (n = 100)

The results of univariate analysis were similar to those of all foodborne outbreaks. Case businesses were significantly more likely to be a larger SME than a micro SME, serve Chinese cuisine or operate for more than 10 hours continuously and significantly less likely to be a pub bar (Table 45). No other business characteristic variables were significantly associated with outbreaks in SME businesses.

Table 45: SME businesses: Univariate analysis of business characteristics

Variable		Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Hotel		17/100 (17%)	13/100 (13%)	1.37 (0.63 – 3.00) p = 0.55	1.80 (0.60 – 5.37) p = 0.29
Pub bar		**4/100 (4%)**	**13/100 (13%)**	**0.28 (0.09 – 0.89) p = 0.02**	**0.10 (0.01 – 0.78) p = 0.006**
Chinese cuisine		**23/100 (23%)**	**7/100 (7%)**	**3.97 (1.62 – 9.75) p = 0.002**	**5.00 (1.71 – 14.63) p = 0.001**
	Micro	**25/60 (42%)**	**45/60 (75%)**	**0.24 (0.11 – 0.52) p <0.001**	**Reference**
SME size**	**Small**	**28/60 (47%)**	**14/60 (23%)**	**2.88 (1.31 – 6.30) p = 0.007**	**9.61 (2.23 – 41.35) p = 0.002**
	Small medium	**7/60 (12%)**	**1/60 (2%)**	**7.79 (0.93 – 64.43) p = 0.06***	**33.82 (2.71 – 422.31) p = 0.006**
Dinner		51/60 (85%)	48/60 (80%)	1.42 (0.55 – 3.66) p = 0.47	1.50 (0.53 – 4.21) p = 0.44
Open 10 hrs continuously		**28/60 (47%)**	**20/60 (33%)**	**1.75 (0.84 – 3.66) p = 0.14**	**2.14 (0.87 – 5.26) p = 0.09**

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls
* Fisher's exact test used where 2 cells have an expected count of less than 5
**SME size is a categorical variable where micro = 1, small = 2 and small medium = 3. Micro SME is the reference category, 2 MORs are calculated for small and small medium SMEs. These should be interpreted relative to Micro SMEs

Case businesses were significantly more likely to have 2 tiers of management between the site manager or owner and the kitchen manager, have a relief manager on duty at the time of the outbreak, to employ casual staff or to pay the head chef's wages above the national average (Table 46). Case businesses were significantly less likely to have the owner or manager working in the kitchen. No other staff employment variables were significantly associated with outbreaks in SME businesses.

Table 46: SME businesses: Univariate analysis of staff employment

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Owner/manager work in the kitchen	**28/100 (28%)**	**51/100 (51%)**	**0.37 (0.21 – 0.67) p = 0.001**	**0.34 (0.18 – 0.66) p <0.001**
2 tiers of management before the kitchen manager/chef	**20/100 (20%)**	**10/100 (10%)**	**2.25 (0.99 – 5.09) p = 0.05**	**2.67 (1.04 – 6.81) p = 0.03**
Relief manager	**11/100 (11%)**	**1/100 (1%)**	**12.24 (1.55 – 96.68) p = 0.003**	**11.00 (1.42 – 85.20) p = 0.004**
Casual staff employed	**23/100 (23%)**	**14/100 (14%)**	**2.04 (0.92 – 4.51) p = 0.07**	**2.00 (0.90 – 4.45) p = 0.08**
Full-time staff employed	56/60 (93%)	59/60 (98%)	0.24 (0.03 – 2.19) p = 0.36	0.25 (0.18 – 0.03) p = 0.18
Only chefs salaried	8/60 (13%)	6/60 (10%)	1.36 (0.44 – 4.19) p = 0.59	1.50 (0.42 – 5.32) p = 0.52
Head chef wages above national average	**28/60 (47%)**	**16/60 (7%)**	**2.41 (1.12 – 5.17) p = 0.02**	**2.33 (1.07 – 5.09) p = 0.03**

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.

Case businesses were significantly more likely to provide staff accommodation, offer staff incentives or have staff with formal food hygiene training (Table 47). Case businesses were significantly less likely to communicate verbally on a daily basis. There were no significant staff management variables.

Table 47: SME businesses: Univariate analysis of staff management

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Staff use customer toilets	33/60 (55%)	26/60 (43%)	1.60 (0.78 – 3.29) p = 0.20	1.70 (0.78 – 3.71) p = 0.18
Provide staff accommodation	**17/60 (28%)**	**7/60 (12%)**	**2.99 (1.14 – 7.88) p = 0.02**	**3.50 (1.15 – 10.63) p = 0.02**
Staff incentives	**30/100 (30%)**	**15/100 (15%)**	**2.43 (1.21 – 4.87) p = 0.01**	**2.50 (1.20 – 5.21) p = 0.01**
Kitchen manager: intermediate FH training	**13/60 (22%)**	**5/60 (8%)**	**3.04 (1.01 – 9.16) p = 0.04**	**3.00 (0.97 – 9.30) p = 0.05**
Kitchen staff: induction FH training	**17/60 (28%)**	**10/60 (17%)**	**3.33 (1.42 – 7.82) p = 0.005**	**3.80 (1.42 – 10.18) p = 0.004**
Kitchen staff: basic FH training	34/60 (57%)	31/60 (52%)	1.22 (0.60 – 2.51) p = 0.58	1.30 (0.57 – 2.96) p = 0.53
F and B staff: basic FH training	24/60 (40%)	10/60 (17%)	1.98 (0.82 – 4.77) p = 0.13	2.17 (0.82 – 5.70) p = 0.11
Business issues communicated daily verbally	**39/100 (39%)**	**56/100 (56%)**	**0.50 (0.29 – 0.88) p = 0.02**	**0.47 (0.25 – 0.87) p = 0.01**

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.

Sixty SMEs were associated with foodborne disease outbreaks. Case businesses were significantly more likely to prepare poultry from raw, serve food from a hot display, reheat rice or pasta to order, serve ice cream that was not prepared from raw or report a change in kitchen practices at the time of the outbreak (Table 48). Case businesses were also significantly more likely to use regional suppliers rather than national or local suppliers for poultry, red meat or eggs.

Table 48: SME businesses: Univariate analysis of operational practices

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odd ratio (95% C.I.) p value
FOOD PREPARATION METHODS				
Vegetables made from raw	22/60 (37%)	17/60 (28%)	1.46 (0.68 – 3.16) p = 0.33	1.83 (0.68 – 4.96) p = 0.23
Vegetables served from a hot display##	23/60 (38%)	13/60 (22%)	2.25 (1.01 – 5.03) p = 0.05	3.00 (1.09 – 8.25) p = 0.03
Fish served from a cold display	1/60 (2%)	3/60 (5%)	0.32 (0.03 – 3.19) p = 0.62	0.33 (0.03 – 3.20) p = 0.32
Shellfish cooked to order	37/60 (62%)	31/60 (52%)	1.51 (0.73 – 3.11) p = 0.27	1.67 (0.73 – 3.81) p = 0.22
Shellfish served from a hot display##	16/60 (27%)	5/60 (8%)	4.00 (1.36 – 11.77) p = 0.008	- p < 0.001#
Poultry made from raw	**42/60 (70%)**	**32/60 (53%)**	**2.04 (0.97 – 4.32) p = 0.06**	**3.00 (1.09 – 8.25) p = 0.03**
Poultry served**	**58/60 (97%)**	**53/60 (88%)**	**3.83 (0.76 – 19.26) p = 0.16**	**3.50 (0.73 – 16.85) p = 0.10**
Poultry served from a hot display##	26/60 (43%)	11/60 (18%)	3.41 (1.49 – 7.81) p = 0.003	8.50 (1.96 – 36.79) p <0.001
Red meat made from raw	40/60 (67%)	35/60 (58%)	1.43 (0.68 – 3.00) p = 0.35	1.83 (0.68 – 4.96) p = 0.23
Red meat served from a hot display##	26/60 (43%)	12/60 (20%)	3.06 (1.36 – 6.90) p = 0.006	8.00 (1.84 – 34.79) p = 0.001
Egg served from a hot display##	19/60 (32%)	7/60 (12%)	3.51 (1.35 – 9.14) p = 0.008	13.00 (1.70 – 99.37) p = 0.001
Rice/pasta reheated to order	**24/60 (40%)**	**14/60 (23%)**	**2.19 (0.99 – 4.83) p = 0.05**	**2.67 (1.04 – 6.81) p = 0.03**
Rice/pasta served from a hot display##	24/60 (40%)	11/60 (18%)	2.97 (1.29 – 6.83) p = 0.09	5.33 (1.55 – 18.30) p = 0.003
Ice cream made from raw	3/60 (5%)	1/60 (2%)	3.11 (0.31 – 30.73) p = 0.62*	3.00 (0.31 – 28.84) p = 0.32
Ice cream served**	**52/60 (87%)**	**42/60 (70%)**	**2.79 (1.10 – 7.04) p = 0.03**	**3.50 (1.15 – 10.63) p = 0.02**
Sauce served from a hot display##	18/60 (30 %)	8/60 (13%)	2.79 (1.10 – 7.04) p = 0.03	3.50 (1.15 – 10.63) p = 0.02
Milk served	**56/60 (93%)**	**50/60 (83%)**	**2.80 (0.83 – 9.49) p = 0.09**	**3.00 (0.81 – 11.08) p = 0.08**
Food served from a hot display	**26/60 (43%)**	**14/60 (23%)**	**2.51 (1.14 – 5.52) p = 0.02**	**4.00 (1.34 – 11.96) p = 0.007**
Poultry served only	16/60 (27%)	21/60 (35%)	0.68 (0.31 – 1.47) p = 0.32	0.44 (0.14 – 1.44) p = 0.17
Ice cream served only	**49/60 (82%)**	**41/60 (68%)**	**2.06 (0.88 – 4.83) p = 0.09**	**2.33 (0.90 – 6.07) p = 0.07**
Change in kitchen practices	**18/100 (18%)**	**4/100 (4%)**	**5.27 (1.17 – 16.19) p = 0.002**	**15.00 (1.98 – 113.56) p <0.001**
SUPPLIERS				
Regional poultry supplier	**19/57 (33%)**	**5/53 (9%)**	**4.80 (1.64 – 14.04) p = 0.002**	**6.00 (1.34 – 26.81) p = 0.008**

Regional red meat supplier	**17/56 (30%)**	**6/53 (11%)**	**3.56 (1.28 – 9.89) p = 0.01**	**10.00 (1.28 – 78.11) p = 0.007**
Regional egg supplier	**21/58 (36%)**	**6/56 (11%)**	**4.73 (1.74 – 12.88) p = 0.001**	**4.00 (1.34 – 11.96) p = 0.007**

Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.

* Fisher's exact test used where 2 cells have an expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR
Variables collapsed into single variable 'food served from hot display'
** Variable refined to 'serve only'

5.5.2 Multivariate analysis: Outbreaks associated with SME businesses

Business characteristics

Four business characteristic variables: Pub bar, Chinese cuisine, SME size and open for 10 hours or more continuously were entered into conditional logistic regression. SME size was the only independently significant risk factor (Table 49).

Table 49: SME businesses: Conditional logistic regression analysis of business characteristics

Variable		Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Pub bar		0.10 (0.01 – 0.78) p = 0.006	0.26 (0.02 – 3.22) p = 0.29
Chinese cuisine		5.00 (1.71 – 14.63) p = 0.001	2.34 (0.64 – 8.63) p = 0.20
	Micro	**Reference**	**Reference**
SME size	**Small**	**9.61 (2.23 – 41.35) p = 0.002**	**11.17 (2.03 – 61.43) p = 0.006**
	Small medium	**33.82 (2.71 – 422.31) p = 0.006**	**31.79 (1.74 – 582.03) p = 0.02**
Open 10 hrs continuously		2.14 (0.87 – 5.26) p = 0.09	0.79 (0.23 – 2.61) p = 0.69

Bold variables are significant at the 5% level when adjusted within their hypothesis group

Staff employment

Five significant variables: owner or manager working in the kitchen, 2 tiers of management before the head chef, relief manager on duty at the time of the outbreak, employing casual staff and head chefs paid above the national average wage were placed in the staff employment model. Owner or manager working in the kitchen was the only independently significant risk factor (Table 50).

Table 50: SME businesses: Conditional logistic regression analysis of staff employment

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Owner/manager working in the kitchen	**0.34 (0.18 – 0.66) p <0.001**	**0.32 (0.12 – 0.90) p = 0.03**
2 tiers of management before head chef	2.67 (1.04 – 6.81) p = 0.03	0.67 (0.15 – 2.96) p = 0.59
Relief manager on duty	11.00 (1.42 – 85.20) p = 0.004	1.35 (0.08 – 23.45) p = 0.84
Casual staff employed	2.00 (0.90 – 4.45) p = 0.08	2.17 (0.87 – 5.38) p = 0.10
Head chefs wages above national average wage	2.33 (1.07 – 5.09) p = 0.03	1.65 (0.65 – 4.18) p = 0.29

Bold variables are significant at the 5% level when adjusted within their hypothesis group

Staff management

The staff management model comprised staff incentives, provision of staff accommodation, kitchen manager with intermediate food hygiene training, kitchen staff with induction training and daily verbal communication. None of these risk factors remained independently significant (Table 51).

Table 51: SME businesses: Conditional logistic regression analysis of staff management

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Staff incentives given	2.50 (1.20 – 5.21) p = 0.01	1.56 (0.53 – 4.60) p = 0.42
Provision of staff accommodation	3.50 (1.15 – 10.63) p = 0.02	2.39 (0.67 – 8.48) p = 0.18
Kitchen manager received intermediate food hygiene training	3.00 (0.97 – 9.30) p = 0.05	1.66 (0.43 – 6.43) p = 0.46
Kitchen staff received induction training	3.80 (1.42 – 10.18) p = 0.004	3.13 (0.98 – 10.08) p = 0.06
Business issues communicated daily verbally	0.47 (0.25 – 0.87) p = 0.01	0.54 (0.23 – 1.27) p = 0.16

Combined model of independently significant staff management practices

The two independently significant variables: SME size and owner or manager working in the kitchen were placed in a final combined model. Only SME size remained independently significant (Table 52).

Table 52: SME businesses: Conditional logistic regression analysis of independently significant staff management practices

Variable		AOR within hypothesis group
	Micro	**Reference**
SME size	**Small**	**8.06 (1.73 – 37.51) p = 0.008**
	Small medium	**27.75 (2.05 – 375.02) p = 0.01**
MS4		0.71 (0.24 – 2.06) p = 0.53

Operational practices

There were nine significant operational practice variables: six food preparation methods and 3 food supplier variables. In the food preparation methods model of change in kitchen practices, food served from a hot display, rice or pasta reheated to order and poultry prepared from raw, rice or pasta reheated to order and food served from a hot display remained independently significant (Table 53). Neither variables: milk served or ice cream served remained independently significant within their hypothesis group. In the food suppliers model of regional red meat supplier, regional egg suppliers and regional poultry supplier none remained independently significant (Table 53).

Table 53: SME businesses: Conditional logistic regression analysis of operational practices

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group	AOR within food preparation methods
FOOD PREPARATION METHODS			
Poultry made from raw	3.00 (1.09 – 8.25) p = 0.03		2.55 (0.82 – 7.93) 0.11
Milk served	3.00 (0.81 – 11.08) p = 0.08	1.73 (0.41 – 7.38) p = 0.46	
Ice cream served only	2.33 (0.90 – 6.07) p = 0.07	2.88 (0.86 – 9.66) p = 0.09	
Rice/pasta reheat to order	**2.67 (1.04 – 6.81) p = 0.03**		**3.38 (1.07 – 10.74) p = 0.04**
Food served from a hot display	**4.00 (1.34 – 11.96) p = 0.007**		**4.39 (1.26 – 15.32) p = 0.02**
Change in kitchen practices	15.00 (1.98 – 113.56) p <0.001		1.76e+15, p = 1.00#
SUPPLIERS			
Regional red meat supplier	10.00 (1.28 – 78.11) p = 0.007	1.07 (0.04 – 25.56) p = 0.97	
Regional poultry supplier	6.00 (1.34 – 26.81) p = 0.008	4.58 (0.46 – 45.30) p = 0.19	
Regional egg supplier	4.00 (1.34 – 11.96) p = 0.007	2.99 (0.91 – 9.84) p = 0.07	

Too few outbreaks available to examine the independent effect of this risk factor in conditional logistic regression

Final model of independently significant operational practices

The remaining 3 independently significant variables: SME size, food served from a hot display and rice or pasta reheated to order were placed in a final model. SME size remained independently associated with foodborne disease outbreaks that occurred in SME businesses (Table 54). Rice or pasta reheated to order was also independently significant at the 5% level but this variable was explained by regional egg suppliers (Rice/pasta: AOR = 2.01, 0.73 – 5.53, p = 0.18; regional egg supplier: AOR = 3.66, 1.20 – 11.14) p = 0.02) and owner or manager working in the kitchen (Rice/pasta: AOR = 1.92, 0.71 – 5.20, p = 0.20; owner or manager working in the kitchen: AOR = 0.38, 0.16 – 0.92, 0.03).

Table 54: SME businesses: Conditional logistic regression of independently significant operational practices

Variable		AOR within hypothesis group
	Micro	**Reference**
SME size	**Small**	**7.80 (1.69 – 36.03) p = 0.008**
	Small medium	**27.04 (2.06 – 355.86) p = 0.01**
Food served from a hot display		2.20 (0.56 – 8.56) p = 0.26
Rice or pasta reheated to order		3.19 (1.00 – 10.19) p = 0.05

5.6 Outbreaks associated with larger businesses

5.6.1 Univariate analysis: Outbreaks associated with larger businesses (n = 48)

Case businesses were significantly more likely to be hotels (Table 55). No other business characteristics were significantly associated with outbreaks in larger businesses.

Table 55: Larger businesses: Univariate analysis of business characteristics

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Hotel	**19/48 (40%)**	**7/48 (15%)**	**3.84 (1.43 – 10.31) p = 0.006**	**7.00 (1.59 – 30.80) p = 0.003**
Pub bar	14/48 (29%)	15/48 (31%)	0.91 (0.38 – 2.17) p = 0.82	0.86 (0.29 – 2.55) p = 0.78
Chinese cuisine	0/48 (0%)	0/48 (0%)	-	-
Micro	0/28 (0%)	0/28 (0%)	-	-
SME size Small	0/28 (0%)	0/28 (0%)	-	-
Small medium	0/28 (0%)	0/28 (0%)	-	-
Dinner	21/28 (75%)	18/28 (64%)	-, p = 0.002*	-, p = 0.003#
Open 10 hrs continuously	22/28 (79%)	17/28 (61%)	2.37 (0.73 – 7.71) p = 0.15	2.25 (0.69 – 7.31) p = 0.17

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR

Case businesses were significantly more likely to provide a salary only to chefs (Table 56). No other staff employment variables were significantly associated with outbreaks in larger businesses.

Table 56: Larger businesses: Univariate analysis of staff employment

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Owner/manager work in the kitchen	0/48 (0%)	0/48 (0%)	-	-
2 tiers of management before the kitchen manager/chef	9/48 (19%)	7/48 (15%)	1.35 (0.46 – 3.98) p = 0.58	1.40 (0.44 – 4.41) p = 0.56
Relief manager on duty	8/48 17%)	1/48 (2%)	9.40 (1.13 – 78.41) p = 0.03*	- p = 0.008#
Casual staff employed	10/28 (36%)	6/28 (21%)	2.04 (0.62 – 6.69) p = 0.24	2.33 (0.60 – 9.02) p = 0.21
Full-time staff employed	27/28 (96%)	28/28 (100%)	- p = 1.00*	-, p = 0.32#
Only chefs salaried	**9/28 (71%)**	**3/28 (11%)**	**3.95 (0.94 – 16.60) p = 0.05**	**4.00 (0.85 – 18.84) p = 0.06**
Head chef wages above national average	20/28 (71%)	14/28 (50%)	2.50 (0.83 – 7.55) p = 0.10	2.50 (0.78 – 7.97) p = 0.11

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR

Case businesses were significantly more likely to provide staff accommodation or have staff with formal food hygiene training (Table 57). There were no other significant staff management variables.

Table 57: Larger businesses: Univariate analysis of staff management

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Staff use customer toilets	14/28 (50%)	9/28 (32%)	2.11 (0.71 – 6.25) p = 0.17	1.83 (0.68 – 4.96) p = 0.23
Provide staff accommodation	**10/28 (36%)**	**5/28 (18%)**	**2.56 (0.74 – 8.81) p = 0.13**	**6.00 (0.72 – 49.84) p = 0.06**
Is there staff incentives	32/48 (67%)	28/48 (58%)	1.43 (0.62 – 3.28) p = 0.40	1.57 (0.61 – 4.05) p = 0.35
Kitchen manager: intermediate FH training	**9/28 (32%)**	**3/28 (11%)**	**3.95 (0.94 – 16.60) p = 0.05**	**7.00 (0.86 – 56.89) p = 0.04**
Kitchen staff: induction FH training	22/28 (79%)	23/28 (82%)	0.80 (0.21 – 2.99) p = 0.74	0.83 (0.25 – 2.73) p = 0.76
Kitchen staff: basic FH training	**25/28 (89%)**	**18/28 (64%)**	**4.63 (1.11 – 19.26) p = 0.03**	**8.00 (1.00 – 63.96) p = 0.02**
F and B staff: basic FH training	**13/28 (46%)**	**8/28 (29%)**	**2.17 (0.72 – 6.55) p = 0.17**	**3.50 (0.73 – 16.96) p = 0.10**
Business issues communicated daily verbally	13/48 (27%)	14/48 (29%)	0.90 (0.37 – 2.20) p = 0.82	0.91 (0.39 – 2.14) p = 0.83

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.

Case businesses were more likely to prepare poultry and red meat dishes from raw, although this was of borderline significance (Table 58).

Table 58: Larger businesses: Univariate analysis of operational practices

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
FOOD PREPARATION METHODS				
Vegetables made from raw	5/28 (18%)	1/28 (4%)	5.87 (0.64 – 53.93) p = 0.19*	- p = 0.05
Vegetables served from a hot display##	13/28 (46%)	13/28 (46%)	1.00 (0.35 – 2.86) p = 1.00	1.00 (0.25 – 4.00) p = 1.00
Fish served from a cold display	2/28 (7%)	5/28 (18%)	0.35 (0.35 – 2.86) p = 0.42*	0.25 (0.03 – 2.24) p = 0.18
Shellfish cooked to order	17/28 (61%)	12/28 (43%)	2.06 (0.71 – 5.98) p = 0.18	2.25 (0.69 – 7.31) p = 0.17
Shellfish served from a hot display##	5/28 (18%)	3/28 (11%)	1.81 (0.39 – 8.44) p = 0.71*	2.00 (0.37 – 10.92) p = 0.41
Poultry made from raw	**16/28 (57%)**	**9/28 (32%)**	**2.82 (0.95 – 8.38) p = 0.66**	**3.33 (0.92 – 12.11) p = 0.05**
Poultry served	28/28 (100%)	25/28 (89%)	- p = 0.24*	- p = 0.08#
Poultry served from a hot display##	13/28 (46%)	13/28 (46%)	1.00 (0.35 – 2.86) p = 1.00	1.00 (0.25 – 4.00) p = 1.00
Red meat made from raw	**18/28 (64%)**	**13/28 (46%)**	**2.08 (0.71 – 6.07) p = 0.18**	**3.50 (0.73 – 16.85) p = 0.10**
Red meat served from a hot display##	13/28 (46%)	12/28 (43%)	1.16 (0.40 – 3.32) p = 0.79	1.25 (0.36 – 4.65) p = 0.74
Egg served from hot display##	6/28 (21%)	7/28 (25%)	0.82 (0.24 – 2.84) p = 0.75	0.67 (0.11 – 3.99) p = 0.65
Rice/pasta reheated to order	4/28 (14%)	2/28 (7%)	2.17 (0.36 – 12.92) p = 0.67	3.00 (0.31 – 28.84) p = 0.32
Rice/pasta served from a hot display##	11/28 (39%)	11/28 (39%)	1.00 (0.34 – 2.92) p = 1.00	1.00 (0.25 – 4.00) p = 1.00
Ice cream made from raw	2/28 (7%)	0/28 (0%)	- p = 0.49*	- p = 0.16#
Ice cream served	28/28 (100%)	24/28 (86%)	- p = 0.11*	- p = 0.05#
Sauce served from hot display##	5/28 (18%)	4/28 (14%)	1.30 (0.31 – 5.47) p = 1.00	1.50 (0.25 – 8.98) p = 0.65
Milk served	28/28 (100%)	27/28 (96%)	0.49 (0.38 – 0.64) p = 1.00*	- p = 0.32#
Food served from a hot display	13/28 (46%)	13/28 (46%)	1.00 (0.35 – 2.86) p = 1.00	1.00 (0.25 – 4.00) p = 1.00
Poultry served only	12/28 (43%)	16/28 (57%)	0.56 (0.20 – 1.62) p = 0.29	0.43 (0.11 – 1.66) p = 0.21
Ice cream served only	26/28 (93%)	24/28 (86%)	2.17 (0.36 – 12.92) p = 0.67	3.00 (0.31 – 28.84) p = 0.32
Change in kitchen practices	5/48 (10%)	0/48 (0%)	- p = 0.06*	- p = 0.03#

SUPPLIERS				
Regional poultry supplier	2/28 (7%)	1/26 (4%)	1.92 (0.16 – 22.56) p = 1.00	2.00 (0.18 – 22.06) p = 0.56
Regional red meat supplier	2/27 (7%)	1/25 (4%)	1.92 (0.16 – 22.58) p = 1.00	2.00 (0.18 – 22.06) p = 0.56
Regional egg supplier	4/26 (15%)	1/26 (4%)	4.55 (0.47 – 43.78) p = 0.35	4.00 (0.45 – 35.79) p = 0.18

Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR
Variables collapsed into single variable 'food served from a hot display'

5.6.2 Multivariate analysis: Outbreaks associated with large businesses

Business characteristics

Hotel was the only business characteristic variable found to be significantly associated with outbreaks in larger businesses.

Staff employment

The only staff employment variable found to be a significant risk factor was chefs being paid a salary.

Staff management

Four significant staff management variables: Provision of staff accommodation, kitchen manager with intermediate food hygiene training, kitchen staff and F&B with basic food hygiene training were placed in a model but none remained independently significant (Table 59).

Table 59: Larger businesses: Conditional logistic regression analysis of staff management

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Provision of staff accommodation	6.00 (0.72 – 49.84) p = 0.06	6.64e+17, p = 1.00
Kitchen manager received intermediate food hygiene training	7.00 (0.86 – 56.89) p = 0.04	1.89e+50, p = 1.00
Kitchen staff received basic food hygiene training	8.00 (1.00 – 63.96) p = 0.02	2.94e+33, p = 1.00
F and B staff received basic food hygiene training	3.50 (0.73 – 16.96) p = 0.10	8.58e+16, p = 1.00

NB. Too few outbreaks associated with larger businesses have prevented full examination of the independent effects of the significant risk factors in this table.

Combined model of independently significant staff management practices

A combined model staff practices model comprised hotel and chefs paid a salary, neither remained independently significant (Table 60).

Table 60: Larger businesses: Conditional logistic regression analysis of significantly independent staff management practices.

Variable	AOR within hypothesis group
Hotel#	7.01e+17, p = 1.00
Chefs paid a salary	1.50 (0.25 – 8.98) p = 0.66

Too few outbreaks available to examine the independent effect of this risk factor in conditional logistic regression

Operational practices

In a conditional logistic regression model of operational practices comprising poultry and red meat prepared from a raw state, neither risk factor remained independently significant (Table 61).

Table 61: Larger businesses: Conditional logistic regression of operational practices

Variable	Unadjusted MOR (95% C.I.)	AOR within food preparation methods
Poultry made from raw	3.33 (0.92 – 12.11) p = 0.05	3.00 (0.31 – 28.84) p = 0.34
Red meat made from raw	3.50 (0.73 – 16.85) p = 0.10	1.17 (0.07 – 18.35) p = 0.91

There were no management risk factors independently associated with foodborne disease outbreaks that occurred in larger businesses.

5.7 Viral foodborne disease outbreaks

5.7.1 Univariate analysis: Viral foodborne disease outbreaks (n = 58)

Case businesses were significantly more likely to be hotels, but no other business characteristics were found to be significantly associated with viral foodborne outbreaks (Table 62).

Table 62: Viral foodborne disease outbreaks: Univariate analysis of business characteristics

Variable		Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Hotel		**27/58 (47%)**	**11/58 (19%)**	**3.72 (1.62 – 8.58) p = 0.002**	**6.33 (1.87 – 21.40) p <0.001**
Pub bar		14/58 (24%)	17/58 (29%)	0.77 (0.34 – 1.75) p = 0.53	0.67 (0.24 – 1.87) p = 0.44
Chinese cuisine		0/58 (0%)	0/58 (0%)	-	-
	Micro	6/30 (20%)	9/30 (30%)	0.58 (0.18 – 1.91) p = 0.37	Reference
SME size**	Small	5/30 (17%)	4/30 (13%)	1.30 (0.31 – 5.40) p = 1.00*	3.00 (0.31 – 28.84) p = 0.34
	Small medium	2/30 (7%)	0/30 (0%)	- p = 0.49*	- p = 1.00#
Dinner		28/30 (93%)	26/30 (87%)	2.15 (0.36 – 12.76) p = 0.67	2.00 (0.37 – 10.92) p = 0.42
Open 10 hrs continuously		21/30 (70%)	18/30 (60%)	1.56 (0.53 – 4.53) p = 0.42	1.60 (0.52 – 4.89) p = 0.41

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5
**SME size is a categorical variable where micro = 1, small = 2 and small medium = 3. Micro SME is the reference category, 2 MORs are calculated for small and small medium SMEs. These should be interpreted relative to micro SMEs
Insufficient strata within the analysis to calculate MOR

Case businesses were significantly more likely to employ casual staff and significantly less likely to have the owner or manager working in the kitchen (Table 63). Providing the chefs with a salary was of borderline significance.

Table 63: Viral foodborne disease outbreaks: Univariate analysis of staff employment

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Owner/manager work in the kitchen	**6/58 (10%)**	**12/58 (21%)**	**0.44 (0.15 – 1.27) p = 0.12**	**0.33 (0.09 – 1.23) p = 0.08**
2 tiers of management before the kitchen manager/chef	12/58 (21%)	9/58 (16%)	1.42 (0.53 – 3.69) p = 0.47	1.50 (0.53 – 4.21) p = 0.44
Relief manager	6/58 (10%)	1/58 (2%)	6.58 (0.77 – 56.47) p = 0.11*	-, p = 0.03#
Casual staff employed	**15/30 (50%)**	**8/30 (27%)**	**2.75 (0.93 – 8.10) p = 0.06**	**4.50 (0.97 – 20.83) p = 0.03**
Full-time staff employed	30/30 (100%)	30/30 (100%)	-	-
Only chefs salaried	**8/30 (27%)**	**4/30 (13%)**	**2.36 (0.63 – 8.92) p = 0.20**	**5.00 (0.58 – 42.80) p = 0.10**
Head chef wages above national average	22/30 (73%)	16/30 (53%)	2.41 (0.82 – 7.10) p = 0.11	2.50 (0.78 – 7.97) p = 0.11

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR

Case businesses were significantly more likely to provide staff accommodation, offer staff incentives or have staff with formal hygiene training (Table 64).

Table 64: Viral foodborne disease outbreaks: Univariate analysis of staff management

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Staff use customer toilets	15/30 (50%)	17/30 (57%)	0.77 (0.28 – 2.11) p = 0.60	0.80 (0.32 – 2.03) p = 0.64
Provide staff accommodation	**12/30 (40%)**	**6/30 (20%)**	**2.67 (0.84 – 8.46) p = 0.09**	**7.00 (0.86 – 56.89) p = 0.03**
Staff incentives	**34/58 (59%)**	**24/58 (41%)**	**2.10 (0.96 – 4.20) p = 0.06**	**2.43 (1.01 – 5.86) p = 0.04**
Kitchen manager: intermediate FH training	**13/30 (43%)**	**2/30 (7%)**	**10.71 (2.15 – 53.35) p = 0.001**	**12.00 (1.56 – 92.29) p = 0.002**
Kitchen staff: induction FH training	**22/30 (73%)**	**15/30 (50%)**	**2.75 (0.93 – 8.10) p = 0.06**	**4.50 (0.97 – 20.83) p = 0.03**
Kitchen staff: basic FH training	**24/30 (80%)**	**15/30 (50%)**	**4.00 (1.27 – 12.58) p = 0.02**	**10.00 (1.28 – 78.11) p = 0.007**
F and B staff: basic FH training	**13/30 (43%)**	**6/30 (20%)**	**3.06 (0.97 – 9.66) p = 0.05**	**4.50 (0.97 – 20.83) p = 0.03**
Business issues communicated daily verbally	21/58 (36%)	24/58 (41%)	0.80 (0.38 – 1.70) p = 0.57	0.79 (0.36 – 1.73) p = 0.55

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.

No operational practice variables were found to be significantly associated with viral foodborne disease outbreaks at the 10% level (Table 65).

Table 65: Viral foodborne disease outbreaks: Univariate analysis of operational practices

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.) p value	Matched odds ratio (95% C.I.) p value
FOOD PREPARATION METHODS				
Vegetables made from raw	7/30 (23%)	4/30 (13%)	1.98 (0.51 – 7.64) p = 0.32	2.50 (0.49 – 12.89) p = 0.26
Vegetables served from a hot display##	9/30 (30%)	10/30 (33%)	0.86 (0.29 – 2.55) p = 0.78	0.80 (0.21 – 2.98) p = 0.74
Fish served from a cold display	1/30 (3%)	3/30 (10%)	0.31 (0.03 – 3.17) p = 0.61*	- p = 0.16#
Shellfish cooked to order	22/30 (73%)	17/30 (57%)	2.10 (0.71 – 6.22) p = 0.18	2.00 (0.68 – 5.85) p = 0.20
Shellfish served from a hot display##	6/30 (20%)	3/30 (10%)	2.25 (0.51 – 9.99) p = 0.47*	- p = 0.08#
Poultry made from raw	17/30 (57%)	13/30 (43%)	1.71 (0.62 – 4.75) p = 0.30	2.33 (0.60 – 9.02) p = 0.21
Poultry served	30/30 (100%)	30/30 (100%)	-	-
Poultry served from a hot display##	10/30 (33%)	11/30 (36%)	0.86 (0.30 – 2.50) p = 0.79	0.75 (0.17 – 3.35) p = 0.71
Red meat made from raw	17/30 (57%)	17/30 (57%)	1.00 (0.36 – 2.78) p = 1.00	1.00 (0.25 – 4.00) p = 1.00
Red meat served from a hot display##	10/30 (33%)	10/30 (33%)	1.00 (0.34 – 2.93) p = 1.00	1.00 (0.25 – 4.00) p = 1.00
Egg served from a hot display##	7/30 (23%)	5/30 (17%)	1.52 (0.42 – 5.47) p = 0.52	3.00 (0.31 – 28.84) p = 0.32
Rice/pasta reheated to order	3/30 (10%)	2/30 (7%)	1.56 (0.24 – 10.05) p = 0.64	2.00 (0.18 – 22.06) p = 0.56
Rice/pasta served from a hot display##	9/30 (30%)	7/30 (23%)	1.41 (0.45 – 4.45) p = 0.56	1.67 (0.40 – 6.97) p = 0.48
Ice cream made from raw	2/30 (7%)	0.30 (0%)	- p = 0.49*	- p = 0.16#
Ice cream served	27/30 (90%)	25/30 (83%)	1.80 (0.39 – 8.32) p = 0.71*	3.00 (0.31 – 28.84) p = 0.32
Sauce served from a hot display##	4/30 (13%)	4/30 (13%)	1.00 (0.23 – 4.43) p = 1.00	1.00 (0.20 – 4.95) p = 1.00
Milk served	30/30 (100%)	27/30 (90%)	- p = 0.24*	- p = 0.08#
Food served from a hot display	10/30 (33%)	10/30 (33%)	1.00 (0.34 – 2.93) p = 1.00	1.00 (0.25 – 4.00) p = 1.00
Poultry served only	13/30 (43%)	17/30 (57%)	0.59 (0.21 – 1.62) p = 0.30	0.43 (0.11 – 1.66) p = 0.21
Ice cream served only	25/30 (83%)	25/30 (83%)	1.00 (0.26 – 3.89) p = 1.00	1.00 (0.20 – 4.95) p = 1.00
Change in kitchen practices	6/58 (10%)	2/58 (3%)	3.23 (0.62 – 16.73) p = 0.27*	5.00 (0.58 – 42.80) p = 0.10
SUPPLIERS				
Regional poultry suppliers	3/30 (10%)	1/30 (3%)	3.22 (0.32 – 32.89) p = 0.61*	3.00 (0.31 – 28.84) p = 0.32

Regional red meat supplier	2/28 (7%)	1/29 (3%)	2.15 (0.18 – 25.19) p = 0.61*	2.00 (0.18 – 22.06) p = 0.56
Regional egg supplier	4/28 (14%)	3/29 (10%)	1.44 (0.29 – 7.13) p = 0.71*	1.33 (0.30 – 5.96) p = 0.71

* Fisher's exact test used where 2 cells have an expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR
Variables collapsed into single variable 'food served from a hot display'

5.7.2 Multivariate analysis: Viral foodborne disease outbreaks

Business characteristics

Hotel was the only business characteristic variable to be significantly associated with viral foodborne disease outbreaks.

Staff employment

Three significant staff employment variables were placed in a logistic regression model: Owner or manager working in the kitchen, casual staff employed and chefs salaried. None of these variables remained independently significant (Table 66).

Table 66: Viral foodborne disease outbreaks: Conditional logistic regression analysis of staff employment

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Owner/manager working in the kitchen	0.33 (0.09 – 1.23) p = 0.08	1.11 (0.13 – 9.47) p = 0.93
Casual staff employed	4.50 (0.97 – 20.83) p = 0.03	3.91 (0.76 – 20.03) p = 0.10
Only chefs salaried	5.00 (0.58 – 42.80) p = 0.10	3.61 (0.40 – 32.63) p = 0.25

Staff management

Six staff management variables were placed in a conditional logistic regression model: Staff incentives, provision of staff accommodation, kitchen manager with intermediate food hygiene training, kitchen staff with induction training, kitchen staff and F&B staff with basic food hygiene training. None of these risk factors remained independently significant (Table 67). The small number of outbreaks associated with larger businesses prevented full examination of the independent effects of these risk factors in logistic regression.

Table 67: Viral foodborne disease outbreaks: Conditional logistic regression analysis of staff management

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Staff incentives given	2.43 (1.01 – 5.86) p = 0.04	1.62e+16, p = 1.00
Provision of staff accommodation	7.00 (0.86 – 56.89) p = 0.03	3.15e+33, p = 1.00
Kitchen manager received intermediate food hygiene training	12.00 (1.56 – 92.29) p = 0.002	3.20e+82, p = 1.00
Kitchen staff received induction training	4.50 (0.97 – 20.83) p = 0.03	2.46e+49, p = 1.00
Kitchen staff received basic food hygiene training	10.00 (1.28 – 78.11) p = 0.007	2.95e+17, p = 1.00
F and B staff received basic food hygiene training	4.50 (0.97 – 20.83) p = 0.03	4.95e+32, p = 1.00

NB Too few outbreaks associated with larger businesses have prevented full examination of the independent effects of the significant risk factors in this table

Operational practices

There were no operational practice variables significant at the 10% level in univariate analysis.

5.8 *Salmonella* foodborne disease outbreaks

5.8.1 Univariate analysis: *Salmonella* foodborne disease outbreaks (n = 72)

The results for *Salmonella* outbreaks were similar to the results obtained from all foodborne disease outbreaks. Case businesses were significantly more likely to be a small or small medium SME rather than a micro SME or to be open for business for 10 or more hours continuously and less likely to be a pub bar (Table 68).

Table 68: *Salmonella* foodborne disease outbreaks: Univariate analysis of business characteristics

Variable		Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Hotel		5/72 (7%)	6/72 (8%)	0.82 (0.24 – 2.82) p = 0.75	0.67 (0.11 – 3.99) p = 0.66
Pub bar		**3/72 (3%)**	**7/72 (10%)**	**0.40 (0.10 – 1.63) p = 0.19**	**0.20 (0.02 – 1.17) p = 0.10**
Chinese cuisine		23/72 (32%)	7/72 (10%)	4.36 (1.73 – 10.98) p = 0.001	5.00 (1.71 – 14.63) p = 0.001
	Micro	**18/51 (35%)**	**32/51 (31%)**	**0.32 (0.14 – 0.73) p = 0.006**	**Reference**
SME size**	**Small**	**19/51 (37%)**	**9/51 (18%)**	**2.77 (1.11 – 6.93) p = 0.03**	**13.35 (1.73 – 10.2.75) p = 0.01**
	Small medium	**5/51 (10%)**	**1/51 (1%)**	**5.44 (0.61 – 48.27) p = 0.21***	**30.87 (1.68 – 568.74) p = 0.02**
Dinner		44/51 (86%)	39/51 (76%)	1.93 (0.69 – 5.40) p = 0.20	2.25 (0.69 – 7.31) p = 0.17
Open 10 hrs continuously		**25/51 (49%)**	**16/51 (31%)**	**2.10 (0.94 – 4.71) p = 0.07**	**2.80 (1.01 – 7.77) p = 0.04**

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5
**SME size is a categorical variable where micro = 1, small = 2 and small medium = 3. Micro SME is the reference category, 2 MORs are calculated for small and small medium SMEs. These should be interpreted relative to micro SMEs

Case businesses were significantly more likely to have 2 tiers of management between the general manager or owner and the kitchen manager or head chef, employ a relief manager at the time of the outbreak or pay the head chef above the national average wage (Table 69). Case businesses were significantly less likely to have the owner or manager working in the kitchen.

Table 69: *Salmonella* foodborne disease outbreaks: Univariate analysis of staff employment

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Owner/manager work in the kitchen	**17/72 (24%)**	**34/72 (47%)**	**0.35 (0.17 – 0.71) p = 0.003**	**0.29 (0.12 – 0.68) p = 0.002**
2 tiers of management before the kitchen manager/chef	**13/72 (18%)**	**5/72 (7%)**	**2.95 (0.99 – 8.77) p = 0.04**	**3.67 (1.02 – 13.14) p = 0.03**
Relief manager on duty	**10/72 (14%)**	**1/72 (1%)**	**11.45 (1.43 – 92.00) p = 0.005**	**10.00 (1.28 – 78.12) p = 0.007**
Casual staff employed	15/51 (29%)	11/51 (22%)	1.52 (0.62 – 3.72) p = 0.36	1.44 (0.62 – 3.38) p = 0.40
Full-time staff employed	47/51 (92%)	50/51 (98%)	0.24 (0.03 – 2.18) p = 0.36*	0.25 (0.03 – 2.24) p = 0.18
Only chefs salaried	6/51 (12%)	4/51 (8%)	1.53 (0.41 – 5.80) p = 0.74*	1.50 (0.42 – 5.32) p = 0.53
Head chef wages above national average	**22/51 (43%)**	**13/51 (25%)**	**2.22 (0.96 – 5.13) p = 0.06**	**2.00 (0.90 – 4.45) p = 0.08**

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5

Case businesses were significantly more likely to allow staff to use customer toilets or provide staff accommodation and significantly less likely to communicate verbally on a daily basis (Table 70). There were no other significant staff management variables.

Table 70: *Salmonella* foodborne disease outbreaks: Univariate analysis of staff management

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95% C.I.), p value	Matched odds ratio (95% C.I.), p value
Staff use customer toilets	**27/51 (53%)**	**16/51 (31%)**	**2.46 (1.10 – 5.52) p = 0.03**	**2.83 (1.12 – 7.19) p = 0.02**
Provide staff accommodation	**14/51 (27%)**	**6/51 (12%)**	**2.84 (0.99 – 8.12) p = 0.05**	**3.00 (0.97 – 9.30) p = 0.05**
Staff incentives	21/72 (29%)	14/72 (19%)	1.71 (0.79 – 3.70) p = 0.17	2.00 (0.81 – 4.96) p = 0.13
Kitchen manager: intermediate FH training	8/51 (16%)	6/51 (12%)	1.40 (0.45 – 4.35) p = 0.57	1.50 (0.42 – 5.32) p = 0.53
Kitchen staff: induction FH training	22/51 (43%)	16/51 (31%)	1.66 (0.74 – 3.73) p = 0.22	1.86 (0.74 – 4.65) p = 0.18
Kitchen staff: basic FH training	29/51 (57%)	30/51 (59%)	0.92 (0.42 – 2.03) p = 0.84	0.90 (0.37 – 2.21) p = 0.82
F and B staff: basic FH training	15/51 (29%)	12/51 (23%)	1.35 (0.56 – 3.28) p = 0.50	1.50 (0.53 – 4.21) p = 0.44
Business issues communicated daily verbally	**27/72 (38%)**	**37/72 (51%)**	**0.57 (0.29 – 1.10) p = 0.09**	**0.53 (0.26 – 1.09) p = 0.08**

Bold variables are significant at the 10% level and do not comprise small numbers of cases and controls.

The results in this analysis were similar to all foodborne disease outbreaks; that is, case businesses were significantly more likely to prepare poultry dishes from raw, serve food from a hot display buffet, report a change in kitchen practices at the time of the outbreak, serve ice cream and use regional suppliers for red meat, poultry and eggs (Table 71). Businesses associated with *Salmonella* outbreaks were also significantly more likely to prepare red meat dishes from raw and more likely to serve poultry dishes, but, when this variable was refined to include only poultry dishes served that were not prepared from raw, it was no longer a significant risk factor.

Table 71: *Salmonella* foodborne disease outbreaks: Univariate analysis of operational practices

Variable	Proportion of cases exposed	Proportion of controls exposed	Unmatched odds ratio (95 C.I.) p value	Matched odds ratio (95% C.I.) p value
FOOD PREPARATION METHODS				
Vegetables made from raw	19/51(37%)	14/51 (27%)	1.57 (0.68 – 3.62) p = 0.29	2.25 (0.69 – 7.31) p = 0.17
Vegetables served from a hot display##	24/51 (47%)	15/51 (29%)	2.13 (0.94 – 4.82) p = 0.07	3.25 (1.06 – 9.97) p = 0.03
Fish served from a cold display	2/51 (4%)	5/51 (10%)	0.38 (0.07 – 2.03) p = 0.44*	0.04 (0.08 – 2.06) p = 0.26
Shellfish cooked to order	29/51 (57%)	24/51 (47%)	1.48 (0.68 – 3.24) p = 0.32	1.71 (0.67 – 4.35) p = 0.25
Shellfish served from a hot display##	13/51 (25%)	5/51 (10%)	3.15 (1.03 – 9.62) p = 0.04	5.00 (1.10 – 22.82) p = 0.03
Poultry made from raw	**37/51 (73%)**	**27/51 (53%)**	**2.35 (1.03 – 5.36) p = 0.04**	**3.00 (1.09 – 8.25) p = 0.03**
Poultry served**	**49/51 (96%)**	**42/51 (82%)**	**5.25 (1.07 – 25.66) p = 0.03**	**4.50 (0.97 – 20.83) p = 0.03**
Poultry served from a hot display##	26/51 (51%)	12/51 (23%)	3.38 (1.45 – 7.90) p = 0.004	8.00 (1.84 – 34.79) p = 0.001
Red meat made from raw	**37/51 (73%)**	**30/51 (59%)**	**1.85 (0.81 – 4.24) p = 0.14**	**2.75 (0.88 – 8.64) p = 0.07**
Red meat served from a hot display##	26/51 (51%)	13/51 (25%)	3.04 (1.32 – 7.01) p = 0.008	7.50 (1.72 – 32.80) p = 0.002
Egg served from a hot display##	18/51 (35%)	8/51 (16%)	2.93 (1.14 – 7.57) p = 0.02	6.00 (1.34 – 26.81) p = 0.008
Rice/pasta reheated to order	21/51 (41%)	14/51 (27%)	1.85 (0.81 – 4.24) p = 0.14	2.17 (0.82 – 5.70) p = 0.11
Rice/pasta served from a hot display##	23/51 (45%)	14/51 (27%)	2.17 (0.95 – 4.96) p = 0.06	3.25 (1.06 – 9.97) p = 0.03
Ice cream made from raw	2/51 (4%)	1/51 (2%)	2.04 (0.18 – 23.24) p = 1.00	2.00 (0.18 – 22.06) p = 0.56
Ice cream served**	**46/51 (90%)**	**37/51 (73%)**	**3.48 (1.15 – 10.55) p = 0.02**	**4.00 (1.13 – 14.17) p = 0.02**
Sauce served from a hot display	17/51 (33%)	7/51 (14%)	3.14 (1.17 – 8.44) p = 0.02	6.00 (1.34 – 26.81) p = 0.008
Milk served	47/51 (92%)	44/51 (86%)	1.87 (0.51 – 6.83) p = 0.34	2.00 (0.50 – 8.00) p = 0.32
Food served from a hot display	**26/51 (51%)**	**16/51 (31%)**	**2.28 (1.02 – 5.10) p = 0.04**	**3.50 (1.15 – 10.63) p = 0.02**
Poultry served only	12/51 (24%)	15/51 (29%)	0.74 (0.31 – 1.79) p = 0.50	0.57 (0.17 – 1.95) p = 0.37
Ice cream served only	**44/51 (86%)**	**36/51 (71%)**	**2.62 (0.96 – 7.12) p = 0.05**	**3.00 (0.97 – 9.30) p = 0.05**
Change in kitchen practices	**11/72 (15%)**	**1/72 (1%)**	**12.80 (1.61 – 102.03) p = 0.003**	**- p = 0.002#**
SUPPLIERS				

Regional poultry supplier	**16/48 (33%)**	**4/43 (9%)**	**4.88 (2.44 – 25.41) p = 0.006**	**5.50 (1.22 – 24.81) p = 0.01**
Regional red meat supplier	**15/48 (31%)**	**5/44 (11%)**	**3.55 (1.17 – 10.79) p = 0.02**	**9.00 (1.14 – 71.04) p = 0.01**
Regional egg supplier	**21/49 (43%)**	**4/46 (9%)**	**7.88 (2.44 – 25.41) p <0.001**	**8.00 (1.84 – 34.79) p = 0.001**

Bold variables are significant at the 10% level, do not provide duplicate or alternative information to another significant variable and do not comprise small numbers of cases and controls.
* Fisher's exact test used where 2 cells have an expected count of less than 5
# Insufficient strata formed in analysis to calculate MOR
Variables collapsed into a single variable 'food served from a hot display'
** Variable was refined to 'served only'

5.8.2 Multivariate analysis: *Salmonella* foodborne disease outbreaks

Business characteristics

Three significant variables were placed in the business characteristics model: Pub bar, SME size and open 10 hours or more continuously. SME size was the only risk factor that remained independently significant (Table 72).

Table 72: *Salmonella* foodborne disease outbreaks: Conditional logistic regression analysis of business characteristics

Variable		Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Pub bar		0.20 (0.02 – 1.17) p = 0.10	0.30 (0.004 – 21.77) p = 0.58
	Micro	**Reference**	**Reference**
SME size	**Small**	**13.35 (1.73 – 102.75) p = 0.01**	**13.45 (1.53 – 118.39) p = 0.02**
	Small medium	**30.87 (1.68 – 568.74) p = 0.02**	**18.31 (0.79 – 421.89) p = 0.07**
Open 10 hrs continuously		2.80 (1.01 – 7.77) p = 0.04	1.42 (0.44 – 4.59) p = 0.56

Bold variables are significant at the 5% level when adjusted within their hypothesis group

Staff employment

Four staff employment variables: owner or manager working in the kitchen, 2 tiers of management before the head chef, relief manager on duty at the time of the outbreak and head chefs paid above the national average wage were placed in a model. Owner or manager working in the kitchen remained independently significant (Table 73).

Table 73: *Salmonella* foodborne disease outbreaks: Conditional logistic regression analysis of staff employment

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Owner/manager working in the kitchen	**0.29 (0.12 – 0.68) p = 0.002**	**0.24 (0.07 – 0.81) p = 0.02**
2 tiers of management before head chef	3.67 (1.02 – 13.14) p = 0.03	0.85 (0.17 – 4.22) p = 0.84
Relief manager on duty	10.00 (1.28 – 78.12) p = 0.07	3.59 (0.26 – 49.93) p = 0.34
Head chefs wages above national average wage	2.00 (0.90 – 4.45) p = 0.08	1.33 (0.52 – 3.38) p = 0.55

Bold variables are significant at the 5% level when adjusted within their hypothesis group

Staff management

Daily verbal communication, provision of staff accommodation and staff using customer toilets were placed in the staff management model, none of these risk factors remained independently significant (Table 74).

Table 74: *Salmonella* foodborne disease outbreaks: Conditional logistic regression analysis of staff management

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group
Daily verbal communication	0.53 (0.26 – 1.04) p = 0.08	0.81 (0.35 – 1.89) p = 0.63
Provision of staff accommodation	3.00 (0.97 – 9.30) p = 0.05	2.48 (0.77 – 7.99) p = 0.13
Staff use customer toilets	2.83 (1.12 – 7.19) p = 0.02	2.46 (0.95 – 6.41) p = 0.07

Combined model of independently significant staff management practices

The two independently significant variables: SME size and owner or manager working in the kitchen were placed in a final combined model. SME size remained a independently significant risk factor (Table 75).

Table 75: *Salmonella* foodborne disease outbreaks: Conditional logistic regression of significantly independent staff management practices.

Variable		AOR
	Micro	**Reference**
SME size	**Small**	**9.80 (1.21 – 79.25) p = 0.03**
	Small medium	**21.31 (1.02 – 444.48) p = 0.05**
Owner/manager working in the kitchen		0.40 (0.10 – 1.53) p = 0.18

Operational practices

There were 9 operational practices significantly associated with *Salmonella* foodborne disease outbreaks. Of the 6 food preparation method variables, neither poultry prepared from raw or red meat prepared from raw remained independently significant in their hypothesis group (Table 76). Serving ice cream, rice or pasta reheated to order, food served from a hot display and changes in kitchen practices at the time of the outbreak were placed in the food preparation methods model and food served from a hot display remained independently significant (Table 76).

In the food suppliers model of regional red meat supplier, regional poultry supplier and regional egg supplier, regional egg supplier remained independently significant (Table 76).

Table 76: *Salmonella* foodborne disease outbreaks: Conditional logistic regression analysis of operational practices

Variable	Unadjusted MOR (95% C.I.)	AOR within hypothesis group	AOR within food preparation methods
FOOD PREPARATION METHODS			
Poultry made from raw	3.00 (1.09 – 8.25) p = 0.03	4.00 (0.45 – 35.79) p = 0.22	
Red meat made from raw	2.75 (0.88 – 8.64) p = 0.07	0.69 (0.06 – 8.15) p = 0.77	
Ice cream served only	3.00 (0.97 – 9.30) p = 0.05		2.00 (0.44 – 8.96) p = 0.37
Rice/pasta reheated to order	2.17 (0.82 – 5.70) p = 0.11		2.94 (0.87 – 9.93) p = 0.08
Food served from a hot display	**3.50 (1.15 – 10.63) p = 0.02**		**5.16 (1.25 – 21.34) p = 0.02**
Change in kitchen practices	- p = 0.002#		2.02e+16, p = 1.00
SUPPLIERS			
Regional red meat supplier	9.00 (1.14 – 71.04) p = 0.01	1.51 (0.06 – 36.86) p = 0.80	
Regional poultry supplier	5.50 (1.22 – 24.81) p = 0.01	2.25 (0.22 – 23.18) p = 0.49	
Regional egg supplier	**8.00 (1.84 – 34.79) p = 0.001**	**5.24 (1.11 – 24.63) p = 0.04**	

Bold variables are significant at the 5% level when adjusted within their hypothesis group
Insufficient strata formed in analysis to calculate MOR

Final model of independently significant operational practices

Three independently significant risk factors were placed in the final combined model: SME size, food served from a hot display and regional egg supplier. The use of regional egg suppliers remained independently associated with *Salmonella* foodborne disease outbreaks but SME size no longer remained independently (Table 77).

Table 77: *Salmonella* foodborne disease outbreaks: Conditional logistic regression of significantly independent operational practices.

Variable		AOR within hypothesis group
	Micro	Reference
SME size	Small	4.13 (0.41 – 41.76) p = 0.23
	Small medium	6.62 (0.32 – 135.78) p = 0.22
Food served from a hot display		7.33 (0.77 – 69.95) p = 0.08
Regional egg supplier		**7.35 (1.23 – 44.01) p = 0.03**

5.9 Egg related outbreaks

Information on the food vehicles associated with the outbreaks was only collected during the main study. Local environmental health investigators provided this information along with other outbreak data when business details were released. Following analysis of the outbreaks associated with *Salmonella* infection the paper records containing information on food vehicles were retrieved.

The most common food vehicles reported were dishes containing egg (24/88, 27%), (Table 78). Four (17%) outbreaks were associated with dishes made from raw egg (3 desserts and 1 fortified milk drink) and 6 (25%) were dishes containing egg that was undercooked (runny eggs and hollandaise sauce). Twenty three of the 24 businesses associated with egg related outbreaks provided information on the use of regional food suppliers. Case businesses (11, 48%) were significantly more likely to use regional egg suppliers than control businesses (2, 9%), (OR = 9.63, 1.82 – 50.89, p = 0.003).

TABLE 78: Food vehicles reported to be associated with foodborne disease outbreaks.

Food vehicle	All outbreaks (%)	*Salmonella* outbreaks (%)	Viral outbreaks (%)
Poultry	11 (13)	5 (10)	2 (7)
Red meat	1 (1)	1 (2)	-
Fish/shellfish	1 (10	-	1 (3)
Salad/vegetable/fruit	13 (15)	7 (14)	5 (17)
Egg/egg dishes	24 (27)	24 (47)	-
Miscellaneous	1 (1)	-	1 (3)
Meals identified	21 (24)	5 (10)	14 (47)
None identified	16 (18)	9 (18)	7 (23)
Total	88	51	30

To try and explain the association between regional egg suppliers and both egg related and *Salmonella* outbreaks, a review of the main study questionnaires was undertaken (n = 176). Only sixteen records contained additional information on the use of eggs. Nine of which were case businesses associated with *Salmonella* Enteritidis outbreaks and 7 were controls. Two out of 9 (22%) cases reported using approved quality assured eggs and all 7 control businesses reported using quality assured eggs. Businesses (0/7) associated with egg related outbreaks were significantly less likely to use eggs produced under an approved quality assurance scheme (Anon 2007; British Egg Industry Council 2008)) than control businesses (5/5), (OR = 0.03, 0.001 – 0.57, p = 0.03) (Jewell 1986).

5.10 <u>Food hygiene inspection scores</u>

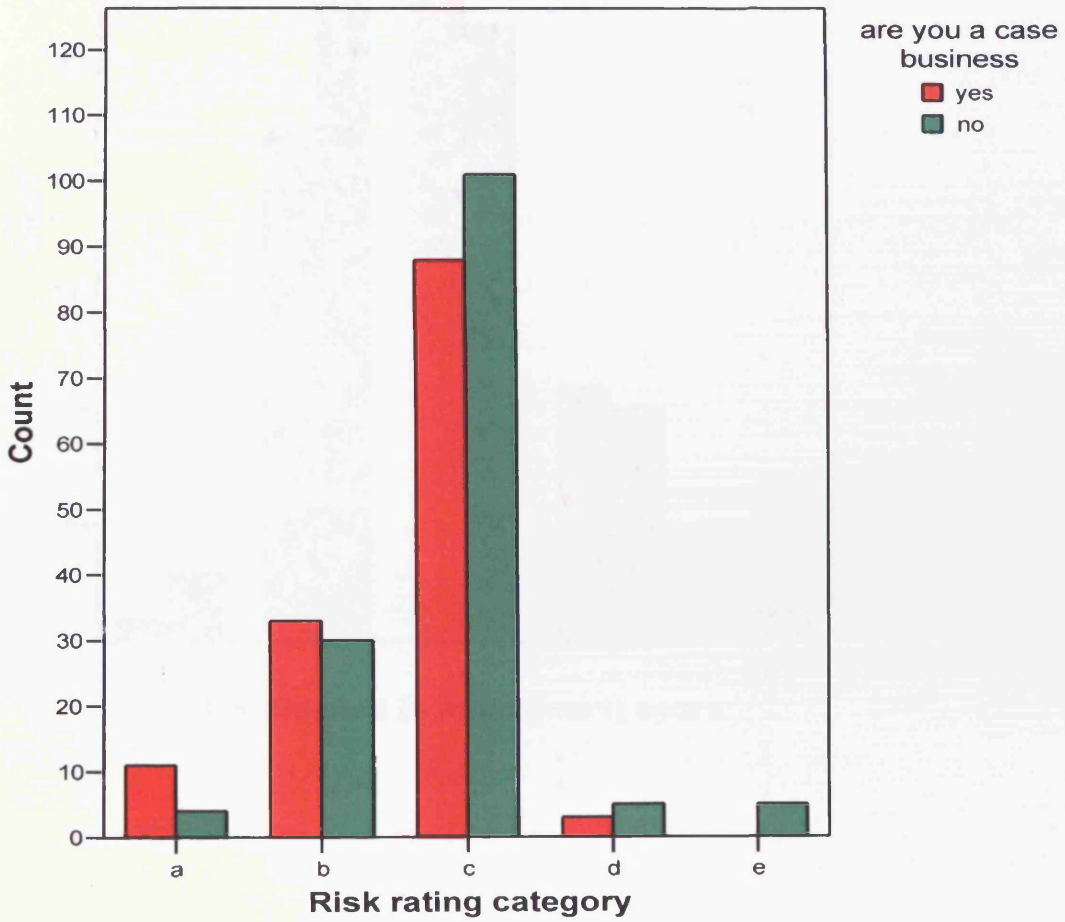
Information on risk rating scores and categories was requested from businesses participating in the pilot and main study (n = 296). Information was not provided on 16 businesses, 10 of which were case businesses not registered at the time of the outbreak. All control businesses were selected from the local authority register and were therefore by definition registered businesses.

The distribution of risk scores for case businesses tended to be shifted toward higher scores (Figure 24) that is toward businesses for which more frequent inspections were required (χ^2 for trend, $p = 0.05$). Although the mean case risk rating score (68.41) differed significantly (68.41 versus 62.17, independent sample t-test, $p = 0.001$), both scores were within the same inspection category (category C).

Figure 24: Inspection frequencies: Box plot to show risk rating scores

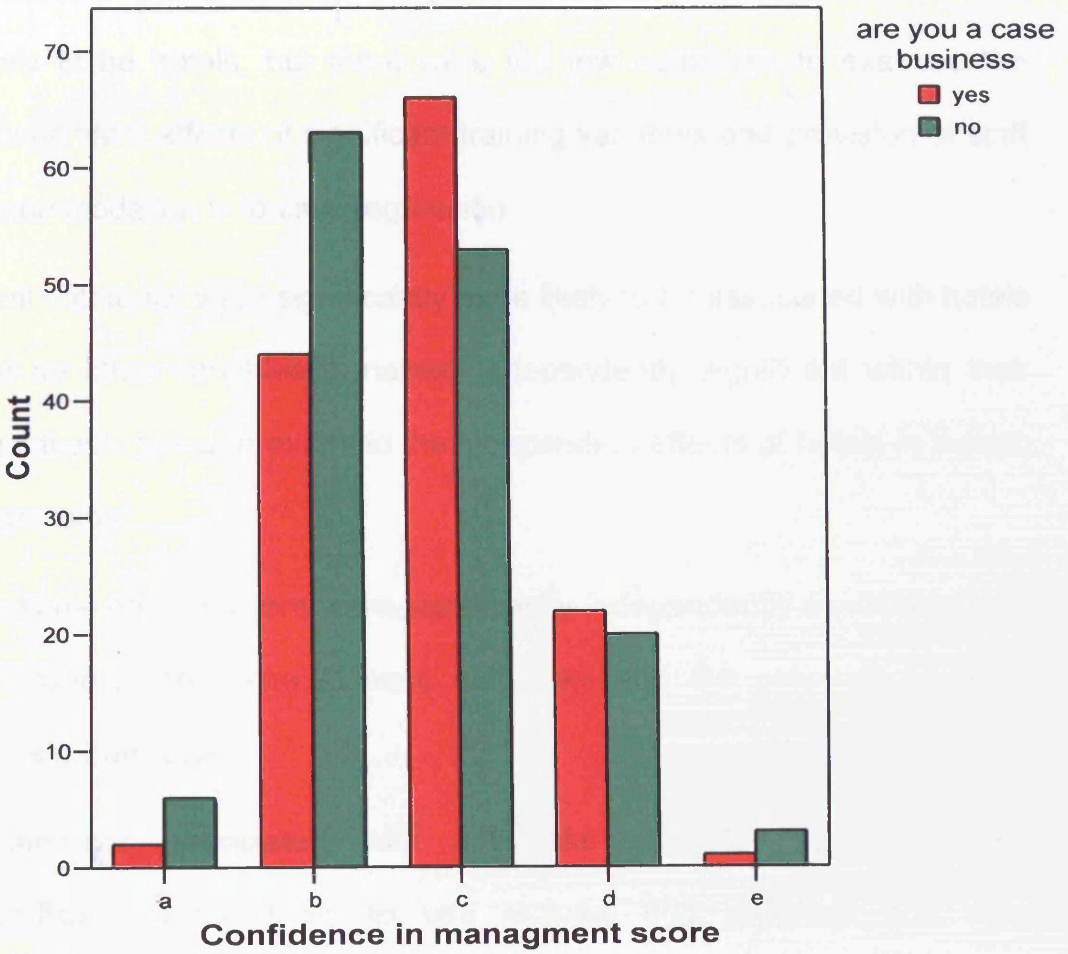
Category C contained 189 (68%) businesses: 88 (47%) businesses associated with outbreaks and 101 (53%) control businesses. Category B contained 63 (22%) businesses: 33 (52%) case businesses and 30 (48%) controls. Category A comprised 15 (5%) businesses: 11 (73%) cases and 4 (27%) control businesses. There were 8 (3%) businesses in Category D: 3 (38%) cases and 5 (62%) control businesses. There were no outbreaks associated with Category E businesses (Figure 25).

Figure 25: Inspection frequencies: Bar graph to show risk rating categories



There was no significant trend in distribution of case business scores for confidence in management scores (χ^2 for trend, p = 0.11) and the mean case score did not differ significantly from the control mean score (10.00 versus 9.21, independent sample t-test p = 0.248) (Figure 26).

Figure 26: Inspection frequencies: Bar graph to show confidence in management scores



5.11 <u>Summary</u>

5.11.1 Management risk factors

SME size and staff accommodation were significantly independently associated with all foodborne disease outbreaks.

SME size and rice/pasta dishes reheated to order were significantly independently associated with outbreaks relating to SME businesses.

Outbreaks associated with larger businesses were significantly more likely to be hotels, but there were too few outbreaks to examine the independent effects of significant training variables and provision of staff accommodation in logistic regression.

Viral outbreaks were significantly more likely to be associated with hotels but no other variables remained independently significant within their hypothesis group to examine the independent effects of hotels in logistic regression.

Regional egg suppliers were significantly independently associated with *Salmonella* foodborne disease outbreaks and the only risk factor to explain SME size.

Businesses associated with outbreaks attributed to eggs were significantly more likely to use regional egg suppliers and were significantly less likely to use eggs produced under an approved quality assurance scheme.

5.11.2 Food hygiene inspection scores

The distribution of total risk rating scores for case businesses tended to be shifted toward higher scores, that is, businesses that required more frequent inspections. The mean case risk rating score differed significantly from the mean control risk rating score but both scores were within the same inspection category.

There was no significant trend in distribution of case business scores for confidence in management. The mean case confidence in management score did not differ significantly from the control mean score.

6 DISCUSSION

6.1 Introduction

This study examined the management related factors that may predispose to foodborne disease outbreaks in the catering industry in England and Wales.

Though the role of staff management and operational practices in foodborne disease outbreaks has been highlighted in individual formal inquiries such as the Committee of Inquiry into the Stanley Royd outbreak in 1984 (Committee of Inquiry 1986) and the Richmond Report (Richmond et al. 1991). There appears to be little evidence that public health authorities systematically evaluate such factors. A thorough systematic literature review retrieved only 27 relevant articles, of which one contained a focused investigation on the management and operation of outbreak and non outbreak restaurants (Hedberg 2006). Management information retrieved from the other 26 articles was incidental to the main aim of the study. It was clear from outset of this study that there was little if any published literature that focused primarily on the management factors associated with foodborne outbreaks and only limited information on management factors contained within published papers. To overcome this and avoid missing relevant papers, considerable time was spent developing the search strategy and method of retrieval which included manually reviewing the text and references of all 113 articles identified from abstract screening process.

6.2 Validation of study methods

A case control study was adapted to compare the management and operational practices in catering businesses where there was a foodborne disease outbreak with a control catering business where no outbreak had occurred. However, case control studies are subject to a number of important biases including confounding (Breslow 2005).

Selection bias occurs when participating cases or controls are not representative of the parent population, resulting in an association between exposure and disease that differs in study participants compared to non study participants (Rothman 2002). The author sought to avoid this bias during case ascertainment by considering all foodborne outbreaks (suspected or confirmed) that occurred within the study period and that were either reported to the national surveillance scheme or the informal professional network. Case and control businesses were sourced from the same parent population – the catering industry in England and Wales. The selection procedure ensured that each catering business had an equal chance of being selected as a control.

At the outset of the study it was uncertain what the response rate was likely to be, since the intrusive nature of the study required case and control businesses to volunteer possibly self-incriminatory information on management and operational practices, and it was thought that case businesses particularly would be reluctant to admit to faults in management. Recruitment and data collection methods were designed to attain high participation rates, and whilst the methods adopted by this study were extremely labour intensive, they proved successful in encouraging business participation. The support of the business community for the study was remarkably good and this is reflected by the high response rates: case businesses 90%, and control businesses 93%. Non participant businesses were comparable with the study population in terms of business type and size and type of pathogen in the case of outbreak businesses.

Case control studies are also prone to information bias which occurs when information collected from the case or controls has unequal or inaccurate recall of exposures (Rothman 2002). The use of incident cases reduced the period of time between exposure, outcome and data collection and thus reduced the potential for recall bias. Recall bias was further minimised in case and control businesses during interview by narrating 'trigger events' such as local and national sporting events, news and festival dates that occurred around the time of the outbreak. School holidays and the weather were particularly useful to catering managers who were being interviewed, since they affect the level of trade within individual businesses. In outbreaks in which case businesses were being prosecuted, their controls were interviewed in advance of case details being released to the study to minimise the recall period for controls.

Information bias was further minimised by using a small number of trained interviewers, who undertook face to face interviews using a structured protocol which ensured that all measurements relating to past exposures were collected in a standardised manner. Exposure suspicion bias, a type of interviewer bias can often result from the interviewer being aware of the status of cases and controls and therefore investigating cases more thoroughly than controls to determine exposure (Abramson & Abramson 1999). In this study, the sensitive and intrusive nature of the investigation meant that interviewers could not be 'blind' to the status of the business. This was compensated for by the interviewers (with the exception of the author) being 'blind' to the specific hypotheses being tested in this study and by applying the same interview techniques and time for interviewing both cases and controls (Palmer 1989).

The accuracy of the data obtained was critical. The priority during data collection was to establish exactly how businesses operated and not just to receive answers that the interviewees thought the interviewer wanted to hear. This required building up a high degree of trust with the business starting during the recruitment process and reinforced before and during the interview. Informal discussions with the person most familiar with the business operation (owner or manager) about issues affecting their business and asking their opinion on general matters relating to catering and food safety was time consuming, but it encouraged truthful answers which reflected actual business operations. This was demonstrated by the fact that many businesses offered different answers to those given to the EHOs who initially investigated the outbreak, including admission of faults in processes. In addition, rather than withholding information, case and control businesses often volunteered self-incriminatory information on operational practices. For example one case business assured the enforcing officer that chicken liver pâté was cooked to a core temperature of 63°C, but during the project interview, the head chef admitted that the pâté was only ever cooked to 40°C and should be pink in the middle. This same business had a formal HACCP and employed chefs with food hygiene training. Several businesses also admitted changes to their suppliers, either for reasons of cost, product availability or changes to ingredients, such as the use of raw shell egg instead of pasteurised egg. Restaurants with and without food safety management systems also argued against the use of pasteurised egg for particular dishes and others commented that the preparation and use of ingredients in dishes was determined by their customers, which in turn determined their income. This information was rarely provided to the enforcing officer.

Case control studies are also prone to the effect of confounding (Rothman 2002; Breslow 2005). In this study SME status and local authority (business location) were identified as two potential confounding variables: SME status is known to be strongly associated with some management factors (IGD 2005). Also, there are possible confounding effects of variations between local authorities in their interpretation and application of risk assessment protocols under the Food Safety Act 1990, which might lead them to differ systematically in the risk rating scores applied to catering businesses. Both confounders were controlled for at the design stage of the study by matching cases and controls for these variables. During analysis, logistic regression was also used to adjust for further confounding not identified at the design stage. A confounding variable may be significantly associated with case status in univariate analysis even though it is not causally linked, because it is also associated with another variable that is causally linked (Schlesselman 1982).

Logistic regression analysis estimates the strength of association between an explanatory variable and the case control status of a business independently of the effect of other variables that are put into the model. For example, smaller SME size and the owner/manager working in the kitchen were both significantly associated with a reduced risk of foodborne outbreaks in univariate analysis, but anyway smaller businesses are more likely to have the owner/manager working in the kitchen. The question of importance is whether having the owner/manager working in the kitchen is the reason outbreaks are less likely, or whether the lower risk has to do with some other aspect of the business being of smaller size. When both variables were placed in a logistic regression model only SME size remained significant. The association with owner/manager working in the kitchen was to do with that variable being linked to SME size. SME size is the variable that is actually associated with foodborne disease outbreaks, and owner/manager working in the kitchen is merely associated with the size of SME.

A large number of variables were analysed and by chance in such a large dataset many statistically significant associations could be expected. To reduce false inferences from multiple analysis a predefined hypothesised causal pathway was followed before undertaking analysis. Variables were grouped into sets according to prior hypotheses:

- Business characteristics
- Staff employment and structure
- Staff management

- Operational practices

The four hypotheses groups are not independent of one another. They reflect the operation and management of a catering business: the type of business, how the business is set up, how staff are managed, how the business delivers and processes the product and service and what happens when something goes wrong. Specific hypotheses were then tested by entering management and operational variables and potential confounders into specific models, enabling identification of the effect of particular factors and the influence of confounders (Rothman 1986; Schlesselman 1982; Parry et al. 1998).

Despite the above, some technical issues confronted in the study may have limited its validity. It seems likely that data collected during interview on 'staff sick leave' may have been inaccurate since the dates of illness were not always verified by documentation or management. This means that staff sickness at the time of the outbreak could have been victims rather than contributing to the outbreak. Some formal environmental health investigations confirmed this concern. Further, it is possible that controls would be less likely to recall episodes of minor sickness, thereby artificially elevating the risk associated with this variable. This variable was, therefore, removed from the analysis and the study could not address the role of sick food handlers.

6.3 Foodborne disease outbreaks

The outbreaks included in the study were all those identified by the voluntary national surveillance scheme operated by the HPA as well as other outbreaks identified informally through professional networks that met the study criteria. This coverage, the high response rate, and descriptive features of the outbreaks, including size of outbreak, causative pathogen and expected seasonal and geographical trends, indicated that the data should be representative of all foodborne outbreaks occurring in England and Wales.

6.4 Management factors

The main finding of this study was, that in comparison to micro businesses, "small" and "small medium" sized catering businesses were significantly more likely to be associated with a foodborne disease outbreak. None of the staff employment or staff management variables measured explained this association, but analysis of *Salmonella* foodborne disease outbreaks identified regional egg suppliers to be a significantly independent risk factor and the only factor in the study to explain SME size.

6.4.1 Business characteristics

Although businesses were matched for SME status, there were differences between SMEs and larger businesses. Larger businesses, particularly hotels, were more commonly associated with viral foodborne disease outbreaks, and SMEs were more commonly associated with Salmonellosis outbreaks.

The association between larger hotels and viral foodborne disease outbreaks could not be explained by the variables examined in the study because the small number of outbreaks associated with larger businesses prevented examination of the independent effects of the significant variables. In comparison to other catering businesses, viral foodborne outbreaks frequently disrupt hotel operations because of their increased size and duration. Transmission is easily facilitated by a large temporary human reservoir sharing living, recreational, working and eating facilities (McDonnell et al 1995; Lopman et al 2003). Incoming guests add to the population at risk which is then compounded by a low infective dose. It is possible that viral outbreaks in hotel guests may spill over to hotel staff and food handlers with the potential for foodborne transmission (ACMSF 1998). Also as larger hotels commonly cater for defined cohorts of people within conferences and specific functions, if foodborne illness occurs it will be more easily recognised (Palmer 1990; O'Brien et al 2002). Hedberg et al. (2006) commented that this in itself could bias the likelihood that the outbreak would be detected, reported and investigated.

In SME businesses, case businesses were more likely to serve Chinese cuisine and were less likely to have the owner/manager working in the kitchen. Within SMEs, size of business remained important; case businesses were more likely to be larger SMEs, and when this factor was taken into account, serving Chinese cuisine and having the owner/manager working in the kitchen no longer remained significant factors. It was hypothesised that any associations with business size would be explained by several of the variables measured, such as closeness of management supervision, training and HACCP controls, but this hypothesis was not supported. In other studies (Irwin et al. 1989; Buchholz et al. 2002) that examined factors associated with foodborne illness the only consistent factor associated with case status was size of business, although, these U.S. studies defined business size by seating capacity rather than number of employees. Irwin et al. (1989) and Buchholz et al. (2002) indicated that the association with business size could simply be related to volume of food served; that is, the larger the seating capacity of a restaurant the greater the volume of food produced, the more likely a foodborne outbreak. However, Buchholz et al (2002) also warned that seating capacity could be a poor indicator of volume as a smaller seated restaurant may serve more customers than a large seated restaurant but use a smaller kitchen, thereby increasing the risk of food safety control failures such as cross contamination and poor temperature control. Therefore, the actual risk of being associated with an outbreak is the result of the size of the kitchen in relation to the number of meals served; a risk factor identified by Luby et al (1993). The issue of kitchen size and number of meals served was not investigated in this study but could possibly explain the association between larger SME businesses and foodborne outbreaks. It is also possible that the association with business size is related to the closeness of management supervision: larger numbers of employees may be less closely supervised. Examination of some staff employment variables considered this relationship.

6.4.2 Staff employment

The catering industry suffers from both skills and labour shortages. It is characterised by a relatively young and transient workforce on low wages and working long hours; recruitment and retention of staff are a common problem. Trade is often seasonal, with a large proportion of the operational workforce working on a casual or part-time basis. Such important staffing issues might be considered to put catering businesses at risk of outbreaks if casual staff are less likely to adhere to good hygiene practices. However, there were no staff employment variables which remained independently significant. Case and control businesses were similar in relation to recruiting and retaining staff and the employment of full-time staff. The use of casual staff was a significant risk factor but did not remain significant when adjusted for SME size. Many managers interviewed reported that they managed casual employment by using a bank of staff who were readily available for casual work, especially in rural areas. These staff may be as well trained and instructed as permanent staff.

Limited supervision of workers has been identified as a management risk factor in a number of studies retrieved in systematic literature review. Staff supervision was not specifically examined in this study but was implied by the management structure variables: owner/manager working in the kitchen represented the most effective supervision of food handlers and 2 tiers of management between the owner or general manager and the kitchen manager or head chef the least effective supervision of food handlers. The former management structure was significantly less likely to be associated with case businesses but two tiers of management between the owner or general manager and the kitchen manager/head chef was significantly associated with being a case business. However, the management structures tended to reflect the size of business. Two tiers of management between the owner or general manager and the kitchen manager/head chef was associated with larger SMEs or larger businesses, and the owner/manager working in the kitchen was only a feature of smaller SMEs. When both variables were adjusted for SME size they no longer remained significant. SME size was the actual variable associated with foodborne disease outbreaks. The risk associated with foodborne disease outbreaks would therefore appear to be related to the number of employees.

6.4.3 Staff management

Staff accommodation was significantly independently associated with foodborne disease outbreaks. It was the only staff management risk factor that remained independent when adjusted for SME size, but this association could not be explained within the dataset. The provision of staff accommodation was not exclusively linked to hotels. Some SME restaurants provided staff accommodation, particularly those serving ethnic cuisine such as Chinese and Indian menus. Pubs and restaurants that were part of a national chain frequently had 'live in' managers, and catering businesses in rural locations offered staff accommodation. Interviews with managers also indicated that staff accommodation was not necessarily located 'on site'. Analysis also indicated that the provision of staff accommodation was common to both viral and *Salmonella* foodborne infections. Further studies of this aspect are required before it can be considered as a genuine risk factor and not a chance association.

The systematic literature review consistently showed that infected food handlers were associated with foodborne disease outbreaks (Rooney et al. 2004; Daniels et al. 2000; Daniels et al. 2002; Schmid et al. 2007). These authors suggested that the reason for this was either the fact that staff were not paid sick leave and so worked when ill, or that staff did not take sick leave for fear they would lose their job. This study examined whether there were any differences in sick leave policies offered by case and control businesses: specifically, if staff were paid for the first 3 days of their sick leave. In contrast to the previous studies, case and control businesses were found to be similar in respect of being paid sick leave. This finding confirms the results of a similar study undertaken by Hedberg et al. (2006) in U.S.A. who found that outbreaks and non outbreak restaurants were similar with respect to staff sickness policies, including sick leave benefits to food workers, reporting of illness to managers and restriction of ill food workers. Whilst it is reasonable to assume that sick staff would continue to work while ill in order to be paid, the stronger evidence suggests that not paying staff sick leave is not associated with foodborne disease outbreaks.

The study also examined the way in which business and food hygiene issues were communicated within a business. Daily verbal communication of business issues (number of bookings, price and menus changes) was more likely to occur in control businesses compared to cases, but this factor did not remain significantly independent when adjusted for other staff management variables.

6.4.4 Operational practices

Few operational practices were found to differ between case and control businesses. Case businesses were more likely to use complex methods of preparation: preparing poultry dishes from raw, reheating rice or pasta to order and serving food from a hot display; factors that were hypothesised to increase the risk of foodborne outbreaks. The consumption of poultry in England and Wales has consistently been identified as the most commonly identified food vehicle associated with foodborne disease outbreaks (Djuretic et al. 1996; O'Brien 2002; Hughes 2007) and work by Bryan, Guzewich and Todd (1997) confirmed that the way foods are processed and prepared affects the survival or proliferation of pathogens such as in reheated and hot held foods. Simple menu preparation, such as 'cook to order', 'freezer to fryer', ready-made multi-or single portion foods regenerated on site, offer less opportunity for failures in food safety controls than foods regenerated following advanced preparation and cooking. However, despite the potential risks associated with these operational practices, when adjusted for SME size in the logistic regression analysis, none of these practices remained independently significant, and this was also true for the subset of *Salmonella* outbreaks. It is possible that some other risk factor more commonly featured in larger SMEs but not measured in this study provides the explanation. Another more likely explanation is that larger SME businesses are more likely to source and use contaminated foods which provide the necessary conditions for outbreaks to occur. This hypothesis is supported by the work of Gillespie et al. (2005) who reviewed 497 foodborne outbreaks of *Salmonella* Enteritidis infection in England and Wales and concluded that food source and supply may have greater impact on the occurrence of outbreaks than the operational practices in the kitchen.

In this study, the type of supplier of food to the businesses varied significantly and independently of SME size. Regional egg supplier was a significantly independent risk factor for *Salmonella* outbreaks. To explain the association between regional egg suppliers and *Salmonella* outbreaks the interview records were retrospectively reviewed and it was found that regional egg suppliers were more likely to be used by case businesses with egg-related outbreaks, and that these suppliers were less likely to use eggs produced under an approved quality assurance scheme. However the number of interviews where egg type was identified in additional text records was very low. It is possible that the association with regional egg suppliers is because these companies were more likely to use eggs that were not produced under approved quality assurance schemes and therefore more likely to be contaminated. There was a resurgence of foodborne disease relating to egg associated *S.* Enteritidis in England and Wales over the period of the study (FSA 2007a) and the use of Spanish eggs, not produced under approved quality assurance schemes, by the catering industry was identified consistently as a significant factor in many of the *S.* Enteritidis outbreaks in England and Wales during 2002 – 2004 (HPA 2005). Further, some managers of businesses associated with *S.* Enteritidis egg related outbreaks commented that the use of imported eggs from regional suppliers was down to a decision of either cost or availability. Imported eggs were always cheaper than eggs produced in the U.K. under an approved quality assurance scheme. It is clear that commercial decisions present one of the greatest barriers to reducing the incidence of foodborne disease (Jones and Angulo 2006).

With regard to operational practices, only the choice of food supplier influenced outcome, and despite formal HACCP and training programmes, poor practice remains common in the catering industry. In the U.S.A. a study of 153 restaurants reported that the prevalence of high risk egg preparation practices that could facilitate the spread of *S.* Enteritidis was high, but none of these businesses were reported to be associated with outbreaks (Lee et al. 2004). Sagoo et al. (2003) assessed cleaning standards and practices in 1,502 food premises in the U.K. and observed poor cleaning practices in 1,007 (67%) premises. Food service workers and restaurant managers often admitted unsafe food preparation practices (Green and Selman 2005). In our study staff trained in food hygiene also admitted adopting unsafe practices. There appears to be little or no difference in operational and hygiene practices between outbreak businesses and non outbreak businesses, and only under certain conditions do these practices result in an outbreak of foodborne disease. The use of contaminated foods from 'high risk' suppliers provides the necessary conditions for outbreaks to occur. Our findings support the focus suggested by Gillespie et al. (2005) in their review of foodborne outbreaks of *S.* Enteritidis in England and Wales, a finding previously acknowledged by

Bryan, Guzewich and Todd (1997), who commented that many outbreaks would not have occurred if contaminated food had not entered the kitchen.

A number of studies have highlighted that increased volume contributes to poor food handling practices which then contribute to foodborne disease outbreaks, but this evidence is inconclusive since the findings were incidental to the main focus of the paper and were accompanied by little detailed explanation. Also, work by Hedberg et al. (2006) found that there was no difference in the number of meals served in outbreak and non outbreak restaurants. In two outbreaks of *E.* coli O157 reported in Canada, authors (Honish 2007; Currie et al. 2007) commented that both businesses blamed increased customer volume for the breakdown in food safety practices. However, other neighbouring catering businesses would have been exposed to the same demands, and in one outbreak the implicated business was part of a small chain of which another outlet was located nearby (Honish 2007). What is not clear is why some businesses are able to manage increased customer demand safely and others cannot.

It is likely that increased customer demand is linked to the catering businesses capacity to deal with the increased volume. A number of studies (Camps et al. 2005; Luby et al. 1993; Slaten et al. 1992; Winquist et al. 2001) highlighted that the businesses associated with the outbreak had exceeded their catering capacity. As none of these studies included comparisons with control businesses the impact of increased high volume catering remains uncertain.

A change in kitchen practices has also been reported to contribute to foodborne disease outbreaks (Honish, 2000; Mazurek et al. 2005). In this study case businesses when compared with control businesses were significantly more likely to have experienced a change in kitchen practices, but this risk factor did not remain significantly independent when adjusted for other operational practices. The most common kitchen practice reported to change was menu preparation (Honish 2000; Mazurek et al. 2005).

6.5 Food safety controls and enforcement

The main finding associated with the control and enforcement of food safety in the catering industry in England and Wales was that case businesses, contrary to the initial hypothesis, were not less likely to have staff trained with formal food hygiene training, nor were they less likely to use HACCP systems either formally or informally. The study also showed weaknesses in the risk rating system and the scoring system for confidence in management currently used in England and Wales.

6.5.1 Food hygiene training

Although consistent with other published evidence, it was disappointing to find that food hygiene training was not a significant "protective" factor, but this concurs with the work of other researchers. Within the last two years work in the U.S.A. (Hedberg et al. 2006) has also found no difference in the training offered to food handlers in outbreak and non outbreak restaurants. Training variables were negatively associated with outbreaks in some of our analyses, but it is unlikely that food hygiene training itself is detrimental. It does suggest however, that greater knowledge and understanding of food safety do not necessarily result in implementation of good food safety practices (Taylor 1996; Ehiri et al. 1997).

For food hygiene training to be effective it must be supported by commitment, motivation and management supervision (Richmond et al. 1991; Taylor 1996; Worsfold Griffith and Worsfold 2004). One of the more prominent training variables: "kitchen manager trained to intermediate food hygiene level" did not remain independently significant when adjusted for business size. This level of training was associated with larger SMEs and larger businesses. Also, none of the 30 businesses who reported having a kitchen manager trained to intermediate food hygiene level had the owner/manager working in the kitchen and this latter management variable was directly associated with micro SMEs. Thus, it is unlikely that intermediate food hygiene training alone is a risk factor for foodborne disease outbreaks. It possible that this level of training is related to the number of staff employed.

It has been argued that knowledge of food hygiene has less impact on food safety controls (and therefore the risk of a business being associated with a foodborne disease outbreak) than commercial pressures (Powell et al. 1997). An investigation of a large restaurant outbreak of Salmonellosis (Luby et al. 1993) reported that both managers and staff had recently undertaken food hygiene training, but the kitchen, designed to prepare 200 – 300 meals per day, was used to prepare over 7,000 meals per day at the time of the outbreak. This reinforces the view that commercial pressures will often override the pressure to prepare food safely.

6.5.2 HACCP

HACCP is a food safety management system, proven to reduce food safety risks associated with food manufacture and processing (Buchanan et al. 1998), but this was not protective in our study. Hedberg et al. (2006) have also found that awareness of HACCP was not independently associated with outbreak status in restaurants in the U.S.A. It was disappointing to find that food safety management systems introduced into food businesses did not offer protection against foodborne disease outbreaks.

Evidence from this study and others (Panisello et al. 1999; Mortlock et al. 1999; Taylor and Kane 2005) suggested that to ensure effective application of HACCP requires careful consideration of the inherent characteristics of catering businesses in England and Wales. Pennington Group (1997) commented that HACCP would only be effective with full commitment from management and the workforce, and the Richmond Report (1991) 15 years ago suggested that the diverse range of products and processes used by catering businesses would make application difficult. To address these concerns the WHO (1999) developed strategies for authorities to adopt when applying HACCP to small business operations. The SFBB initiative introduced by the FSA with full consultation of the catering industry may address some of the issues relating to the diversity of catering operations and the manner in which catering businesses manage food safety.

6.5.3 Risk rating system

This study also showed weaknesses in the risk rating system and the 'confidence in management' scores currently used in England and Wales. Although the trends in distribution of case and control businesses within risk rating categories was statistically different, category A, the 'high' risk category, only accounted for 7% of the outbreaks. Category A businesses are inspected every 6 months to ensure compliance with food hygiene legislation. If the risk rating system was designed to identify businesses likely to be associated with foodborne outbreaks a higher proportion of outbreaks would have been observed in this category. Most foodborne disease outbreaks occurred in category C where the highest number of controls were also found, Category C businesses being inspected every 18 months. The total risk rating scores for case and control businesses differed significantly but, both scores were within category C, so this difference would not have had an impact on the inspection frequency of cases and controls. The current risk rating system is not useful in predicting businesses that will be associated with foodborne disease outbreaks. In Scotland (Mullen et al. 2002) 6 years ago a case control study found no significant difference between risk rating scores in outbreak and non outbreak businesses. In the U.S.A. Jones et al. (2004a) examined 167,574 restaurant inspections between 1993 and 2000 and concluded that inspection scores alone did not predict the likelihood of a foodborne outbreak occurring in a particular restaurant. Other studies in the U.S.A. (Irwin et al. 1989; Cruz et al. 2001; Buchholz et al. 2002) present conflicting results, but nevertheless question the validity of inspection scores in predicting and reducing the incidence of foodborne disease.

6.5.4 Implications to the environmental health profession

The findings of this study present four key implications to the environmental health profession:

(i) The current risk rating system is not helpful in predicting businesses that are likely to be associated with foodborne disease outbreaks. Catering businesses currently categorised as "high risk" and receiving the greatest amount of intervention from environmental health officers are not the businesses that are most likely to be associated with foodborne outbreaks. To make more effective use of the environmental health service within local authorities the risk rating system should be reviewed to include indicators that are known to be associated with foodborne outbreaks such as larger SME businesses.

(ii) Training and HACCP were not found to be protective. Further work is required to understand the reason behind this finding. It is possible that there needs to be a change in the approach to training and assessment within catering businesses, but any change should first be tested within the industry. The FSA has recently introduced the SFBB initiative to applying HACCP within the catering industry and this is now being extended into Welsh businesses. The effectiveness of this initiative should also be investigated.

(iii) Foodborne disease outbreak investigations should report management and operational information as well as food safety control failures associated with outbreak businesses. This will then support an increased understanding of the role of management and operational practices in foodborne outbreaks.

(iv) The role of larger SME catering businesses in foodborne disease outbreaks needs to be investigated to examine features commonly associated with this size of business but which were not considered by this study such as size of the kitchen, volume of food served and more detailed staff information.

(v) The provision of staff accommodation was an independently significant risk factor although the data did not explain the significance of this variable. Further work is required to establish if this risk factor is genuinely associated with foodborne outbreaks or simply a chance association.

7 CONCLUSION

To the author's knowledge this study, funded by the Food Standards Agency, and resulting in two publications (Jones et al. 2008; Jones et al. 2008a) is the first to use analytical epidemiology to study a wide range of management risk factors associated with foodborne disease outbreaks. A systematic literature review identified limited information on the role of management factors in contributing to foodborne outbreaks, the majority of information being incidental to the main focus of the published work. The findings of this thesis therefore provide an informative base for the environmental health and catering profession on the factors thought to contribute or prevent outbreaks of foodborne disease in the catering industry in England and Wales. Many staff employment and recruitment features known to burden the catering industry, such as high staff turnover, recruiting and retaining staff and employing casual staff, were found not to be associated with the occurrence of foodborne outbreaks.

Larger SMEs were more likely to have outbreaks but the numerous staff management, employment and operational variables measured were not able to explain this association. Management and operational practices did not vary significantly in case and control businesses. However, in *Salmonella* foodborne outbreaks the use of regional egg suppliers was the main explanatory factor and appeared to explain the association between outbreaks and SME size. Businesses associated with outbreaks attributed to eggs by local public health investigators were less likely to use eggs from an approved quality assurance scheme. It therefore seems probable that the underlying risk associated with regional egg suppliers is related to the supply of contaminated eggs. HACCP systems in place in the catering industry in England and Wales at the time of this study did not appear to address this risk.

Furthermore, neither HACCP nor formal food hygiene training were found to be protective against foodborne disease outbreaks and food hygiene inspection scores were not useful in predicting which catering businesses would be associated with outbreaks.

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APPENDICES

APPENDIX 1: Example of a study newsletter

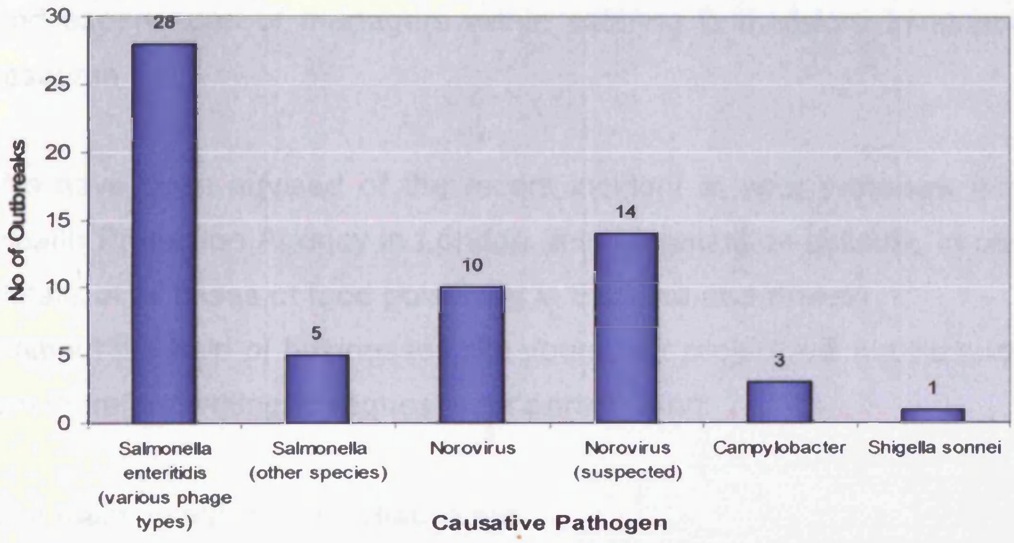
Management Risk Factors Resulting in Foodborne Disease Outbreaks in the Catering Industry: A Case-Control Study

Funded by the Food Standards Agency

Our fourth and penultimate newsletter outlines the progress of our main study throughout the year 2003. We will continue to collect details of bacterial and viral outbreaks associated with catering businesses until 31st December this year. Our research continues to receive tremendous support from the catering industry. This is reflected by our current response rates of 95% for case businesses and 97% for control businesses. Both EHOs and CCDCs continue to provide a valuable network which has provided a more efficient notification system. Thank you for your continued support.

Mrs Sarah Jones, Dr. Sharon Parry, Prof. Stephen Palmer, University of Wales College of Medicine and Dr. Sarah O'Brien, Health Protection Agency.

To date, 167 notifications have been received, of these 61 outbreaks come within case definition with a further 22 currently being processed. The Chart below outlines the causative pathogen associated with these 61outbreaks. The tables provides an indication of their geographical distribution.



Region	No of Outbreaks
North West	4
North East	6
North	6
Wales	4
Midlands	8
East	7
South East	8
South West	10
South	6
London	2

Have you been involved in a bacterial or viral outbreak in the last 6 months?

Please contact Sarah Jones (Tel: 029 20742119) if that outbreak occurred in a catering business including:

- Hotels/guest houses
- Restaurants/cafés/bars
- Pubs/takeaways
- Voluntary/home/commercial caterers
- Nursing/residential care homes (foodborne only)

We would also like to know about any Scombrotoxin outbreaks.

APPENDIX 2: Recruitment letters to case and control businesses

Dear

RE: PREVENTING FOOD POISONING IN THE CATERING INDUSTRY IN ENGLAND AND WALES

I am the Project Coordinator for this study which is attempting to identify the operational causes of food poisoning outbreaks in England and Wales. We are investigating the way in which restaurants who have been involved in an outbreak of food poisoning operate their business in comparison to a restaurant which has not been associated with a food poisoning outbreak. We are primarily concerned with meeting the needs of restaurant businesses by providing more practical guidance and advice to this industry. The opinions and experiences of managers within catering is therefore invaluable to our research

We have been advised of the recent incident at your premises through the Health Protection Agency in London (this organization collects, in confidence, details of all cases of food poisoning in England and Wales).
Without the help of businesses like yours, our project will not be successful. I am therefore writing to request your participation.

The main details of this initiative are:

- It is an independent research project, headed by the University of Wales, College of Medicine based in Cardiff.
- Business details and all information collected are entirely confidential to this project and you would not incur any cost.
- All interviewers have considerable experience in food hygiene and catering and as a result can offer free consultancy advice at the end of the visit, if requested.
- Our study involves an informal discussion at your convenience to discuss how you operate your catering business.

- This meeting will only take 30 minutes of your time. We are not interested in inspecting your kitchen only your opinions and experience as a restaurant manager.
- The aim of the project is to provide more relevant hygiene guidance to the catering industry which reflects the way in which businesses operate within a competitive market. It is intended that the guidance will focus on good operational practice in business terms rather than solely focusing on the elements of food hygiene.

As food poisoning continues to rise, further distress will be caused to those people who suffer illness and catering businesses will continue to lose income and face possible closure or bankruptcy. In an effort to reduce the number of food poisoning cases and enhance the reputation of the catering industry, we believe that with your help the work involved in this project will significantly improve this situation. With this in mind, I would like to contact you again towards the end of this week to discuss this matter further with the view to possibly arranging an appointment to meet you at your convenience.

Alternatively please feel at liberty to contact me directly on Tel: 02920742119.

Many thanks for your time

Sarah Jones, Project Coordinator

Dear ,

RE: PREVENTING FOODBORNE DISEASE OUTBREAKS IN THE CATERING INDUSTRY IN ENGLAND AND WALES

I am the Project Coordinator for this FSA study which is attempting to identify the operational causes of foodborne disease outbreaks in England and Wales. We are investigating the way in which catering businesses who have been involved in an outbreak of food poisoning operate their business in comparison to catering businesses which has not been associated with a food poisoning outbreak. We are primarily concerned with meeting the needs of catering businesses by providing more practical guidance and advice to your industry. The opinions and experiences of managers is therefore invaluable to our research

There has recently been an outbreak in the ******** area involving a comparable business to yours. The ********** was randomly selected from the Local Authority Food Register as a 'control' business for this outbreak. Without the help of 'control' businesses like yours i.e. business where food poisoning outbreak has not occurred, our project will not be successful. I am therefore writing to request your participation.

The main details of this initiative include:

- It is an independent research project, headed by the University of Wales College of Medicine based in Cardiff.
- The aim of the project is to provide more relevant hygiene guidance to the catering industry which reflects the way in which businesses operate within a competitive market. It is intended that the guidance will focus on good operational practice in business terms rather than solely focusing on the elements of food hygiene.
- All business details and all information collected during this project is entirely confidential to this project and there is no cost to any business that participates.

- We ask for half an hour of the businesses time when the manager would be interviewed to a standard protocol. Please note that this meeting DOES NOT involve an inspection only an informal discussion at a time to suit you.
- We send you regularly updates on the project progress and results.

During the data collection part of this study, all case and control businesses are identified by numerical code only. I am the only person together with my colleague ****** who undertakes interviews in the North of England who will know the details of our discussions. I also input all data into a secure database at the University, where the only hard copy of the interview is also securely stored. When the results of the study are written up, no business or person interviewed is identified by either name or numerical code.

As food poisoning continues to rise, further distress will be caused to those people who suffer illness and our businesses will continue to lose income and face possible closure or bankruptcy. In an effort to reduce the number of food poisoning cases and enhance the reputation of the catering industry, we believe that with your help the work involved in this project will significantly improve this situation.

With this in mind, please feel at liberty to contact at your convenience on Tel: 02920742119

Many thanks for your time.

Sarah Jones, Project Coordinator