

Understanding the use of antibiotics in the management of dental problems in primary care



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To G.F.C and G.M.C

Summary

Antimicrobial resistance is an international public health problem and is associated with increased morbidity, mortality, and healthcare costs. Antibiotic consumption, particularly indiscriminate use of these agents, is recognised as a major cause of resistance.

Clinical guidelines recommend that in otherwise healthy individuals, antibiotics should not be used in the management of acute dental conditions, in the absence of spreading infection and systemic upset. Instead, a surgical intervention should be the first-line treatment for such problems.

This thesis describes the use of antibiotics for acute dental conditions in primary care in the UK, and explores factors that influence prescribing for dental problems using a mixed methods approach.

Within this work over half of patients who consulted a primary care practitioner for an acute dental problem received an antibiotic, often in the absence of operative treatment. Less than 20% of antibiotics were prescribed in compliance with clinical guidelines. General dental practitioners' antibiotic prescribing behaviours were influenced by their attitude to clinical guidelines, and the presence of diagnostic and prognostic uncertainty. Patient-related factors such as clinical presentation, willingness and ability to accept operative treatment, and requests for antibiotics also modified prescribing behaviours, as did pressures of clinical time and workload. Within general medical practice, antibiotic therapy was associated with increased reconsultation rates for dental problems within a two-year period. General medical practitioners' prescribing decisions for dental conditions were contingent on how they balanced patients' immediate needs against their desire to motivate them to seek more appropriate care. This may be influenced by medical practitioners' perceptions of access to local dental services, and their attitudes towards managing dental problems.

This thesis progresses understanding regarding the use of antibiotics for acute dental conditions. It highlights the need for interventions to optimise prescribing for dental conditions in UK primary care.

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Declaration

This work has not been submitted in substance for any other degree or award at this or any other university or place of learning, nor is being submitted concurrently in candidature for any degree or other award.

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Abbreviations

AAE	American Association of Endodontists
ABM UHB	Abertawe Bro Morgannwg University Health Board
AC	Ms Anwen Cope (candidate)
Aneurin Bevan HB	Aneurin Bevan Health Board
APICAL	Antibiotics and Primary Care Dental Problems (study name)
Betsi Cadwaladr UHB	Betsi Cadwaladr University Health Board
BNF	British National Formulary
Cardiff and Vale UHB	Cardiff and Vale University Health Board
CI	Confidence interval
CPD	Continued professional development
CPRD	Clinical Practice Research Datalink
CRF	Case report form
Cwm Taf HB	Cwm Taf Health Board
DIC	Deviance Information Criterion
DPF	Dental Practitioners' Formulary
ED	Emergency department
EDS	Emergency dental service
FGDP(UK)	Faculty of General Dental Practice UK
FW	Dr Fiona Wood (supervisor)
GDC	General Dental Council
GDP	General dental practitioner
GMP	General medical practitioner
Hywel Dda LHB	Hywel Dda Local Health Board
ICC	Intra-cluster correlation co-efficient
IGC	Professor Ivor G. Chestnutt (supervisor)
IGLS	Iterative Generalised Least Squares
IQR	Inter-quartile range
IT	Information technology
LHB	Local Health Board
MCMC	Monte-Carlo Markov Chain
MFDS	Membership of the Faculty of Dental Surgery
MJDF	Membership of the Joint Dental Faculties

MQL	Marginal Quasi Likelihood
MSc	Master of Science
NF	Dr Nick Francis (supervisor)
NHS	National Health Service
NTDC	Non-traumatic dental conditions
OMFS	Oral and maxillofacial surgery
Pen V	Phenoxymethylpenicillin
Powys LHB	Powys Local Health Board
PQL	Penalised Quasi Likelihood
R&D	Research and Development
RSD	Root surface debridement
RTI	Respiratory tract infection
SD	Standard deviation
SDCEP	Scottish Dental Clinical Effectiveness Programme
UK	United Kingdom
USA	United States of America
VPC	Variance partition co-efficient
WIMD '11	Wales Index of Multiple Deprivation 2011

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1. The Use of Antibiotics in the Management of Acute Dental Conditions - Background and Appraisal of the Evidence Base

1.1 Introduction

This chapter briefly describes the aetiology of antimicrobial resistance, outlines the potential contribution of dental prescribing to the emergence of resistance, and explores other key considerations regarding antibiotic use (Section 1.2). The pathogenesis and presentation of commonly encountered acute dental problems is then described in Section 1.3. This is followed by a literature review evaluating the effects of systemic antibiotics in such conditions (Section 1.4).

An overview of primary care services in relation to dental problems is presented in Section 1.5. The second literature review then evaluates the existing national and international evidence regarding the use of systemic antibiotics in the management of dental problems in primary care, and factors that influence the use of these agents (Section 1.6). This review then informs the aims and objectives of this thesis which are presented in Section 1.7.

1.2 Antibiotic use and resistance

Since their introduction in the 1930s and 1940s, antibiotics have saved countless lives. Their availability has contributed to major advances in health, and has substantially increased life expectancy. However soon after the earliest trials of antibiotics it became evident that some bacteria possessed, or could acquire, genetic mutations conferring resistance to these agents. During the intervening 80 years there has been a gradual and sustained emergence of antimicrobial resistant bacterial strains, whilst the number of new antibiotics has dramatically decreased. This has led to increasing concern about the potential impact antibiotic resistance could have on the management of infectious diseases. Resistant infections are more difficult and expensive to treat, and result in increased morbidity, mortality and healthcare costs (Cosgrove 2006, European Centre for Disease Prevention and Control (ECDC) / European Medicines Agency (EMA) 2009). Consequently, antimicrobial resistance is now widely considered a grave threat to international public health (Davies 2013, The Lancet Infectious Diseases 2013).

Antibiotic consumption is recognised as a major cause of emerging resistance, and some of the increase in resistance is directly attributed to the indiscriminate or poor use of antibiotics (Laxminarayan et al. 2013). The association between levels of antibiotic prescribing and prevalence of antibiotic resistance has been established at the individual (Costelloe et al. 2010), general practice (Vellinga et al. 2010), and country-wide level (Goossens et al. 2005).

1.2.1 Antibiotic use in primary care dentistry

Approximately 80% of human consumption of antibiotics in the United Kingdom (UK) occurs in primary care (Standing Medical Advisory Committee Sub-Group on Antimicrobial Resistance 1998). As dentists currently prescribe approximately 9-10% of all antibiotics dispensed in primary care in the UK (Holyfield and Karki 2009, Health & Social Care Information Centre 2014), the possible contribution of dental prescribing to the development of antibiotic resistance should not be underestimated.

In addition, antibiotic therapy prescribed by dentists is typically empirical, not employing routine culture and sensitivity testing, and often involves broad-spectrum agents, which can predispose to the selection of resistant strains (Sweeney et al. 2004). Antibiotic resistant bacteria have been isolated from odontogenic infections (Teng et al. 1998, Eick et al. 1999, Kuriyama et al. 2002), and studies have identified a correlation between the emergence of antibiotic resistant bacteria such as *Prevotella sp.* and previous administration of antibiotics for dental infections (Kuriyama et al. 2000). Whilst clinical audit has demonstrated that the presence of penicillin-resistant bacteria may not adversely affect clinical outcomes following local measures such as dental extraction (Kuriyama et al. 2005), the prescription of systemic antibiotics for dental problems does not just apply a selective pressure to oral bacteria. The overuse of penicillins in the treatment of dental conditions could potentially impact on the prevalence of antibiotic resistant colonies implicated in the aetiology of pneumonia, bacterial meningitis and upper respiratory tract infections (Kaplan and Mason 1998).

1.2.2 Other considerations regarding the use of antibiotics in dental problems in primary care

Whilst antimicrobial resistance represents a significant concern, other issues such as adverse events, resource management, morbidity, and prescribing rates in subsequent consultations

should also be considered when discussing the use of antibiotics in the management of acute dental conditions.

1.2.2.1 Adverse events

Every prescription for an antibiotic carries with it the small but significant risk of an adverse event, such as a hypersensitivity reaction. Approximately 0.02% to 0.04% of the population are at risk of anaphylaxis following penicillin exposure, the most commonly prescribed type of antibiotics for dental problems (Idsoe et al. 1968, Anderson et al. 2000, Holyfield and Karki 2009, Health and Social Care Information Centre 2014). Significantly more will experience other symptoms of hypersensitivity, or other side effects such as antibiotic-associated colitis (Scottish Dental Clinical Effectiveness Programme 2011).

1.2.2.2 Resource management

In 2013 the Net Ingredient Cost for antibiotics prescribed by dentists in England was £5.8 million (Health and Social Care Information Centre, 2014). This represents significant government investment and does not include costs associated with dispensing medications or the contribution of prescribing in Wales, Scotland, and Northern Ireland.

1.2.2.3 Morbidity

Evidence suggests that antibiotics are being used as an alternative to providing operative treatment for patients with acute dental conditions (Dailey and Martin 2001, Tulip and Palmer 2008). Deferral of operative treatment has previously been identified as a risk factor for severe infectious complications from an odontogenic infection (Seppanen et al. 2011). Such infections are potentially life threatening and are a common cause of admission to Oral and Maxillofacial Surgery units.

1.2.2.4 Prescribing rates in subsequent consultations

Evidence from general medical practice indicates that prescribing antibiotics for infections generates increased medical consultation rates for the same condition in the future (Little et al.

1997). Receiving a prescription for antibiotics may also affect a patient or carer's expectation of receiving a similar medicine in the future. Since patient expectation has been demonstrated to be a significant influencing factor on clinicians' prescribing behaviour, this could lead to a cycle of inappropriate prescribing (Cockburn and Pit 1997, Macfarlane et al. 1997, Coenen et al. 2006).

1.3 Acute dental conditions

Acute dental conditions arise due to pathologies within the tooth or its supporting structures, as a sequelae of dental caries, periodontal disease, trauma, or iatrogenic damage (Sindet-Pedersen et al. 1985). Dental pain, or odontalgia, is a common symptom of an acute dental condition (Tulip and Palmer 2008), and is known to have a detrimental impact on an individual's social functioning, economic productivity and quality of life (Reisine and Locker 1995, Pau et al. 2005). It therefore vital that patients with acute dental conditions receive effective dental care.

The most frequently occurring acute dental problems are pulpitis, apical periodontitis and apical abscess (pulpal and apical pathologies), and pericoronitis and periodontal abscesses (periodontal pathologies). Together these conditions accounted for over of 80% of adult presentations at a UK emergency dental clinic (Dailey and Martin 2001).

1.3.1 Acute pulpal and apical pathologies

Pulpal pathologies are disorders of the dental pulp, whilst apical pathologies are conditions of the tissues surrounding the apex, or end, of the tooth root.

Several methods of classifying pulpal and apical pathologies have been proposed (Weine 1989, World Health Organization 1995, Abbott and Yu 2007, Ingle et al. 2008, Hargreaves and Cohen 2011, Orstavik and Ford 2008). However, as there is an inconsistent correlation between clinical signs and symptoms of dental pain and the histological appearance of the pulp and apical tissues of affected teeth, there has been a move towards a more clinical classification with emphasis on effective treatment planning. With this in mind, the American Association of Endodontists (AAE) convened the Consensus Conference on Diagnostic Terminology in 2008 to standardise the diagnostic terminology used within the dental profession (Glickman 2009). The terminology and classification that follows within this thesis reflects the consensus recommendations of this congress (AAE Consensus Conference Recommended Diagnostic Terminology 2009) (Figure 1.1).

PULPAL DIAGNOSTIC TERMINOLOGIES

Normal pulp - A clinical diagnostic category in which the pulp is symptom-free and normally responsive to pulp testing.

Reversible pulpitis* - A clinical diagnosis based on subjective and objective findings indicating that the inflammation should resolve and the pulp return to normal.

Symptomatic irreversible pulpitis* - A clinical diagnosis based on subjective and objective findings indicating that the vital inflamed pulp is incapable of healing. Additional descriptors: lingering thermal pain, spontaneous pain, referred pain.

Asymptomatic irreversible pulpitis - A clinical diagnosis based on subjective and objective findings indicating that the vital inflamed pulp is incapable of healing. Additional descriptors: no clinical symptoms but inflammation produced by caries, caries excavation, trauma.

Pulp necrosis - A clinical diagnostic category indicating death of the dental pulp. The pulp is usually nonresponsive to pulp testing.

Previously treated - A clinical diagnostic category indicating that the tooth has been endodontically treated and the canals are obturated with various filling materials other than intracanal medicaments.

Previously initiated therapy - A clinical diagnostic category indicating that the tooth has been previously treated by partial endodontic therapy (e.g. pulpotomy, pulpectomy).

APICAL DIAGNOSTIC TERMINOLOGIES

Normal apical tissues - Teeth with normal periradicular tissues that are not sensitive to percussion or palpation testing. The lamina dura surrounding the root is intact, and the periodontal ligament space is uniform.

Symptomatic apical periodontitis* - Inflammation, usually of the apical periodontium, producing clinical symptoms including a painful response to biting and/or percussion or palpation. It might or might not be associated with an apical radiolucent area.

Asymptomatic apical periodontitis - Inflammation and destruction of apical periodontium that is of pulpal origin, appears as an apical radiolucent area, and does not produce clinical symptoms.

Acute apical abscess* - An inflammatory reaction to pulpal infection and necrosis characterized by rapid onset, spontaneous pain, tenderness of the tooth to pressure, pus formation, and swelling of associated tissues.

Chronic apical abscess - An inflammatory reaction to pulpal infection and necrosis characterized by gradual onset, little or no discomfort, and the intermittent discharge of pus through an associated sinus tract.

Condensing osteitis - Diffuse radiopaque lesion representing a localized bony reaction to a low-grade inflammatory stimulus, usually seen at apex of tooth.

Figure 1.1 - AAE Consensus Conference Recommended Diagnostic Terminology (2009)

***highlighted terms are those included in the literature review (Section 1.4).**

1.3.1.1 Pulpal pathologies

The dental pulp is an innervated, vascular connective tissue encased by dentine, enamel and cementum (Berkovitz et al. 2009). As a living tissue, the pulp may become inflamed, or pulpitic, if irritated or injured. This most commonly occurs due to bacterial, mechanical, thermal or chemical insults due to dental caries, trauma or mechanical preparation of a tooth (Selwitz et al. 2007).

Pulpitis is primarily a protective response and is characterised by increased blood flow within the pulp and the local migration of inflammatory cell infiltrate. However, in contrast to the inflammatory process within other connective tissues, when inflammation occurs within the rigid dentinal chamber there is no capacity for the pulpal tissue to swell to accommodate the increased fluid volume. As a result, the pressure in the pulp increases, compressing the vascular supply.

Pulpitis is classified as either reversible or irreversible based on the potential of the pulp to recover from its state of inflammation (AAE Consensus Conference Recommended Diagnostic Terminology 2009). Teeth exhibiting reversible pulpitis are often acutely painful on the application of stimuli, such as thermal changes, but become quiescent once the stimulus is removed. No spontaneous pain is exhibited and the pulp can return to a non-inflamed state if adequate treatment, usually the removal of the bacterial irritant, is provided (Seltzer et al. 1963, Lundy and Standley 1969, Dummer et al. 1980).

In contrast, patients diagnosed with irreversible pulpitis report lingering, or even spontaneous pain. Irreversible pulpitis results from widespread pulpal inflammation, which cannot be resolved by removal of the inflammatory irritant. Referred pain, the sensation of pain in areas not affected by the causative pathology, is also not uncommonly encountered in patients with irreversible pulpitis (McCarthy et al. 2010).

The recommended operative treatment for irreversible pulpitis is pulpal extirpation, also known as a pulpectomy, a type of endodontic, or root canal, treatment. Alternatively, the causative tooth can be extracted (Carrotte 2004). If a tooth with irreversible pulpitis remains untreated, it will eventually become necrotic, although the period over which this occurs is unclear (Gallatin et al. 2000). Pulpal necrosis is a clinical diagnosis indicating that there is no longer a functional neurovascular supply within the tooth (Hargreaves and Cohen 2011). Following necrosis, a tooth will often become quiescent and asymptomatic until the instigation of inflammatory processes within the apical tissues.

In an observational study of an English emergency dental clinic, 35% of adult patients with dental pain were diagnosed with pulpitis (Dailey and Martin 2001). However, there exists little epidemiological data about the incidence and prevalence of pulpitis within the UK population as a whole.

1.3.1.2 Apical pathologies

1.3.1.2.1 Apical periodontitis

Apical periodontitis is an inflammatory lesion of the periradicular tissues. It principally arises due to the egress of irritants, such as bacteria and toxins, from an inflamed or necrotic pulp. Its evolutionary role is protective; to contain the root canal bacteria and prevent the spread of infection (Estrela 2009). Apical periodontitis may arise in a tooth with an extensive inflammatory lesion of the pulp, a recently necrosed tooth, a tooth that has been necrotic for many years, or a tooth with failing endodontic therapy. Apical periodontitis can also arise in response to iatrogenic injury, such as the extrusion of endodontic instruments or medicaments beyond the apical foramen, or following lateral perforation of a root canal (Bergenholtz et al. 2010).

Apical periodontitis exists in both symptomatic and asymptomatic forms. Teeth with asymptomatic apical periodontitis display no clinical symptoms, but may have an associated apical radiolucency or condensing osteitis when examined radiographically. Symptomatic apical periodontitis can arise either from a tooth undergoing pulpal necrosis, following irreversible pulpitis, or as a 'flare-up' of a previously asymptomatic apical periodontitis. It is characterised by acute pain, which is exacerbated by biting. In comparison to irreversible pulpitis, patients are much more likely to be able to identify the causative tooth, as the apical inflammation has engaged the tactile fibres of the periodontal ligament. Furthermore, the presence of oedema within the apical region can produce the sensation that the tooth is in supraocclusion, or is raised in the bite. Radiographic changes, including widening of the periodontal ligament may be seen, but frank apical radiolucency is unusual unless the situation represents a flare-up of an established asymptomatic apical periodontitis. The affected tooth usually has a negative or delayed positive response to sensibility testing and is often highly sensitive to percussive forces (Bergenholtz et al. 2010).

Bacterially induced apical periodontitis lesions rarely resolve spontaneously. Despite the host defence, the body is unable to destroy the bacterial biofilm residing within the necrotic pulp,

and therefore the inflammatory irritant cannot be eliminated. Chronic presence of irritants within the apical tissue can lead to establishment of asymptomatic apical periodontitis, an acute apical abscess, or apical cyst (Nair 1997). The most commonly recommended operative treatments for apical periodontitis are pulpectomy or exodontia (tooth extraction) (Carrotte 2004).

The prevalence of asymptomatic apical periodontitis amongst European adults is reported to be between 15–70% depending on the population and type of radiographic examination undertaken (Cleen et al. 1993, Aleksejuniene et al. 2000, Jiménez-Pinzón et al. 2004, Skudutyte-Rysstad et al. 2012). In comparison, the relative incidence and prevalence of symptomatic apical periodontitis is less well described. In an observational study of an English emergency dental clinic, 9% of adult patients with dental pain were diagnosed with symptomatic apical periodontitis (Dailey and Martin 2001).

1.3.1.2.1 Apical abscesses

An apical abscess arises when there is a shift in the microbial flora of the non-vital tooth, resulting in the massive influx of polymorphonuclear leukocytes into the apical tissues. The bacterial change is usually both quantitative, with an increase in the number of bacteria, and qualitative, indicating a shift in the ecology of the bacterial population towards anaerobic species (Fouad 2009). The accumulation of dead leukocytes and connective tissue breakdown products results in pus formation, a characteristic feature of an acute apical abscess (Ingle et al. 2008).

An acute apical abscess is characterised by throbbing pain of rapid onset, tenderness of the tooth to pressure and percussion, and the erythema and swelling of associated tissues (AAE Consensus Conference Recommended Diagnostic Terminology 2009). Swelling can occur intra- or extraorally, or both, depending on the relative amount of inflammatory infiltrate, oedema and pus formation, and the spread of these through the connective tissue spaces. Pain is often severe in the initial stages of abscess formation, however upon perforation of the periosteum and spread of infectious products into the loose connective tissue spaces, pain will often dissipate. The tooth will be negative to sensibility testing, and radiographic presentation may be variable. In an observational study of an English emergency dental clinic, 27% of adult patients with dental pain were diagnosed with an apical abscess (Dailey and Martin 2001).

The aim of operative treatment performed in the management of acute apical abscess is to relieve pressure by establishing drainage. This is usually done by extraction of the affected tooth or by gaining access to the pulp chamber. If a soft-tissue swelling is present, it may be incised to establish drainage (Carrotte 2004). Controversy exists as to whether exodontia should be performed in the presence of acute infection (Williams 2013). However a literature review has confirmed that immediate extraction results in faster resolution, decreased pain, and earlier return of function and oral intake, whilst the risk of seeding the infection into deeper tissues is low (Johri and Piecuch 2011).

If untreated, an acute apical abscesses can spread, either locally, resulting in diffuse swelling or cellulitis, or systemically, causing symptoms such as fever and malaise. The spread of infection into adjacent, and occasionally remote, connective tissue compartments can also result in potentially fatal sequelae. Incidences of Ludwig's angina (Candamourty et al. 2012), intracranial abscess (Haggerty and Tender 2012), cavernous sinus thrombosis (Kiddee et al. 2010), mediastinitis (Sarna et al. 2012), necrotising fasciitis (Farrier et al. 2007), septic shock (Rosado et al. 2009) and death (Carter and Lowis 2007, Sarna et al. 2012) originating from odontogenic infections have all been reported.

Similar to the dynamic relationship that exists between symptomatic and asymptomatic apical periodontitis, acute apical abscesses can become chronic following the formation of a sinus tract, and chronic apical abscesses can enter acute phases (Abbott 2004). Chronic apical abscesses are characterised by little or no discomfort and the intermittent discharge of pus through an associated sinus tract (AAE Consensus Conference Recommended Diagnostic Terminology 2009).

1.3.2 Acute periodontal pathologies

1.3.2.1 Periodontal abscesses

Abscesses of the periodontium are classified based on location. Gingival abscesses involve the marginal gingiva or interdental papilla and usually occur due to the presence of foreign bodies. In comparison, periodontal abscesses occur within the tissues adjacent to the periodontal pocket. Pericoronal abscesses are localised within the tissue surrounding the crown of a partially erupted tooth (Lang et al. 1999, Meng 1999).

Periodontal abscesses can develop in periodontitis-affected or previously healthy sites, and may initiate following bacterial invasion into the tissues surrounding the periodontal pocket (Herrera et al. 2014). Chemotactic factors released by bacteria then attract inflammatory cells to the site, leading to tissue destruction, the encapsulation of the bacterial infection and the production of pus. The microbiology of the periodontal abscess is polymicrobial and is dominated by non-motile, gram-negative, strictly anaerobic, species (Ellison 2009).

Periodontal abscesses have a heterogeneous presentation with respect to degree of pain, tenderness, swelling, tooth mobility, tooth elevation and sensitivity (Ahl et al. 1986, Herrera et al. 2000). The radiographic examination may reveal a normal appearance, or in cases of pre-existing periodontal disease, bone loss (Herrera et al. 2014). In an observational study conducted in an English emergency dental clinic, 5% of adult patients with dental pain were diagnosed with a periodontal abscess (Dailey and Martin 2001).

Similar to acute apical abscesses, infections of the periodontium can spread locally or to distant sites or cause systemic upset (Gallagher et al. 1981, Pearle and Wendel 1993, Herrera et al. 2014). The most commonly recommended operative treatment for abscesses of the periodontium is irrigation and debridement of the periodontal pocket (Herrera et al. 2014).

1.3.2.2 Pericoronitis and pericoronal abscesses

Pericoronitis is inflammation of the tissues surrounding the crown of a partially erupted tooth, most commonly a mandibular third molar (Moloney and Stassen 2009). This occurs due to trauma from the opposing maxillary third molar, or entrapment of debris and associated microorganisms underneath the operculum, the lid of gingival tissue covering the erupting tooth. Pericoronitis most commonly affects young adults and is associated with horizontal impaction of third molars. Patients with pericoronitis typically present with pain, swelling and trismus (limited mouth opening) (Moloney and Stassen 2009). In an observational study of an English emergency dental clinic, 5% of adult patients with dental pain were diagnosed with pericoronitis (Dailey and Martin 2001).

If the pericoronal tissues become infected, an abscess may form. The causative organisms are typically Gram-negative anaerobic bacteria, and the condition presents with pain, bad taste, and inflammation and suppuration of the pericoronal tissues. Once established, a pericoronal abscesses behave similarly to an acute apical or periodontal abscess, and may spread posteriorly

into the oropharyngeal area and associated connective tissue spaces (Meng 1999). Whilst pericoronal abscesses represent a different pathological process from that of pericoronitis, infections associated with partially erupted teeth are commonly referred to as 'pericoronitis' within the clinical environment (Moloney and Stassen 2009).

Due to morbidity associated with third molar extractions, guidelines recommend that patients experiencing their first episode of pericoronitis, unless particularly severe, should not undergo exodontia (National Institute for Health and Care Excellence 2000). Instead, mild episodes of pericoronitis may respond to irrigation and debridement of the operculum or extraction of the opposing maxillary tooth (Moloney and Stassen 2009). However, exodontia is advised in patients who have experienced significant infection associated with a pericoronal abscess, or those who have suffered two or more episodes of pericoronitis (National Institute for Health and Care Excellence 2000).

1.3.2.3 Combined periodontal-endodontic lesions

The pulpal, apical and periodontal tissues are closely related and the potential for disease transmission between these regions is relatively well documented (Kobayashi et al. 1990, Kerekes and Olsen 1990). The migration of bacteria and their products from a periodontal lesion into the endodontic tissues, or vice versa, can occur through anatomical pathways such as the apical foramen and lateral canals, or via non-physiological pathways such as iatrogenic root canal perforation or root fracture (Sunitha et al. 2008).

The periodontal-endodontic lesion develops by expansion of periodontal destruction into the apical tissues or by extension of an endodontic lesion into an existing periodontal lesion (Herrera et al. 2014), and therefore periodontal-endodontic lesions may be:

- A primary endodontic lesion with secondary periodontal involvement
- A primary periodontal lesion with secondary endodontic involvement
- A true combined lesion (Simon et al. 1972)

Clinical presentation of periodontal-endodontic lesions is variable, and depending on whether the lesion is undergoing an acute exacerbation, patients may or may not present with odontalgia. Acute exacerbations are associated with pain, swelling, pus or other exudates, pocket formation, and tooth mobility. Signs of a chronic lesion include an isolated deep periodontal pocket, or the exudation of pus on probing (Sunitha et al. 2008).

Combined periodontal and endodontic therapy is generally required for the successful healing of periodontal-endodontic lesions. However the prognosis of teeth with these lesions is generally more unpredictable than those with isolated periodontal or endodontic pathology (Sunitha et al. 2008).

1.4 The effects of systemic antibiotics in the management of common acute dental conditions in adults – a literature review

“To avoid the deleterious effects of needless antibiotics on patients and the environment, the most important initial decision is not which antibiotic to prescribe, but whether to use one at all.” (Morrow 2012 p. 3)

In a time where there is widespread concern about the increasing prevalence of antimicrobial resistant bacteria, it is important that antibiotics are used judiciously and only where they are likely to convey clinical benefit to a patient. Whilst the majority of acute dental problems are bacterially mediated, most are dominated by inflammatory, not infectious, processes, raising concerns regarding the efficacy of antibiotics in such conditions.

Therefore, it was important to establish whether antibiotics are effective in the management of acute dental conditions, and to quantify any benefit that does exist. Previous reviews evaluating the effects of antibiotics in the management of acute dental conditions either evaluated only a small number of conditions, or were over a decade old (Matthews et al. 2003, Sutherland and Matthews 2003, Fedorowicz et al. 2013). Consequently, it was pertinent to perform a review to consolidate and update the evidence regarding the effects of systemic antibiotics in the management of acute dental conditions.

The researcher (AC) as part of her PhD studies subsequently undertook a Cochrane Review of systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults. This review is presented in Appendix I. In comparison to the review described below, the Cochrane Review included a smaller range of dental conditions and excluded non-placebo controlled trials.

1.4.1 Objectives

The objectives of this review were to evaluate the effects of systemic antibiotics provided for reversible pulpitis, irreversible pulpitis, symptomatic apical periodontitis, acute apical abscess, periodontal abscess, combined periodontal-endodontic lesions, pericoronitis, and other undifferentiated acute dental conditions, with or without a surgical intervention, such as extraction, incision and drainage of a swelling or endodontic treatment, and with or without analgesics.

1.4.2 Methods

1.4.2.1 Criteria for considering studies for this review

Inclusion criteria were as follows:

- Type of study: only randomised controlled trials were considered for inclusion.
- Type of participant: adults or children diagnosed with a single tooth with reversible pulpitis, irreversible pulpitis, symptomatic apical periodontitis, acute apical abscess, periodontal abscess, combined periodontal-endodontic lesions, pericoronitis, or an undifferentiated acute dental condition.
- Type of intervention: systemic antibiotics, any type or dosage, either as a sole treatment or in conjunction with a surgical intervention.
- Type of control: a matched placebo, or no antibiotic.
- Type of outcome: measures of patient-reported pain, swelling or other indicators of infection such as swelling, temperature, trismus, regional lymphadenopathy (abnormality in the size or character of lymph nodes), or cellulitis, or clinician-reported measures of infection.

1.4.2.2 Search methods for identification of studies

A detailed search strategy was developed for each database searched (Appendix II). The searches were conducted in MEDLINE (1946 to 6th November 2014) and EMBASE (1947 to 6th November 2014) via OVID, and the Cochrane Central Register of Controlled Trials.

No language restrictions were applied. No additional hand searching was carried out, although reference lists of relevant articles were searched in an attempt to identify potentially relevant additional studies.

1.4.2.3 Data collection and analysis

One author (AC) assessed the titles and abstracts (where available) of the articles identified by the search strategy and made decisions regarding eligibility. Full text versions were obtained for all articles being considered for inclusion, as were those with insufficient information in the title or abstract to make a clear decision. Data were then extracted, and reasons given for the exclusion of studies. Included studies then underwent more detailed data extraction and were assessed for methodological quality and risk of bias.

1.4.2.4 Measures of treatment effect

All studies reported continuous outcomes and therefore mean differences (MD) and their corresponding 95% CI were reported. Standardised mean differences (SMD) were used in instances where there were different scales measuring the same outcome.

1.4.2.5 Unit of analysis issues

The nature of the outcome variables being recorded meant there were likely to be repeat observations. As results from more than one time point for each study cannot be combined in a standard meta-analysis without a unit-of-analysis error, outcomes were assessed at 24, 48 and 72 hours, and seven days postoperatively, as the data allowed.

1.4.2.6 Data synthesis

Meta-analysis was conducted where studies of similar comparisons reported similar outcomes for participants with similar conditions. Mean differences and SMDs were combined using a fixed effects model, as there were only two studies suitable for synthesis. A random effects model would have been used if there were four or more studies.

1.4.3 Results

After deduplication, the search strategy identified 297 references (Appendix III). One extra reference was identified by checking the bibliographies of the selected trials (Matijević et al. 2009b). After examining the titles and abstracts, where available, 278 records were excluded. Full copies of the 20 remaining papers were obtained for further analysis, of which eight papers met the inclusion criteria:

- One assessed antibiotics as a standalone treatment for irreversible pulpitis (Nagle et al. 2000)
- One assessed antibiotics as a standalone treatment for patients with undifferentiated acute dental pain with no signs of spreading infection or systemic involvement (Runyon et al. 2004).
- One assessed antibiotics as an adjunct to endodontic treatment in symptomatic apical periodontitis (Lindeboom et al. 2005).
- Five assessed antibiotics as an adjunctive treatment for acute apical abscess (Fouad et al. 1996, Henry et al. 2001, Al-Belasy and Hairam 2003, Matijević et al. 2009a, 2009b).

The excluded studies are described in Appendix IV.

No trials were identified that assessed the effects of antibiotics in:

- Reversible pulpitis
- Periodontal abscess
- Combined periodontal-endodontic lesions
- Pericoronitis

1.4.4 Systemic antibiotics as a stand-alone treatment

1.4.4.1 Irreversible pulpitis

One randomised, double-blind, placebo-controlled trial based at a dental hospital in the United States of America (USA) investigated systemic antibiotics as a standalone treatment for adults with irreversible pulpitis (Nagle et al. 2000). In this trial investigators randomised 40 patients in a 1:1 ratio to a seven-day course of oral penicillin or a matched placebo. Both groups also received oral analgesics but no operative intervention. Participants recorded pain and

percussive pain on an ordinal 4-point scale during a 7-day follow up. The number and type of analgesia medication required was also recorded.

Authors reported that there were no statistically significant differences ($p>0.05$) between groups in terms of pain, percussion pain (Table 1.1), or the quantity of analgesia required by the participants. Although methodologically sound, the trial was underpowered and therefore it is not possible to be confident that no difference exists between the treatment groups. It should also be noted that the inclusion criteria for the trial contained ambiguity, as included teeth also had percussion sensitivity, a feature more commonly associated with symptomatic apical periodontitis.

	Penicillin (n=20)	Placebo (n=20)	P value
Sum of pain intensity difference*	6.0 (10.5)	6.0 (9.5)	0.776
Sum of percussion pain intensity difference*	3.5 (7.5)	2.0 (7.0)	0.290

Table 1.1 - Sum of pain and percussion pain intensity difference and number of analgesics required (Nagle et al. 2000) *Median and interquartile range

1.4.4.2 Undifferentiated acute dental pain

One randomised, double-blind, placebo-controlled trial based at an emergency department (ED) in the USA investigated systemic antibiotics as a standalone treatment for adults with dental pain and no clinical overt infection (Runyon et al. 2004). In this trial investigators randomised 195 participants in a 1:1 ratio to receive either oral penicillin or a non-matched placebo. Both groups also received oral analgesics but no operative intervention. The primary outcome was development of signs of infection (temperature $>38.1^{\circ}\text{C}$, intra- or extra-oral swelling, purulence or trismus) as judged by a clinician between 5- and 7 days postoperatively. A secondary outcome was patient-reported pain at follow-up.

Authors report that, within this relatively diagnostically heterogeneous sample, there were no statistically significant differences between penicillin and placebo groups with respect to development of overt infection or patient-reported pain at the follow up (Table 1.2). However there was high and unequal attrition between the intervention and control arms (65% follow up penicillin vs 70% placebo). This may have been due to differences in outcome, making this trial at high risk of attrition bias. Furthermore, observed rates of overt infection were lower than

predicted in the sample size calculation making it likely that the study was also underpowered. Finally, placebo and penicillin capsules were of different appearances, which could have resulted in detection bias.

	Penicillin (n=70)	Placebo (n=64)	P value
Patients with signs of infection at follow-up (%)	7 (10%)	6 (9%)	0.90
Mean patient-reported pain at follow up (SD)	43.5 (34.8)	42.0 (31.0)	0.80

Table 1.2 - Primary and secondary outcome measures by treatment group (Runyon et al. 2004)

1.4.5 Systemic antibiotics as an adjunct to operative treatment

1.4.5.1 Symptomatic apical periodontitis

One randomised, double-blind, placebo-controlled trial conducted in an academic medical centre in the Netherlands assessed the effect of preoperative antibiotics in the surgical endodontic management of symptomatic apical periodontitis in adult patients (Lindeboom et al. 2005). The sample included 256 adults with symptomatic apical periodontitis referred for endodontic surgical procedures. All teeth were judged by investigators to have an adequate root filling and coronal restoration, and all participants were free of signs of infection at the time of enrolment.

Participants were randomised 1:1 to receive either a single oral dose of 600mg clindamycin or a matched placebo 1 hour before undergoing surgical endodontic treatment. All participants received oral analgesics, chlorhexidine mouthwash and the same postoperative care regime. Patients, surgeons, and operators were all blind to group allocation. The primary outcome measure, incidence of wound infection, was assessed 1, 2, and 4 weeks after surgery.

Authors reported a non-significant difference in the incidence of post-operative infection between groups ($p=0.448$). However, the incidence of the primary outcome was low (2.3%), and therefore the trial may have been underpowered to detect differences between experimental groups. There were also differences between the groups with regard to surgical location.

Primarily however, it should be noted that this trial did not evaluate the longer-term effectiveness of systemic antibiotics on the resolution of symptomatic apical periodontitis

following surgical endodontic management and as a result its usefulness in answering the review question is limited.

1.4.5.2 Acute apical abscess with no signs of spreading infection or systemic involvement

Two randomised controlled trials (Fouad et al. 1996, Henry et al. 2001) investigated the effects of systemic antibiotics in the management of acute apical abscess without signs of spreading infection or systemic involvement when provided in conjunction with endodontic treatment. Both studies were of a parallel group design, one had three arms (Fouad et al. 1996), and the other had two arms (Henry et al. 2001). Both were conducted at university dental schools in the USA and were based at a single centre. Neither study reported sample size calculations.

Sixty-two participants in the analysis for this review; 21 participants analysed in the trial by Fouad and colleagues (1996), and 41 participants analysed in the trial by Henry et al. (2001). Participants in one study a clinical diagnosis of acute apical abscess with pulpal necrosis, periapical pain or swelling, or both (Fouad et al. 1996), whilst participants in the other had a symptomatic necrotic tooth with a periapical radiolucency and no mucosal sinus tract (Henry et al. 2001).

In one trial, participants underwent total or partial pulpectomy under local anaesthesia with temporary restoration at the baseline visit (Fouad et al. 1996), whilst in the other trial, all participants underwent total pulpectomy with temporary restoration at the baseline visit (Henry et al. 2001). In the study by Fouad 1996, participants in the penicillin group received oral penicillin VK 1 g following treatment and then 500mg, every six hours for seven days. Participants in the placebo group received an oral matched placebo taken according to the same regimen. In the trial by Henry et al. (2001), participants in the penicillin group received oral penicillin VK tablets, 500 mg, every six hours for seven days and participants in the placebo group received an oral matched placebo taken according to the same regimen. Participants in both studies also received oral analgesics.

Due to the similarities of these two studies they are suitable for combination in a fixed-effects model analysis (Table 1.3). There were no statistically significant differences in participant-reported measures of pain or swelling at any of the time points assessed within the review either in the individual studies or following combination in the meta-analysis. However, some caution

should be exercised due to heterogeneity with respect to operative intervention and type, dose and frequency of analgesics provided to participants between the two studies.

Whilst generally well designed, the trial by Fouad and colleagues (1996) was severely underpowered; each experimental group only had follow-up data for 10 participants. It also had high attrition rates; in excess of 25% (n=10) of participants dropped out or withdrew. Whilst seven can be classified as 'missing at random', the 3 patients that withdrew (two from the placebo group, one from the no medicine group) were judged to require further treatment, a withdrawal related to outcome, and therefore the trial was at high risk of attrition bias.

The trial by Henry and colleagues (2001) was also well designed with respect to participant allocation and blinding. However investigators did not report relative attrition rates and therefore it is unclear as to whether attrition bias may have been present. Furthermore, both trials excluded participants with co-morbidities or who may be immunocompromised. Therefore the results of this may not be generalisable to this group of patients who would be expected to be at higher risk of infection.

Outcome	No. of participants (number of studies)	Measures of treatment effect (95% CI)
Pain		
Pain at 24 hours (short ordinal scale, 0-3)	61 (2)	MD = -0.03 (-0.52, 0.47)
Pain at 48 hours (short ordinal scale, 0-3)	61 (2)	MD = 0.32 (-0.22, 0.86)
Pain at 72 hours (short ordinal scale, 0-3)	61 (2)	MD = 0.08 (-0.38, 0.54)
Pain at 7 days (short ordinal scale, 0-3)	41 (1)	MD = -0.05 (-0.41, 0.30)
Swelling		
Swelling at 24 hours (different short ordinal numerical scales)	62 (2)	SMD = 0.27 (-0.23, 0.78)
Swelling at 48 hours (different short ordinal numerical scales)	61 (2)	SMD = 0.04 (-0.47, 0.55)
Swelling at 72 hours (different short ordinal numerical scales)	61 (2)	SMD = 0.02 (-0.49, 0.52)
Swelling at 7 days (different short ordinal numerical scales)	41 (1)	MD = 0.02 (-0.28, 0.32)
Percussion pain		
Percussion pain at 24 hours (short ordinal scale, 0-3)	41 (1)	MD = -0.32 (-0.85, 0.21)
Percussion pain at 48 hours (short ordinal scale, 0-3)	41 (1)	MD = -0.09 (-0.44, 0.62)
Percussion pain at 72 hours (short ordinal scale, 0-3)	41 (1)	MD = 0.05 (-0.55, 0.65)
Percussion pain at 7 days (short ordinal scale, 0-3)	41 (1)	MD = 0.06 (-0.29, 0.41)

Table 1.3 - Primary outcomes for studies of antibiotics in acute apical abscess with no signs of spreading infection or systemic involvement (Fouad et al. 1996, Henry et al. 2001)

1.4.5.3 Acute apical abscess with signs of spreading infection or systemic involvement

Three articles described trials investigating the effects of systemic antibiotics in the management of acute apical abscess in the presence of signs of spreading infection or systemic involvement when provided in conjunction with a surgical intervention treatment (Al-Belasy and Hairam 2003, Matijević et al. 2009a, 2009b). Two of these articles appeared to report different trial arms of the same study, as description of the methods and control group results were almost identical for both articles (Matijević et al. 2009a, 2009b). Although confirmation was sought from the original study authors, none was received and therefore, in order to avoid multiple publication bias these papers are reported as one study. However, results should be interpreted cautiously.

Both studies were of parallel group design, one had four arms (Matijević et al. 2009a, 2009b), the other three (Al-Belasy and Hairam 2003). One study was conducted in a military medical academy in Belgrade, Serbia and the other at a university dental school in the USA. Neither study reported sample size calculations so it not clear if the studies were adequately powered to detect differences.

The trial by Matijević and colleagues (2009a, 2009b) included 120 patients of all ages with acute apical abscess, swelling and regional lymphadenopathy. Patients with severe infections 'requiring hospitalisation and/or parental antibiotic therapy' were excluded. In comparison, the trial by Al-Belasy and colleagues (2003) included 60 adult patients with acute infraorbital space infection secondary to an acute apical abscess. These patients also had pain, swelling, and general malaise.

In both trials patients underwent a surgical intervention; exodontia, incision and drainage of the abscess, or both, before being randomised to a trial arm. However an unspecified number of participants in the trial by Al-Belasy and Hairam (2003) had the surgical intervention at a review appointments up to 7 days later as investigators considered it 'inappropriate to extract their teeth at the initial visit'. The intervention and control groups are described below.

Matijević 2009a, 2009b

- Active treatment 1 (n=30) – oral amoxicillin 500mg, every 6 hours, until symptom resolution
- Active treatment 2 (n=30) – oral cefalexin 500mg, every 6 hours, until symptom resolution
- Active treatment 3 (n=30) – oral ampicillin 500mg, every 6 hours, until symptom resolution
- Control (n=30) – no further treatment, no placebo

Al-Belasy and Hairam 2003

- Active treatment 1 (n=20) – oral azithromycin 500mg, once daily, for 3 days
- Active treatment 2 (n=20) – oral erythromycin 250mg, every 6 hours, for 3 days
- Control (n=20) – no further treatment, no placebo

In the trial by Al-Belasy and Hairam (2003), investigators were blinded to the allocation of the patient. The trial by Matijević and colleagues (2009a, 2009b) was open label.

The primary outcome measure in the trial by Matijević et al. (2009a, 2009b) was clinician-reported signs of infection. This was judged on non-validated measures of inflammatory swelling, trismus, regional lymphadenitis and febrility. Individual patient-level data is presented up to day 10 of follow-up for some of the outcomes. The primary outcome measures in the trial by Al-Belasy and Hairam al. (2003) were clinician-recorded measure of pain (judged on statements given by the patient), swelling and lymphadenopathy over a 7-day follow-up period. However, the study report only presents aggregated group level data.

As the two trials were heterogeneous with respect to the characteristics of participants, they were not suitable for combination in a meta-analysis and the findings are therefore reported separately.

Whilst investigators Matijevic et al. (2009a, 2009b) reported that patients in the antibiotic intervention groups recovered significantly quicker than the participants who received surgery alone ($p < 0.05$), there were no differences in swelling or regional lymphadenitis between intervention and control groups at any of the time points assessed in this review (Table 1.4). Furthermore, the results of this trial should be interpreted cautiously as this study was an open label trial and therefore should be considered at high risk of bias (Pildal et al. 2007, Higgins and Green 2011).

In the trial by Al-Belasy and Hairam (2003) all three groups had similar baseline characteristics in relation to demographics, disease severity and treatment modality received. Investigators reported that patients who received azithromycin had a significantly greater reduction in mean pain at 48 ($p = 0.002$) and 72 hours ($p = 0.02$), than those who received no antibiotic. However there were no statistically significant differences at 24 hours. In comparison, whilst there were no statistically significant differences in mean pain at 24 and 48 hours between erythromycin and the control group, the erythromycin group had statistically lower mean pain at 72 hours ($p = 0.03$). When swelling is considered, investigators reported that patients who received azithromycin had significantly less swelling than the control group at 48 ($p = 0.001$) and 72 hours ($p = 0.013$), but not at 24 hours. In comparison, whilst there were no statistically significant differences in mean swelling between the erythromycin and control groups at 24 or 48 hours, the erythromycin group had statistically lower mean swelling at 72 hours ($p = 0.046$). Investigators reported that all patients had achieved total symptomatic resolution at 7 days.

The principal weaknesses of the trial by Al-Belasy and Hairam (2003) relate to the lack of matched-placebo controls and lack of participant blinding. Failure to include a matched-placebo

control group means that there could have been a performance bias induced by which patients' expectation of recovery differed between groups.

Furthermore, all three trials in this section employed non-validated outcomes measures. Validation is important in ensuring the integrity of the tool used, and provides assurance that health states have been quantified accurately. The absence of validated outcome measures may not only introduce misclassification bias, it makes comparison between the results of different trials problematic. In addition, neither trial reported whether outcome measures were consistently measured by the same individual. If multiple examiners were used, without inter-rater reliability statistics it is unclear whether outcomes were measured consistently.

	Antibiotic and surgery (n=90)	Surgery only (n=30)	Mean difference (MD) and 95% CI
Swelling			
Mean swelling at 24 hours (SD)	1.356 (0.504)	1.500 (0.731)	-0.14 (-0.43, 0.14)
Mean swelling at 48 hours (SD)	1.233 (0.451)	1.367 (0.669)	-0.13 (-0.39, 0.12)
Mean swelling at 72 hours (SD)	1.089 (0.286)	1.233 (0.568)	-0.14 (-0.36, 0.07)
Mean swelling at 7 days (SD)	0.000 (0.000)	0.067 (0.254)	N/A
Regional lymphadenitis			
Mean score for regional lymphadenitis at 24 hours (SD)	1.494 (0.503)*	1.367 (0.490)	0.13 (-0.08, 0.33)
Mean score for regional lymphadenitis at 48 hours (SD)	1.333 (0.474)	1.333 (0.479)	0.00 (-0.20, 0.20)
Mean score for regional lymphadenitis at 72 hours (SD)	1.156 (0.364)	1.267 (0.450)	-0.11 (-0.29, 0.07)
Mean score for regional lymphadenitis at 7 days (SD)	0.000 (0.000)	0.100 (0.403)	N/A

Table 1.4 - Some of the primary outcome measures for a trial of systemic antibiotics in conjunction with operative treatment in the management of acute apical abscess with spreading infection or systemic involvement (Matijević et al. 2009a, 2009b) *(n=87)

1.4.6 Discussion

1.4.6.1 Summary of evidence

The review process identified eight studies suitable for inclusion. Two studies assessed the use of antibiotics as a solitary treatment for irreversible pulpitis or undifferentiated acute dental pain respectively. The remaining six studies assessed the use of antibiotics as an adjunct to surgical intervention in symptomatic apical periodontitis and acute apical abscess, with or without signs of spreading infection or systemic involvement.

Due to methodological weaknesses of the included studies there is currently insufficient evidence to determine the effectiveness of systemic antibiotics in the management of either irreversible pulpitis or undifferentiated acute dental pain in absence of overt infection, when provided without operative intervention. Furthermore, there is no evidence regarding the use of antibiotics in conjunction with operative treatment in these conditions.

There is some evidence that suggests that a single dose of antibiotic does not reduce the incidence of wound infection following endodontic surgery for symptomatic apical periodontitis. However no studies have assessed the effects of antibiotics when provided with common surgical interventions such as orthograde endodontic treatment or exodontia. Furthermore, no studies reported the effects of systemic antibiotics for symptomatic apical periodontitis when provided without a surgical intervention.

Based on the currently available data, which are of low quality, there is insufficient evidence to determine the effects of the administration of systemic antibiotics to adults with acute apical abscess without spreading infection or systemic involvement. There is no evidence regarding the use of antibiotics without operative treatment in this condition.

There is contradictory evidence as to whether antibiotics confer improved outcomes when provided in combination with exodontia and/or incision and drainage in patients with acute apical abscess with signs of spreading infection or systemic involvement. There is no evidence regarding the use of antibiotics without operative treatment in this condition.

There is an absence of evidence regarding the use of systemic antibiotics with or without a surgical intervention in the management of: reversible pulpitis; periodontal abscess; combined periodontal-endodontic lesions and pericoronitis.

1.4.6.2 Strengths and limitations of this literature review

A comprehensive search strategy was employed and therefore it is possible to be confident that the majority of published trials are included in this review. Efforts were made to identify all relevant studies and no studies were excluded due to language. Despite this however, it must be acknowledged that there is a small possibility that there were additional studies, published and unpublished, that were not identified.

Only one author (AC) extracted data and assessed the methodological quality of each study. To increase the rigour of this review two authors could have independently extracted and assessed data.

1.4.6.3 Implications for policy, practice and research

There is currently insufficient high quality data to confidently determine the effects of antibiotics in acute dental conditions when provided with or without operative treatment such as extraction, incision and drainage or endodontic treatment.

Given the problems associated with indiscriminate use of antibiotics, adequately powered and well-designed randomised controlled trials are needed to clarify the effectiveness of systemic antibiotics in the management of acute dental conditions. All future trials should be carefully designed to ensure the potential benefits of providing systemic antibiotics to participants outweigh risks associated with antibiotic usage, both adverse effects and the possible contribution to antibiotic resistance.

1.4.7 Summary of evidence regarding antibiotic type and length of course in odontogenic infections

Despite there being limited evidence to determine the effects of systemic antibiotics in the management of acute dental conditions, a number of trials have sought to investigate the comparative effects of different antibiotics in the management of odontogenic infections when provided in conjunction with a surgical intervention (Davis and Balcom 1969, Ingham et al. 1977, Von Konow and Nord 1983, Lewis et al. 1986, Gilmore et al. 1988, Mangundjaja and Hardjawanata 1990, Von Konow et al. 1992, Lewis et al. 1993, Adriaenssen 1998, Al-Nawas et al. 2009, Matijević et al. 2009a). However, two systematic reviews investigating the empirical antibiotic of choice for odontogenic infections have both concluded that no one antibiotic is superior to all others (Matthews et al. 2003, Flynn 2011).

One review also compared duration of antibiotic therapy for odontogenic infections (Flynn 2011). It concluded that, within the limitations of the data available, there were no significant differences in clinical cure between shorter (3-4 day) and longer (7 day) courses of antibiotics when used in combination with a surgical intervention.

1.4.8 The role of systemic antibiotics as recommended by UK clinical guidelines

In the absence of a high quality evidence base regarding the use of antibiotics in acute dental conditions, currently available clinical guidelines are primarily based on expert opinion and trials described in the review above (Section 1.3). Guidelines available in the UK recommend that the first line treatment of acute dental conditions should be local measures aimed at relieving or removing the source of infection or inflammation (Scottish Dental Clinical Effectiveness Programme 2011, Joint Formulary Committee 2012, Palmer et al. 2012). Examples of local measures include exodontia, endodontic treatment or incision and drainage of a swelling.

Appropriate use of antibiotics in the treatment of acute dental conditions, as defined by Scottish Dental Clinical Effectiveness Programme (SDCEP) and the Faculty of General Dental Practice (UK) (FGDP(UK)) clinical guidelines, is limited to situations where:

- There is evidence of spreading infection and/or systemic involvement: diffuse facial swelling, lymphadenopathy, fever, dysphagia, cellulitis, sublingual swelling or trismus.
- Local measures are also attempted. (Scottish Dental Clinical Effectiveness Programme 2011, Palmer et al. 2012)

Guidelines also recommend that antibiotics may be useful in the treatment of immunocompromised individuals with acute apical abscess, in situations where local measures have failed, or if referral to specialist services is required (Scottish Dental Clinical Effectiveness Programme 2011, Joint Formulary Committee 2012, Palmer et al. 2012). All guidelines recommend that appropriate analgesia should be recommended or prescribed to patients in pain.

The first-line antibiotics recommended for use in apical abscesses with evidence of spreading infection or systemic involvement are amoxicillin and metronidazole (Scottish Dental Clinical Effectiveness Programme 2011, Joint Formulary Committee 2012, Palmer et al. 2012). Recommended second-line antibiotics include: erythromycin; clarithromycin; phenoxymethylpenicillin; clindamycin; co-amoxiclav and azithromycin (Scottish Dental Clinical Effectiveness Programme 2011, Palmer et al. 2012) (Table 1.5).

Recommended doses vary and duration of course vary between guidelines (Table 1.5). The FGDP(UK) guidelines recommend discontinuing antimicrobials after 2-3 days if an operative intervention has been provided and the infection has resolved (Palmer et al. 2012). In comparison, SDCEP guidelines recommend 5 days courses (Scottish Dental Clinical Effectiveness

Programme 2011), and the British National Formulary (BNF) (Joint Formulary Committee 2012) recommend 3-5 day courses.

	Antimicrobial Prescribing for General Dental Practitioners, 2nd Ed. (Palmer et al. 2012)	Drug Prescribing for Dentistry, 2nd Ed. (Scottish Dental Clinical Effectiveness Programme 2011)	British National Formulary, 64th ed. (Joint Formulary Committee 2012)
Amoxicillin	250mg or 500mg, every 8 hours, up to 5 days	250mg or 500mg, every 8 hours, usually 5 days (3 in some conditions)	250mg or 500mg, every 8 hours, 5 days (3 in some conditions)
Metronidazole	200mg, every eight hours, for three days	200mg, every eight hours, for 3 days	200mg, 250mg, 400mg or 500mg, every 8 hours, up to 7 days
Erythromycin	Not recommended by guideline	250mg, every six hours, for 5 days	Not recommended by guideline
Co-amoxiclav	Not recommended by guideline	250/125 or 500/125, every 8 hours, for 5 days	Not recommended by guideline
Clindamycin	Not recommended by guideline	150mg, every 6 hours, for 5 days	Not recommended by guideline
Other antibiotics	Clarithromycin, 250mg, every twelve hours, for up to 5 days Azithromycin, 500mg, every twenty-four hours, for 2-3 days	Phenoxymethylpenicillin, 500mg, every 6 hours, for 5 days Clarithromycin, 250mg, every twelve hours, for 7 days	N/A

Table 1.5 - Antibiotic type, dose, frequency and duration recommended by guidelines published by the Faculty of General Dental Practice (UK) (Palmer et al. 2012), Scottish Dental Clinical Effectiveness Programme (2011) and British National Formulary (Joint Formulary Committee 2012) guidelines.

1.5 Consultations in primary care for dental problems

1.5.1 Provision of primary dental care services in the UK

Over 90% of dental care in the UK takes place in the General Dental Service (GDS). This is made up of independently run ‘high street dental practices’, providing either NHS-subsidised or private treatment, or more commonly a mixture of both, to adult and child patients. General

Dental Practitioners (GDPs) who provide NHS treatment are independent contractors to the NHS.

Since the introduction of the new dental contract between dentists and commissioning bodies in England and Wales on 1st April 2006 NHS patients are no longer 'registered' with a particular dentist unless actively undergoing treatment. The new contract also introduced a new way of calculating dental activity so that NHS dentists in England and Wales are paid according to how many Units of Dental Activity (UDA) they deliver per year. In comparison, GDPs in Scotland and Northern Ireland still maintain registered lists of patients and get remunerated via a 'fee-per-item' contract.

Some patients are served under the NHS by the Community, Public and Salaried Dental Services. This service predominantly provides care for people who cannot easily visit a GDS dentist, such as people with learning disabilities or those who live in residential care homes.

The Emergency Dental Service (EDS) provides dental emergency and out-of-hours care to individuals with acute dental conditions. Provision of services varies between regions and is usually accessed via a telephone helpline. Within Wales, emergency dental care is provided by a mixture of GDS, Community Dental Service and secondary care providers.

1.5.2 Attendances in general medical practice for dental problems

A study of routinely collected consultation data reported that approximately 0.3% of all consultations in general medical practices in Wales were for oral or dental problems. Of these 44.2% were specifically for tooth-related problems whilst the remainder were for non-tooth related oral problems such as salivary gland disease and soft tissue disorders. This relates to an average consultation rate of 6.90 consultations per 1000 patient years for tooth-related problems. However, rates are thought to vary considerably between practices (Anderson et al. 1999).

1.5.3 Factors that influence choice of primary care practitioner for dental problems

Research has indicated that choice of primary care practitioner during episodes of dental problems may be influenced by a number of different factors. These include: access to healthcare services; dental anxiety; costs associated with treatment; the attributes of the dental

practice; presentation of dentoalveolar pain; perceptions of the clinical responsibility of medical and dental providers and patients' preferences regarding healthcare practitioners (Freeman 1999, Mansour and Cox 2006, Bell et al. 2008, Cohen et al. 2011, Nuttal et al. 2011).

1.6 The use of antibiotics in the management of dental problems in primary care – a literature review

Having established the evidence regarding the effects of systemic antibiotics in the management of acute dental problems, this section presents a narrative literature review of the existing national and international evidence regarding the use of systemic antibiotics in the management of dental problems in primary care.

1.6.1 Objectives

The objectives of this review were to:

- Describe the use of systemic antibiotics in the management of acute dental problems in adults in primary care.
- Explore what can influence the likelihood of an antibiotic being prescribed, and factors that determine compliance with clinical guidelines.

1.6.2 Methods

1.6.2.1 Criteria for considering studies for this review

Inclusion criteria were as follows:

- Type of study: all types of research study were considered for inclusion, as were reports from the grey literature.
- Type of participant: primary care practitioners and their patients.
- Type of outcome: therapeutic use of antibiotics in the management of acute dental problems and/or factors that influence antibiotic usage for acute dental conditions in primary care.

1.6.2.2 Search methods for identification of studies

A detailed search strategy was developed for each database searched (Appendix V). The searches were conducted in MEDLINE (1946 – September 2014), EMBASE (1947 – September 2014) and PsycINFO (2002 – September 2014) using the OVID platform.

No restrictions were placed on the type of paper considered for inclusion and every effort was made to obtain original source data in cases of review articles or editorials. Only English language articles were considered for inclusion.

1.6.2.3 Data collection and analysis

One author (AC) assessed the titles and abstracts (where available) of the articles identified by the search strategy and made decisions regarding eligibility. Full text versions were obtained for all articles being considered for inclusion, as were those with insufficient information in the title or abstract to make a clear decision.

1.6.3 Results

After deduplication, the search strategy identified 424 references. Five further studies and seven official health reports were identified by checking the bibliographies of included studies. After examining the titles and abstracts, where available, 352 records were excluded. Full text copies of the remaining 72 papers were obtained and 31 were considered suitable for inclusion. The breakdown of papers included: 1 randomised controlled trial; 17 observational studies; 5 clinical audits; 7 official health reports and 1 qualitative interview study (Appendix VI).

Supplementary searches were conducted to identify articles regarding: antibiotic use for acute dental conditions in countries other than the UK; factors that influence the use of antibiotics in primary care, and factors that influence the integration of best practice guidelines into clinical practice.

1.6.4 The use of systemic antibiotics in the management of acute dental problems in adults in primary care

1.6.4.1 Proportion of adult patients with acute dental problems prescribed antibiotics in the UK

The reported proportion of adult patients who receive antibiotics as part of the management of an acute dental problem varies between studies. In a randomised controlled trial of academic detailing in general dental practices in South Wales, in the control non-intervention arm the prevalence of prescribing was 32.0% (Seager et al. 2006). Similar prescribing rates were reported in a retrospective analysis of a GDP emergency rota where 28.2% of patients received an antibiotic (Anderson et al. 2000). In contrast, higher proportions were reported in studies conducted in an EDS where between 38.7% and 56.9% of patients received an antibiotic (Anderson et al. 2000, Dailey and Martin 2001, Tulip and Palmer 2008).

There was one study reporting antibiotic usage by general medical practitioners (GMPs) for dental problems. This describes how patients who consult their GMP due to tooth-related problem have a greater likelihood of being prescribed a systemic antibiotic compared to individuals who consult with a dentist for a similar problem (Anderson et al. 2000). Approximately two-thirds (67.6%) of consultations for a 'tooth-related problem' extracted from the General Practice Morbidity Database for Wales resulted in an antibiotic prescription (Anderson et al. 2000).

1.6.4.2 Antibiotic prescribing by clinical diagnosis in the UK

Within the literature antibiotic usage by clinical diagnosis is reported in two ways. Firstly, the proportion of all total antibiotics prescribed for a clinical diagnosis. Secondly, the proportion of patients presenting with a specific clinical diagnosis who receive antibiotics as part of their management.

Studies which describe the proportion of total antibiotic use by clinical diagnoses include observational studies, clinical audit and a randomised controlled trial. However different settings, methodology, inclusion and diagnostic criteria mean direct comparisons between studies is difficult. Within each study the clinical diagnoses responsible for the greatest proportion of antibiotics are:

- Pulpitis and dentoalveolar abscess (Dailey and Martin 2001)

- Pulpitis, acute periapical infection, acute periodontal abscess and post-surgical procedure (Palmer et al. 2001a)
- Toothache, painful/infected gums and facial swelling (Seager et al. 2006)
- Acute periapical infection, acute periodontal abscess and pericoronitis (Chate et al. 2006)
- Caries, periapical periodontitis and periodontal infection (Tulip and Palmer 2008)
- Abscess, pulpitis, apical periodontitis and periocoronitis (Kudiyirickal and Hollinshead 2011)

Wide variations also exist in the frequency of antibiotic prescribing per clinical diagnosis (Table 1.6). This is likely due to the heterogeneity of practitioner and patient populations, study design and diagnostic terminology employed. However in general, questionnaire-based studies reported lower rates of antibiotic prescribing for pulpitis and higher rates for apical abscess, pericoronitis and periodontal abscess than observational studies.

Clinical diagnosis	Proportion of presenting cases prescribed an antibiotic	References
Pulpitis	13-73%	(Palmer and Martin 1998, Palmer et al. 2000a, Dailey and Martin 2001, Tulip and Palmer 2008)
Apical periodontitis	68.3%	(Tulip and Palmer 2008)
Acute apical abscess	23-85%	(Palmer and Martin 1998, Palmer et al. 2000a, Dailey and Martin 2001, Tulip and Palmer 2008)
Pericoronitis	51-98%	(Palmer and Martin 1998, Palmer et al. 2000a, Dailey and Martin 2001, Tulip and Palmer 2008)
Periodontal abscess	66-98%	(Palmer and Martin 1998, Palmer et al. 2000a, Dailey and Martin 2001, Tulip and Palmer 2008)

Table 1.6 – Proportion of presenting cases prescribed an antibiotic by dentists, by clinical diagnosis (Palmer and Martin 1998, Palmer et al. 2000a, Dailey and Martin 2001, Tulip and Palmer 2008)

There are no reports describing the relative proportion of patients with specific pulpal, apical or periodontal conditions that receive antibiotics following consultation with a GMP. This is likely due to the general paucity of information regarding consultations for dental problems within primary medical care. However, it may also be due to the limited diagnostic awareness of dental problems amongst the medical profession which results in clinical diagnoses not being routinely or correctly recorded (McCann et al. 2005, Gill and Scully 2006).

1.6.4.3 Antibiotic use as an adjunctive measure or lone treatment in the UK

Therapeutic antibiotics can be used in the management of acute dental conditions in two ways: either as a lone treatment or as an adjunctive measure alongside operative treatment (such as exodontia, endodontic treatment, incision and drainage of a swelling or debridement and irrigation of a periodontal pocket) (Tulip and Palmer 2008). However, only two articles both from primary dental care, report the relative proportion of each use. Both were conducted in the EDS and indicate that only a minority of patients (3.2% - 17.3%) receiving an antibiotic will also undergo concurrent dental treatment (Dailey and Martin 2001, Tulip and Palmer 2008). This suggests that antibiotics may be frequently used as an alternative, not adjunct to operative measures, contrary to recommendations by current clinical guidelines (Scottish Dental Clinical Effectiveness Programme 2011, Palmer et al. 2012). However, no studies were identified that assessed the proportion of antibiotics provided with and without operative treatment in the GDS.

Whilst no reports exist, it is reasonable to expect that, given the training, personnel and facilities available in general medical practice, most if not all antibiotics prescribed for dental problems by medical practitioners will be given without operative treatment to relieve or remove the source of infection.

1.6.4.4 Compliance with clinical guidelines on therapeutic antibiotic prescribing in the UK

The literature indicates that whilst therapeutic antibiotics are commonly utilised by GDPs for a wide range of pulpal, apical and periodontal complaints, prescribing frequently displays limited compliance with clinical guidelines. This lack of compliance occurs either in respect to the clinical signs and symptoms in which the use of antibiotics is indicated, or with recommendations that antibiotics should only be used in conjunction with operative treatment (Seager et al. 2006,

Chate et al. 2006). Within the non-intervention arm of a randomised controlled trial in general dental practice in South Wales, only 29.0% of patients prescribed a therapeutic antibiotic had evidence of a spreading infection (Seager et al. 2006). This is similar to reports of a clinical audit conducted in England in 2002-2004 where 29.2% of prescriptions were considered justifiable according to FGDP(UK) guidelines of the time (Chate et al. 2006).

Furthermore, several studies report substantial variation in the dose, frequency and duration of antibiotic courses prescribed by GPs for the treatment of odontogenic infections (Muthukrishnan et al. 1996, Palmer et al. 2000a, 2000b, Palmer et al. 2001a, Chate et al. 2006). Authors analysing all adult dental prescriptions for antibiotics issued by GPs across 10 Health Authorities in England reported that 44% of prescriptions for amoxicillin, 33% for metronidazole, 87% for penicillin and 42% for erythromycin strayed from the recommendations of the Dental Practitioners Formulary (DPF) (Palmer et al. 2000b). A similar study conducted in Scotland reported that with the exception of tetracyclines, antibiotics were prescribed at the DPF recommended dose but there were wide variations in the frequency and duration of the prescriptions for all antibiotics (Roy and Bagg 2000). Similar errors in antibacterial prescribing were reported in two clinical audits in North West and East England (Palmer et al. 2001a, Chate et al. 2006).

Of particular concern regarding prescribing inaccuracies are long courses of antibiotics, as these have been more strongly implicated in the emergence of antibiotic-resistant bacterial colonies (Moller et al. 1977). Protracted courses are also associated with a reduction in patient compliance, which can further increase the likelihood of resistance developing (Coates et al. 2002). In a retrospective analysis of prescriptions written by Scottish GPs, 34% of prescriptions for penicillin, 26% for amoxicillin and 17% for metronidazole were for 7 days duration or greater (Roy and Bagg 2000). Furthermore, in a questionnaire-based study of GPs, in excess of 14% of all antibiotic courses for acute apical abscess were for 7 days duration or greater (Palmer et al. 2000a). In a retrospective analyses of dental antibiotic prescriptions, courses of up to and including 21 days duration were encountered (Palmer et al. 2000b).

There are no reports that describe GPs' compliance with clinical guidelines in relation to antibiotic use for dental problems.

1.6.4.5 Antibiotics prescribed for dental problems in primary care in the UK

1.6.4.5.1 Antibiotics prescribed by General Dental Practitioners

Antibiotic prescribing by NHS GPs has consistently accounted for approximately 9.5% of all antibiotic prescribing in England between 2007 and 2013 (Health and Social Care Information Centre 2008, 2009, 2010, 2011, 2012, 2013, 2014). Whilst such comprehensive prescribing data is not routinely published for other areas of the United Kingdom, Welsh GPs prescribed 9% of all primary care antibacterials in 2008-2009 (Holyfield and Karki 2009).

Between 2005 and 2013, the number of systemic antibacterial preparations annually prescribed by dentists in England has remained between 3.65 and 3.95 million items (Figure 1.2). Throughout this time antibiotics have been the most common pharmaceuticals prescribed by dentists (Health and Social Care Information Centre 2008, 2009, 2010, 2011, 2012, 2013, 2014).

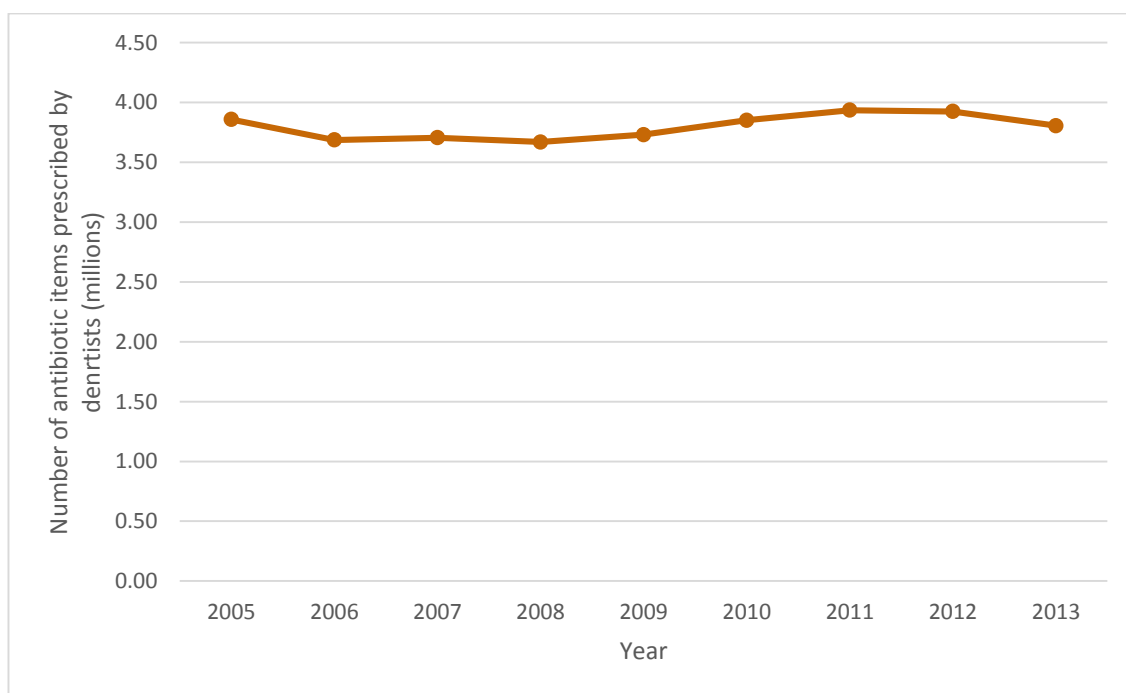


Figure 1.2 - Graph showing number of antibacterial preparations dispensed by GPs in England, 2005 - 2013 (Health and Social Care Information Centre 2008, 2009, 2010, 2011, 2012, 2013, 2014)

The types of antibiotics prescribed by English GPs have remained relatively stable between 2005 and 2013 (Figure 1.3). Penicillins account for approximately two-thirds of all antibiotics, with the proportion of metronidazole increasing marginally from 24.6% in 2005 to 28.1% in 2013. Macrolides account for approximately 5% of all prescribing, and cephalosporins,

clindamycin and tetracyclines together account for less than 5% of all antibiotics prescribed by dentists. When considered as a whole, dental prescribing accounts for just less than 10% of all antibiotic items prescribed within England, yet dental prescribing of metronidazole (and tinidazole) and clindamycin account for approximately 57% and 37% of all prescriptions for these antibacterials. Similarly, in Wales, penicillins account for two thirds of antibacterial prescriptions, metronidazole approximately a quarter, with macrolides and clindamycin making up the majority of the remainder (Holyfield and Karki 2009).

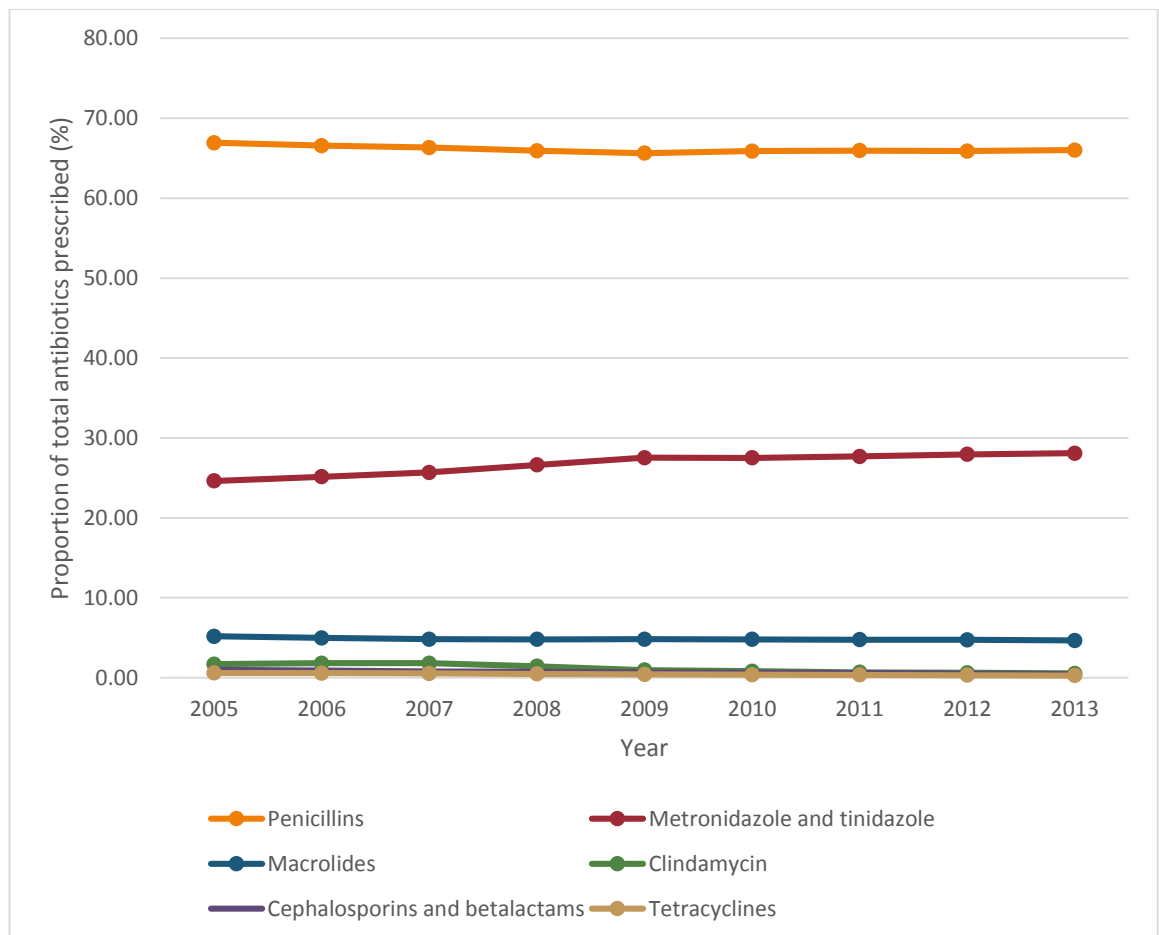


Figure 1.3 - Graph illustrating the types of antibiotic prescribed between GPs in England, 2005 – 2013 (Health and Social Care Information Centre 2008, 2009, 2010, 2011, 2012, 2013, 2014)

Whilst there does not appear to be substantial changes in the class of antibiotics being prescribed by English GPs between 2005 and 2013, there is evidence that practitioners may be altering the specific agent or dose of antibiotic they routinely use. Other than those preparations used pre-2008 for antibiotic prophylaxis, the individual antibacterials with the largest reported changes in England are:

- Amoxicillin Capsules 500mg– change of +45.2% between 2007 and 2013
- Metronidazole Capsules 400mg –change of +35.4% between 2007 and 2012
- Co-amoxiclav Capsules 250/125mg – change of +131.7% between 2010 and 2012
- Clindamycin HCl Capsules 150mg –change of -47.2% between 2007 and 2009
- Phenoxymethyl Penicillin 250mg –change of -28.0% between 2009 and 2011 (Health and Social Care Information Centre 2008, 2009, 2010, 2011, 2012, 2013, 2014)

Overall, the scientific literature relating to type, dose, frequency and duration of antibiotic courses prescribed by dental professions reflects information on prescribing held within the grey literature. Collation of all the studies conducted into antibiotic prescribing by primary care dentists between 1989 and 2011 show that there appears to have been an evolution in the type of antibiotics GPs are using. Older studies report penicillin, particularly phenoxymethylpenicillin (Pen V), was the antibiotic of choice amongst GPs (Lewis et al. 1989, Steed and Gibson 1997). This was followed by a transition period when there were similar rates of penicillin V and amoxicillin use were reported (Thomas et al. 1996), whilst more recent studies report high proportions of amoxicillin use and little to no use of penicillin (Anderson et al. 2000, Roy and Bagg 2000, Palmer et al. 2000a, 2000b, Palmer et al. 2001a, 2001b, Dailey and Martin 2001, Tulip and Palmer 2008, Chate et al. 2006, Kudiyirickal and Hollinshead 2011).

1.6.4.5.2 *Regional variation in General Dental Practitioner prescribing*

Wide variation in rates of antibacterial prescribing by dentists per head of population throughout Local Health Boards in Wales was reported by Holyfield and Karki (2009). During 2007-2008, rural regions such as Powys, Pembrokeshire and Flintshire had lower levels of antibiotic prescribing per head of population than more urban areas such as Blaenau Gwent and Bridgend. Whilst this variation maybe due to regional differences in antimicrobial use between practitioners, the authors highlight that it could also be due to differing levels of dental need; the health seeking behaviour of local individuals and the relative availability of NHS and private dental services. Antibiotics dispensed privately are not included in published figures (Holyfield and Karki 2009).

1.6.4.5.3 Prescribing by General Medical Practitioners for dental problems

The types of antibiotics prescribed by GMPs for dental problems are broadly similar to those used by GDPs, although articles describing the use of antibiotics by GMPs for dental problems are much less common within the literature. GMPs are less likely to prescribe amoxicillin and metronidazole, the antibiotics recommended for first-line use by SDCEP, FGDP(UK) guidelines and the BNF, and more likely to prescribe co-amoxiclav, flucloxacillin and cephalosporins than GDPs (Muthukrishnan et al. 1996, Thomas et al. 1996, Anderson et al. 2000). There is no data available regarding the dose, frequency or duration of antibiotics prescribed by GMPs for dental problems.

1.6.4.6 Use of antibiotics for primary care dental problems: an international perspective

1.6.4.6.1 Primary dental care

The literature suggests that widespread use of antibiotics by primary care dental professionals is an international phenomenon. Studies report that continental European GDPs prescribe between 6.5% and 8.5% of all primary care antibiotics within their respective countries (Al-Haroni and Skaug 2007, Pipalova et al. 2014,). Furthermore, there are multiple reports of antibiotic prescribing in the management of inflammatory conditions such as pulpitis and apical periodontitis. Whilst variation exists regarding the proportion of patients who receive antibiotics per clinical diagnosis, international reports seems broadly congruent with the findings of UK-based studies (Whitten et al. 1996, Jaunay et al. 2000, Slaus and Bottenberg 2002, Salako et al. 2004, Al-Haroni and Skaug 2006, Murti and Morse 2007, Mainjot et al. 2009, Segura-Egea et al. 2010, Skucaite et al. 2010, Nabavizadeh et al. 2011, Kaptan et al. 2013, Garg et al. 2014). However, whilst inter-practitioner variation has received relatively little attention within UK studies, substantial clustering of antibiotic prescribing was reported in a cross-sectional study conducted in Belgium (Mainjot et al. 2009).

The literature suggests that penicillins are the most frequently used class of antibiotic among dentists worldwide. Some reports indicate a preference towards of penicillin VK (Preus et al. 1992, Demirbas et al. 2006, Al-Haroni and Skaug 2007), whilst other studies have reported amoxicillin or co-amoxiclav is the preferred agent (Salako et al. 2004, Murti and Morse 2007, Garg et al. 2014, Mainjot et al. 2009, Kaptan et al. 2013). Variation also exists with regard to second-choice antibiotic, with some studies reporting that metronidazole was the second-

choice agent (Salako et al. 2004, Al-Haroni and Skaug 2007), whilst others cite co-amoxiclav (Mainjot et al. 2009, Skucaite et al. 2010, Garg et al. 2014)

International studies also describe wide variations in dose and duration of therapeutic antibiotics, in particular the use of long courses (up to 21 days), of antibiotics for dental conditions (Epstein et al. 2000, Vessal et al. 2011). However, in a trend not previously described in studies conducted in the UK, up to a third of antibiotics prescribed in a Belgian observational study were given as delayed prescriptions – only to be taken if symptoms become more severe (Mainjot et al. 2009).

Low levels of adherence to clinical guidelines were reported in a cross-sectional, questionnaire based study of antibiotic use in paediatric dental patients in the USA (Cherry et al. 2012). Furthermore, similar to UK studies (Dailey and Martin 2001, Tulip and Palmer 2008), an observational study conducted in Belgium reported that large numbers of patients receiving antibiotics for an acute dental condition had no adjunctive operative treatment to relieve or remove the source of inflammation or infection (Mainjot et al. 2009). Likewise, in a study conducted amongst Australian primary care dentists, 50% of respondents reported that antibiotics would be the sole treatment they would provide for a patient with a dentoalveolar abscess with evidence of systemic spread (Murthi and Morse 2007).

1.6.4.6.2 Primary medical care

One study describing the use of antibiotics for dental problems within a general practice environment outside the UK was identified. In this small scale (n=71) questionnaire study of Spanish GMPs, respondents reported that they would be most likely to prescribe co-amoxiclav or amoxicillin as first line agents in non-penicillin allergic patients consulting with a dental problem (Gonzalez-Martinez et al. 2012).

The remaining reports describe attendances for dental problems at EDs in the USA. In a retrospective analysis of prescribing records relating to ED consultations for non-traumatic dental conditions (NTDC) collected by the National Hospital Ambulatory Medical Care Survey for 1997–2007 in the USA, 47.6% of patients received an antibiotic and analgesic, 8.8% received an antibiotic only and 26% an analgesic only (Okunseri et al. 2012). Furthermore, the prescription of antibiotics at EDs for NTDC demonstrated a statistically significant year-on-year increase during the study period (Okunseri et al. 2012).

1.6.5 Factors that influence the antibiotic prescribing behaviours of primary care providers for acute dental problems

A number of reports which describe factors that may influence antibiotic prescribing for acute dental conditions by primary care providers were identified. However, the investigation of such factors does not appear to be the primary objective of any of the studies, and therefore descriptions of these issues are often limited. These studies all describe prescribing by dentists as, to date, no work has been done to investigate factors that might influence the prescribing practices of GMPs for dental problems.

Two systematic reviews were identified which identify factors that influence the antibiotic prescribing behaviours of healthcare providers, one synthesising quantitative studies (Lopez-Vazquez et al. 2012) and one qualitative (Teixeira Rodrigues et al. 2013). Three further systematic reviews investigated barriers to physician adherence to clinical practice guidelines (Cabana et al. 1999, Francke et al. 2008), and doctors' perception of evidence based medicine (Swennen et al. 2013).

1.6.5.1 Clinician characteristics

Gender, medical specialisation, previous clinical experience, years of practice, country of primary medical qualification and continuous medical education are all clinician characteristics described as influencing prescribing behaviour amongst healthcare providers.

An association between length of practicing career and rates of guideline incongruent prescribing have been described by several studies within general medicine (Lopez-Vazquez et al. 2012). However, in a randomised controlled trial conducted amongst Welsh GDPs no clinician characteristics (GDP gender, postgraduate qualification status, number of years since qualification and LHB level of dental provision) were significantly associated with inappropriate antibiotic use (Seager et al. 2006). Although it should be highlighted that the trial was not powered to detect such differences, the findings of this trial are corroborated by a questionnaire study of GDPs in which authors reported that neither the length of time since qualification, nor attendance on postgraduate education courses about antimicrobial prescribing significantly affected prescribing behaviour (Palmer and Martin 1998). In contrast, international studies report that more recently qualified practitioners are less likely to prescribe antibiotics for symptomatic apical periodontitis (Skucaite et al. 2010), and that older practitioners were more

likely to prescribe antibiotics on a daily basis (Murti and Morse 2007). This may be confounded by differing clinical workloads of older and younger dentists.

1.6.5.2 Knowledge

Prescribing behaviours of physicians appears to be influenced by awareness of evidence regarding the efficacy of antibiotics, and the relationship between overprescribing and antibiotic resistance, with the levels of awareness varying between speciality and specific guideline (Cabana et al. 1999, Swennen et al. 2013, Teixeira Rodrigues et al. 2013). Furthermore, awareness of a guideline does not necessarily guarantee familiarity with its recommendations. Evidence that is easy to understand and to assimilate into practice is more likely to be actioned than complex recommendations that require specialist resources (Francke et al. 2008). Whilst clinicians continue to acquire knowledge throughout their practicing career through continuous medical education, a strong association between early-career knowledge acquisition and teaching and future prescribing behaviours has been reported (Teixeira Rodrigues et al. 2013).

In a large questionnaire-based study conducted amongst English and Scottish GPs, the majority of respondents could identify clinical signs indicating the need to prescribe antibiotics, and non-clinical factors that should not influence prescribing. However, practitioners were less familiar with recommendations regarding antibiotic prescribing in relation to specific clinical diagnoses (Palmer et al. 2001c). In addition, a clinical audit of recently qualified dentists reported that the prescribing of antibiotics by this group of practitioners was not consistent with best practice guidelines and suggested that this may be due to problems related to undergraduate education or retention of knowledge (Palmer and Batchelor 2004).

Qualitative analysis of experiences of collaborative clinical audit on antibiotic prescribing amongst GPs, reported that some practitioners attributed outdated practices to isolation within a general dental practice environment which can lead to difficulties in keeping up-to-date with current practice (Palmer and Dailey 2002). International studies reveal variable levels of knowledge about the mode of action of antibiotics (Al-Huwayrini et al. 2013), and antimicrobial resistance (Jaunay et al. 2000), among primary care dentists.

1.6.5.3 Attitudes

Attitudes can be defined as enduring beliefs, feelings, and behavioural tendencies towards socially significant objects, groups, events or symbols (Hogg and Vaughan 2005) and the literature describes a number of attitudes that may influence clinicians' antibiotic usage.

Even if a practitioner is familiar with a piece of evidence or a clinical guideline, if they do not agree with the way it was devised, or if their personal interpretation of the evidence differs from that of the guideline developers, it can limit the likelihood of them implementing its recommendations (Cabana et al. 1999). Therefore levels of confidence in the credibility, usability and potential clinical benefits of a guideline will influence its assimilation into everyday practice.

More general attitudes to clinical guidelines will also influence the uptake of recommendations by a specific practitioner. Some providers may feel that evidence based guidelines undermines their clinical expertise and reduces their professional autonomy (Cabana et al. 1999, Swennen et al. 2013), whilst others may feel that guidelines lack applicability to their patient population or are oversimplifications of complex clinical scenarios (Cabana et al. 1999). In contrast however, others may feel that following a guideline reduces their medico legal liability and allows them to more confidently discuss and justify their clinical decision making with patients (Swennen et al. 2013). Application of evidence based guidelines also relies on practitioners' self-efficacy with regard to performing the specific tasks recommended. Practitioners may not have a specific skills, or lack confidence in their ability to perform a task successfully (Cabana et al. 1999).

Clinicians' level of personal, professional and social responsibility will influence how strongly motivated they are to modify their prescribing to minimise the emergence of antibiotic resistance. Some clinicians may feel indifferent to the issue, (Teixeira Rodrigues et al. 2013) whilst others may feel that even if they change their own practice, this will lead to little or no change in the prevalence of resistance, a lack of outcome expectancy. Similarly, other practitioners consider it the responsibility of others (i.e. other physicians, patients or other healthcare providers) to instigate a change in antimicrobial usage (Lopez-Vazquez et al. 2012, Teixeira Rodrigues et al. 2013). Furthermore, the readiness of a practitioner to change their clinical practice will also relate to their attitude towards change. Some may feel uncomfortable deviating from their trusted clinical routines (Cabana et al. 1999, Swennen et al. 2013), and this may vary according to practitioner age and personality type (Swennen et al. 2013).

Diagnostic uncertainty and the fear of possible complications arising from withholding antibiotics are associated with the misprescription (a term used to indicate guideline

incongruent prescribing) of antibiotics (Lopez-Vazquez et al. 2012, Teixeira Rodrigues et al. 2013). In studies of English GPs, approximately 3% of antibiotics are prescribed due to diagnostic uncertainty (Chate et al. 2006), with 47.3% of practitioners reporting that they may prescribe an antibiotic in such circumstances (Palmer et al. 2000a). In circumstances where a practitioner may be unsure of a definitive clinical diagnosis, antibiotics may be viewed as an alternative to invasive operative treatment. Furthermore, even if clinicians do provide operative treatment for an odontogenic infection, they may also prescribe an antibiotic in a situation where one may not be indicated, if they have concerns about the prognosis of treatment, particularly if a patient may be due to go on holiday (Chate et al. 2006).

1.6.5.4 Healthcare system-related factors

Healthcare system-related factors including the organisation of the delivery of care, pressures relating to clinical practice, and professional group norms, have all been described as influencing antibiotic prescribing behaviours and application of evidence-based clinical guidelines by medical professionals. These factors are often initially distinct from practitioner attitudes, but will if persistent, eventually affect clinicians' self-efficacy, outcome expectancy or motivation (Swennen et al. 2013).

Pressures of time, particularly relating to patient volume, have been demonstrated to have a strong association with the misprescription of antibiotics in a number of medical settings (Cabana et al. 1999). The influence of time pressures and clinical workload on the antimicrobial prescribing practices of GPs is well documented. In a clinical audit of prescribing behaviours of English GPs, 2.7% of all prescriptions in the pre-audit period were due to time pressures or workload and 7.4% were because treatment had to be delayed (Chate et al. 2006). Furthermore, in questionnaire study of GPs (Palmer et al. 2000a), 30.3% of participants reported that pressure of time and work load would influence their decision to prescribe antibiotics. These results were corroborated by other studies describing UK GP antimicrobial usage (Steed and Gibson 1997, Palmer et al. 2001a, Palmer and Dailey 2002, Palmer and Batchelor 2004).

Levels of financial reimbursement associated with different treatment options (Cabana et al. 1999, Swennen et al. 2013, Teixeira Rodrigues et al. 2013) may also influence clinical decision making. The location of a healthcare centre, its private or public status, and the structure and pressure exerted by pharmaceutical companies have all also been reported to influence the prescribing behaviours of clinicians working (Lopez-Vazquez et al. 2012, Teixeira Rodrigues et al.

2013). Whilst practice location and its effect on antimicrobial usage has not previously been investigated within primary care dentistry in the UK, the authors of a study of antimicrobial use by Lithuanian dentists reported that rural practitioners were statistically more likely to prescribe antibiotics for symptomatic apical periodontitis and pulpitis than their urban counterparts (Skucaite et al. 2010). Similarly, whilst no UK studies have addressed differences between the prescribing practices of dentists providing treatment under an NHS or private basis, an observational study of Fijian dentists reported that GPs in public service were more likely to prescribe daily (71%) compared with private practitioners (52%) (Murthi and Morse 2007). However, whilst this could reflect differences in prescribing habits of different types of dentist. Such findings may be subject to confounding factors such as public service practitioners seeing a higher number of patients as part of their daily workload or differing levels of clinical need among patients accessing state funded or private care.

Professional group norms and the culture of the healthcare environment in which practitioners are employed have also been reported to influence prescribing behaviours, particularly the integration of best practice guidelines into clinical care (Swennen et al. 2013). Respectful and reciprocal communication among doctors is described as a strong facilitator of the integration of evidence based recommendations into practice, as opposed to an expert-based hierarchy where the opinions of more established practitioners were more likely to become practice norms (Swennen et al. 2013). The culture towards change within a healthcare environment also influences practitioners' uptake of evidence based best practice, and the attitudes and practices of clinical role models may also affect how younger practitioners use antibiotics (Swennen et al. 2013).

1.6.5.5 Patient-related factors

Patient-related factors have also been reported to influence prescribing behaviours of their treating clinicians. A number of quantitative studies report an association between increasing patient age and likelihood of receiving an inappropriate antibiotic. However, results are highly contingent on the specific condition and setting studied, with the inverse relationship reported in a minority of studies (Lopez-Vazquez et al. 2012). Within a randomised controlled trial of antimicrobial usage in primary dental care in South Wales, younger patients (amongst an adult-only population) were significantly more likely to receive an antibiotic during a consultation with a GP for an acute dental condition than older patients (Seager et al. 2006). However, patient age is not significantly associated with inappropriate prescription of an antibiotic,

suggesting that younger patients may be more likely to present with odontogenic infections with signs of systemic spread than older patients. Within the trial patient gender was not significantly associated with antibiotic prescribing (Seager et al. 2006).

Patient economic and social factors and educational level are also described as having a direct influence on antibiotic prescribing in a number of studies within primary medical care; with patients from socioeconomically deprived backgrounds and lower levels of education reported to be most likely to receive an antibiotic (Kumar 2003, McNulty 2007). In the questionnaire study of English GPs, 8.2% of participants reported that a patient's social history (8.2%) could affect their decision to prescribe antibiotics (Palmer et al. 2000a) although extent to which social background influences prescribing decisions remains unclear.

Several studies also describe associations between particular signs and symptoms and antibiotic prescribing behaviours: patients perceived to be more severely ill by a primary care practitioner are more likely to receive an antibiotic (Lopez-Vazquez et al. 2012, Teixeira Rodrigues et al. 2013), as are patients known to have co-morbidities (Francke et al. 2008, Teixeira Rodrigues et al. 2013). However, to date, comparable associations have not been investigated within primary dental care.

The ability of practitioners to reconcile patient preferences with guideline recommendations on antibiotic use may influence their use of antimicrobials (Cabana et al. 1999). Clinicians keen to avoid conflicts in the practitioner-patient relationship may be less likely to follow evidence based guidelines and comply with patient expectations or requests, and this finding is particularly prevalent amongst primary care practitioners (Swennen et al. 2013). A large number of studies report an association between perceived patient expectation of antibiotics and prescribing in situations not indicated by clinical guidelines in primary medical care, although the magnitude of the effect differs between studies (Lopez-Vazquez et al. 2012, Teixeira Rodrigues et al. 2013). In the questionnaire study of English GPs, 8% of participants reported that patient's expectation of prescription could affect their decision to prescribe antibiotics (Palmer et al. 2000a), and in a clinical audit of antibiotic use among English GPs, 3.5% of prescriptions were reportedly written in response to perceived patient expectation (Chate et al. 2006).

The response of practitioners to patient expectation and the effect this can have on prescribing profile becomes clinically important when the proportion of patients who expect or hope to receive an antibiotic when suffering from an acute dental condition is considered. In one study up to 40% of patients reported that they expected to receive an antibiotic prescription as part of their treatment plan (Steed and Gibson 1997). Fundamentally however, as patients were

asked about their expectations of the consultation after, rather than before they were seen by a dentist, reports of their expectation could be biased by the treatment they did indeed receive.

1.7 Research aims and objectives

Acute dental conditions can have a detrimental impact on an individual's social functioning, economic productivity and quality of life. Acute pulpal, apical and periodontal pathologies are responsible for the majority of acute dental conditions in primary care. These conditions are often bacterially mediated, but have a large inflammatory component.

Although there is an absence of high quality evidence base regarding the use of antibiotics in acute dental conditions, current clinical guidelines recommend that they should be reserved for situations where odontogenic infections demonstrate evidence of spreading infection or systemic involvement. Instead, first line treatment of acute dental conditions should be local operative measures aimed at relieving or removing the source of infection or inflammation.

Heightened awareness of the problems associated with increasing antimicrobial resistance highlights the need for judicious use of antibiotics in relation to dental problems within primary care. Despite the fact that dentists prescribe almost 1 in 10 of all antibiotics dispensed in primary care in the UK, there are still evidence gaps with respect to aspects of their use. The current research describing whether antibiotics are used as adjunctive measures to operative treatment or lone therapies in the management of acute dental conditions is limited. Furthermore, the introduction of updated clinical guidelines relating to antibiotic use for acute dental problems mean that previous reports of levels of compliance with best-practice recommendations may no longer be valid, and therefore an up-to-date appraisal of the prescribing behaviours of GPs is warranted. In addition, comparatively little is known about what influences the management of patients with acute dental conditions by GPs; including what factors affect the decision to prescribe an antibiotic, and whether it is used as a sole treatment or as an adjunct to an operative intervention.

There is even less evidence about antibiotic usage for dental problems in primary medical care. Studies which describe dental consultations and the use of antibiotics for these conditions in general medical practice in the UK are few in number and now over a decade old. During this time it is possible that changes have occurred in the rates of dental consultation in general medical practice, especially considering that there may have been changes in the provision of

primary dental care following the introduction of the new NHS Dental Contract in 2006. Furthermore, during the last decade concerns about antimicrobial resistance have increased and this may have influenced antimicrobial prescribing for dental conditions in general medical practice. Therefore, an evidence gap exists regarding the rates of consultation for dental problems, factors that influence the use of antibiotics for these conditions, and whether antibiotic prescription affects future consultations for dental problems. In addition, little is known about factors that may influence the type of treatment patients with dental problems receive from GMPs.

In the light of the evidence presented in this literature review, a number of questions remained regarding the use of antibiotics in acute dental conditions in primary care in the UK. These are the focus of the remainder of this thesis and are presented in the research aims and objectives.

1.7.1 Research aim

This thesis aims to explore the use of systemic antibiotics in the management of acute dental conditions in primary care in the United Kingdom.

1.7.2 Research objectives

1.7.2.1 Use of antibiotics for dental problems in primary dental care

To describe:

- The treatment modalities patients with acute dental conditions receive from a GDP.
- The proportion of adult patients presenting to a GDP with an acute dental condition who receive an antibiotic.
- Whether antibiotics used as standalone treatments or used in conjunction with operative interventions.
- The degree to which antibiotic prescribing complies with current best-practice clinical guidelines.
- Factors, clinical and non-clinical, which may be associated with an increased likelihood of a patient with an acute dental condition receiving an antibiotic from a GDP.

1.7.2.2 Use of antibiotics for dental problems in primary medical care

To describe:

- The characteristics of the patients who consult a GMP for a dental problem and to explore whether these have changed over time.
- The incidence of consultations for dental problems and to explore whether rates in England and Wales changed since the introduction of the new Dental Contract in 2006.
- How dental problems are managed in general medical practice, exploring in particular the use of antibiotics and analgesics in such conditions.
- The predictors of antibiotic and analgesic prescribing for dental problems in general medical practice.
- The predictors of consultation for a subsequent episode of dental problems within a two-year period, and to explore whether there is an association between the treatment patients receive for a dental problem in general medical practice and reconsultation for tooth-related problems in the future.

1.7.2.3 Clinical decision making regarding the use of antibiotics for dental problems in primary care

To explore:

- How primary care clinicians (GDPs and GMPs) make treatment decisions when managing patients with acute dental conditions.
- Factors that influence how a primary care clinician manage patients with acute dental conditions.
- Specific influences on the antibiotic prescribing behaviours of primary care clinicians with respect to acute dental conditions.
- Attitudes towards the use of antibiotics in the management of dental problems amongst primary care clinicians.

1.7.3 Research approach

These research questions were addressed using a mixed-methods study consisting of four sub-studies; two quantitative and two qualitative (Figure 1.4). A mixed methods design was selected as being best suited to answering the research questions posed. Furthermore, it was anticipated

that combination of both quantitative and qualitative evidence would produce a more comprehensive account of the use of antibiotics for dental problems in primary care.

A mixed methods approach was planned from the start of the research process and therefore the study was of a fixed mixed methods design (Creswell and Plano Clark 2011). Overall, the project had a convergent parallel design, in which the quantitative and qualitative elements were conducted during the same phase of the research process and analysed independently, and then combined in the overall interpretation (Creswell and Plano Clark 2011). However the investigation of antibiotic use in general dental practice also had features of an explanatory sequential design as some of the findings from the observational study informed data collection in the qualitative study of GDPs.

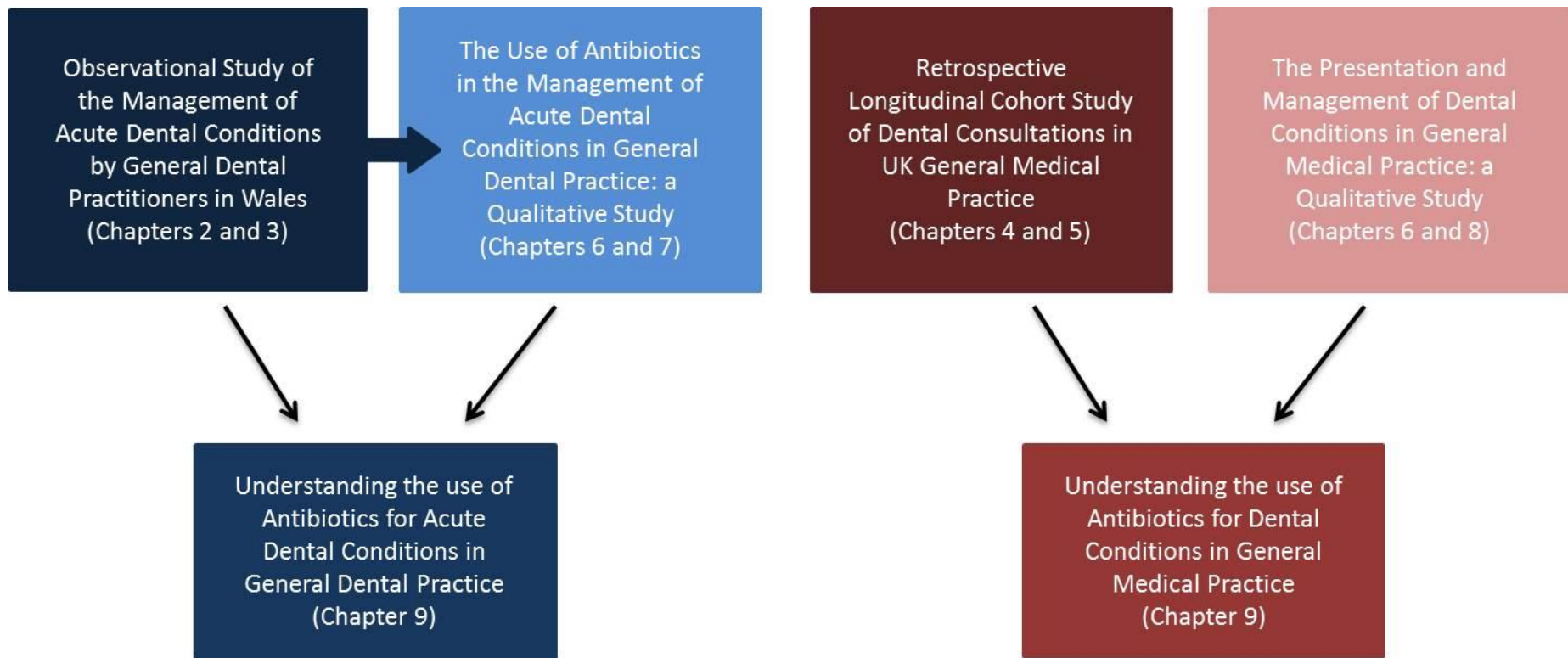


Figure 1.4 – Diagram of the convergent parallel mixed methods design used in this thesis.

2. Observation Study of the Management of Acute Dental Conditions by General Dental Practitioners in Wales – Materials and Methods

2.1 Introduction

This chapter presents the methods of the observational study of the management of adult patients with acute dental conditions by general dental practitioners (GDPs) in Wales. This study aimed to describe the current use of systemic antibiotics in the management of acute dental conditions, to describe current levels of conformity with clinical guidelines on antibiotic usage amongst GDPs, and to investigate the factors associated with increased likelihood of a patient being prescribed an antibiotic.

The research questions, study design and outcomes are described in Sections 2.2, 2.3 and 2.4. Section 2.5 describes the study population, sample size calculation and recruitment of GDPs. Data collection, management and analysis are described in Sections 2.6, 2.7 and 2.8. Section 2.9 described the study approvals monitoring and funding, and Section 2.10 provides a justification of the study design selected.

The results of this study are presented in Chapter 3.

2.2 Research questions

This study sought to answer the following questions:

- What treatment modalities do patients with acute dental conditions receive from a GDP?
- How are systemic antibiotics used by GDPs in the management of acute dental conditions?
- What proportion of patients presenting to a GDP with an acute dental condition receive antibiotics?
- Are antibiotics used as standalone treatments or used in conjunction with operative interventions?
- To what degree does prescribing comply with current best-practice clinical guidelines?
- What factors, clinical and non-clinical, are associated with an increased likelihood of a patient with an acute dental condition receiving an antibiotic from a GDP?

2.3 Study design

This was a cross-sectional study conducted in Wales, UK between October 2012 and June 2013. The setting was general dental practices and participants were GDPs providing care to adult patients with acute dental conditions. Data were collected prospectively¹.

2.4 Outcomes

2.4.1 Primary outcome

The primary outcome of this study was the proportion of adult patients who received a systemic antibiotic during a consultation with a GDP for an acute dental condition.

2.4.2 Secondary outcomes

The secondary outcomes of this study were:

- A description of surgical and pharmacological management by GDPs of adult patients presenting with acute dental conditions.
- A description of the usage of antibiotics amongst GDPs: type, dose, duration and frequency; their use as adjunctive or sole treatment; use by clinical signs and symptoms; use by clinical diagnosis.
- An analysis of the compliance of antibiotic prescribing with clinical guidelines.
- A description of intra-appointment features associated with an increased likelihood of an antibiotic prescription.
- A description of analgesic prescribing by GDPs.
- An exploration of factors (patient characteristics, GDP characteristics and appointment features) associated with antibiotic prescription.

¹ Within this context the term prospective is used to describe the method of data collection which will occur following a consultation. This is used to differentiate it from other studies which have collected data retrospectively from dental records.

- An exploration of factors (patient characteristics, GDP characteristics and appointment features) associated with antibiotic prescribing deviating from clinical guidelines.

2.5 Study population

2.5.1 Inclusion and exclusion criteria

2.5.1.1 Practitioner eligibility criteria

Practitioners were considered eligible for the study if they met all the following inclusion criteria:

- Registered on the Welsh Dental Performers List or with Health Inspectorate Wales (Section 2.5.3).
- They provided dental care to patients over the age of 18.
- There was not another dentist in the same practice enrolled in the study.

2.5.1.2 Patient eligibility criteria

Patients were considered suitable for inclusion if they met the following criteria:

- Were aged 18 years or over on the day of consultation
- Had a clinical diagnosis of one of the following conditions:
 - Reversible pulpitis
 - Irreversible pulpitis
 - Acute apical periodontitis
 - Chronic apical periodontitis (also termed apical granuloma)
 - Acute apical abscess (with or without systemic involvement)
 - Chronic apical abscess
 - Cystic lesion (such as a radicular cyst, periodontal cyst)
 - Periodontal abscess
 - Combined periodontal-endodontic lesion
 - Pericoronitis

2.5.2 Sample size calculation

The sample size calculation was based around estimation of the primary outcome (the proportion of patients receiving an antibiotic during a consultation for an acute dental condition) to within a specified precision. Using the most conservative proportion for sample calculation, 50%, it was initially calculated that 385 completed case report forms (CRFs) would be required in order to estimate a 95% confidence interval width of 10% (5% above and below) (Glaziou 2005, Gelman and Hill 2007).

However, as groups of patients were going to be treated by the same practitioner, this initial figure needed to be adjusted to account for clustering. The most commonly used measure of the degree of similarity of responses within a cluster is the intraclass correlation coefficient (ICC), the measure of the fraction of total variation in the data that is accounted for by between-group variation.

For sample size calculations in public health trials, the ICC has often been assumed to take values between 0 and 0.05 (Hannan et al. 1994). As no similar studies existed within primary care dentistry to provide a value for an ICC, an estimated value of 0.04 was used, based on a study in general medical practice (Butler et al. 2002). A pragmatic decision was made by the research team that it was reasonable to ask each enrolled practitioner to complete 15 CRFs. Therefore with a cluster size of 15, this produces an ultimate value of 600 CRFs, requiring the recruitment of at least 41 GDPs (see Figure 2.1). To allow for up to 10% drop out of GDPs we aimed to recruit 45 GDPs.

$$N = n(1 + (m - 1)\rho)$$

N is the corrected sample size, *n* is the uncorrected sample size, *m* is the number of subjects in a cluster and ρ is the ICC.

Figure 2.1 - Formula to inflate sample size to account for clustering (Gelman and Hill 2007).

2.5.3 Recruitment of GDPs

In order to recruit GDPs in a timely and efficient manner, invitations were sent to a random sample of 200 GDPs, across seven regional strata (based on LHB), with the aim of selecting the first 45 to respond. The names and practice addresses of all GDPs in Wales were obtained from publically available registers (Dental Performers Lists of GDPs providing NHS services, held by

Local Health Boards; Healthcare Inspectorate Wales register of dentists providing private treatment in Wales) and duplicate records removed. A study invitation letter (Appendix VII) was then sent to a randomly selected (using a random number generator) sample of practitioners in each strata (Figure 2.2). The numbers of invitation letters sent per strata varied between 10 and 45 depending on the number of practitioners working in the area and the date of recruitment (Section 3.2).

The invitation letter outlined the study, and contained a return form and prepaid envelope. GDPs who returned their statement of interest were sent a study information sheet (Appendix VIII), consent form (Appendix IX) and prepaid envelope.

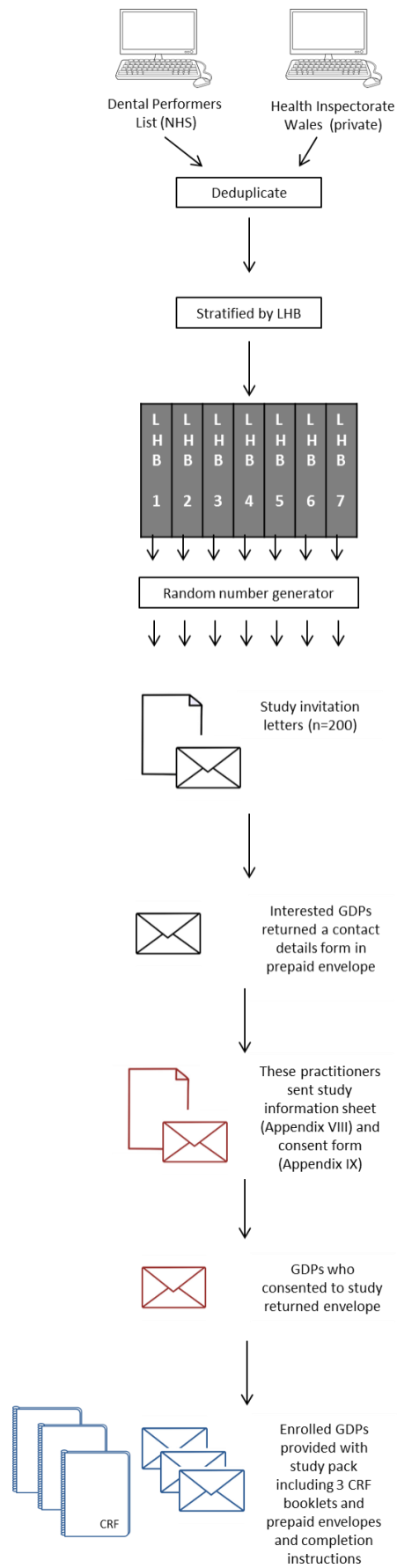


Figure 2.2 – Recruitment of practitioners

2.6 Data collection

2.6.1 Case Report Form (CRF) and Practitioner Demographic Questionnaire

Design of the CRF was informed by the research objectives, existing literature, CRFs used in similar cross-sectional studies in primary care and the clinical experience of the research team. The final design (Appendix X) was a six-section, double-sided A4 CRF. This captured:

- Clinical history - patient age, gender, duration of symptoms, symptomatic tooth, NHS/private status
- Signs and symptoms – including signs of spreading infection or systemic involvement
- Clinical diagnosis
- Treatment – surgical and non-surgical
- Antibiotic prescriptions – type, dose, frequency, duration and instructions for use for any antibiotics prescribed *if applicable*.
- Non-clinical factors that influenced treatment

The practitioner demographic questionnaire (Appendix XI) collected information on:

- Practitioner gender
- Year of qualification
- Region where primary dental qualification was obtained (UK, EEA (non-UK) or non-EEA)
- Whether the practitioner held dental postgraduate qualifications such as MFDS, MJDF, MFS, MFGDP, MSc, MClintDent or postgraduate diplomas
- How many sessions of general dental care they provided in the average week (one session defined as a morning *or* afternoon)
- The approximate percentage of time spent undertaking NHS and private work
- Whether they had or were currently completing the 1000 Lives Plus Antibiotic Prescribing Audit ²

² The Wales Deanery in collaboration with 1000 Lives Plus campaign developed an antimicrobial prescribing audit for GPs in Wales. The audit aims to support the most effective clinical use of antimicrobials and reduce the number of unnecessary prescriptions (Wales Deanery 2012). Participation in the audit is voluntary.

2.6.2 Study procedures for data collection

Enrolled clinicians were provided with a study pack (see Figure 2.2) including:

- Information about completing the CRFs, including patient inclusion criteria (letter and front page of each booklet)
- Three booklets, each containing five CRFs (Appendix X)
- Practitioner demographics questionnaire (contained within the first CRF booklet) (Appendix XI)
- Three prepaid envelopes for the return of the CRF booklets.

Enrolled clinicians were asked to complete a CRF for 15 *consecutive* adult patients with an acute dental condition listed in the inclusion criteria after treating the patient according to their usual practice. The CRFs were packaged into booklets of five to maximise data return. Once they had completed a booklet, practitioners posted them back in prepaid envelopes.

Each practitioner was assigned a unique ID number. This was recorded in a password protected spreadsheet together with the name, practice address, date of invitation letter, date consent form was sent and received, date study pack was dispatched, and date CRF booklets 1, 2 and 3 were returned. The CRF booklets in each study pack had the same unique practitioner ID number on the front and on each subsequent sheet. During data cleaning, analysing and reporting of the findings, the researcher used only the ID code to ensure anonymity.

2.7 Data management

2.7.1 Data handling

Three IBM SPSS Statistics for Windows, Version 20.0 (IBM Corp) files were created to store all of the study data: two contained the double-entered CRF data, and one the returns from the practitioner demographic questionnaire. This folder was stored on a server owned by Cardiff University and was backed up weekly by Cardiff University Information Services. All primary source material was stored in a locked cupboard.

2.7.2 Data cleaning

Data cleaning are processes by which errors within datasets can be identified and remedied prior to analysis being run. Due to the nature of the dataset, the errors were anticipated during the data entry process.

2.7.2.1 CRF double entry

All of the CRFs were manually double entered upon receipt. The two datasets were compared using the *update* command in SPSS. Eight errors were detected giving a case wide error rate of 1.41% (8/568) and a cell wide error rate of 0.03% (8/28968), much less than 2% cell-error rate considered acceptable. The majority of errors occurred in the binary input columns due to rapid pressing of the tab-key.

2.7.2.2 Missing data, range and validity checks

Missing data were coded at -99 in the SPSS datasets. During the analysis all instances of missing data were checked against primary sources. Categorical variables (such as gender, registration status etc.) were checked using descriptive frequencies including minimum and maximum values. Continuous variables were verified using mean values and range checks.

2.8 Analysis

Analysis was conducted using SPSS Version 20.0 and MLwiN, Version 2.28 (Rasbash et al. 2013). All syntax and output files were dated and saved, to act as an ongoing record of the data cleaning and analysis process.

2.8.1 Descriptive analysis

GDP and patient characteristics are described using mean, median and range, and presented in frequency tables with 95% confidence intervals.

2.8.2 Primary outcome

The proportion of patients prescribed an antibiotic was calculated from responses to the 'Antibiotic' field within 'Section 4 – Treatment' of the CRF. This was recorded as a binary variable. The variance in the proportion of patients who received an antibiotic was calculated using the formula in Figure 2.3, which takes into account differential cluster sizes within the sample (Frerichs 2004).

$$v(p) = \frac{\sum_{i=1}^n (a_i - p m_i)^2}{n(n-1)\bar{m}^2}$$

$$SE(p) = \sqrt{v(p)}$$

$$CI_{95\%}(p) = p \pm (1.96 SE(p))$$

Where $v(p)$ is the variance in the proportion of patients prescribed an antibiotic, a_i is the number of patients prescribed an antibiotic in the i_{th} cluster, p is the proportion of patients prescribed an antibiotic within the whole sample, m_i is the number of patients in the i_{th} cluster, n is the number of clusters (i.e. number of GDPs), \bar{m} is the average number of patients per cluster, $SE(p)$ is the standard error and $CI_{95\%}(p)$ the 95% confidence interval associated with p .

Figure 2.3 – Formula to calculate 95% confidence interval associated with the proportion of patients who receive an antibiotic (Frerichs 2004).

2.8.3 Secondary outcomes

2.8.3.1 Management of acute dental conditions, antibiotic usage, intra-appointment features and analgesic use

The management of acute dental conditions per diagnosis and secondary outcomes related to antibiotic usage, intra-appointment features and analgesic use are described using mean, median and range, and presented in frequency tables with 95% confidence intervals.

During data analysis clinical diagnoses, 'acute apical periodontitis' and 'chronic apical periodontitis' were combined into 'symptomatic apical periodontitis' to reflect the AAE Consensus Conference Recommended Diagnostic Terminology (2009).

2.8.3.2 Post-hoc analysis of differences between antibiotics prescribed for NHS and private patients

A post-hoc analysis was conducted to investigate whether differences existed in the number, type, or duration of antibiotics prescribed to NHS and private patients. In addition, an analysis were also performed to assess whether private and NHS patients received differing recommendations for antibiotic use. Differences in number of antibiotics prescribed to NHS and private patients were investigated using the Chi-square test, whilst types of antibiotic and recommendations for use were investigated using the Fisher's exact test. In comparison, differences in mean duration of antibiotic course between NHS and private patients was assessed using an independent samples t-test.

2.8.3.3 Concordance with clinical guidelines for antibiotic usage

The type, dose, duration and frequency of antibiotic prescriptions prescribed within the study were compared against the standards published by the Royal College of Surgeons Faculty of General Dental Practitioner (FGDP(UK)) (Palmer et al. 2012), Scottish Dental Clinical Effectiveness Programme (SDCEP) (Scottish Dental Clinical Effectiveness Programme 2011) and British National Formulary (BNF) (Joint Formulary Committee 2012) (Table 1.5).

Appropriate use of antibiotics was judged against the SCDEP and FGDP(UK) guidelines as these provide more detailed recommendations than the BNF. Appropriate use of antibiotics in the treatment of acute dental conditions, as defined by these guidelines, is limited to situations where:

- There was evidence of spreading infection and/or systemic involvement: diffuse facial swelling, lymphadenopathy, fever, dysphagia, cellulitis, sublingual swelling or trismus.
- Local measures (such as exodontia, endodontic treatment or incision and drainage of a swelling) were also attempted
- Where definitive treatment had to be delayed due to referral to specialist services or in situations where local measures have been ineffective (Scottish Dental Clinical Effectiveness Programme 2011, Palmer et al. 2012)

2.8.3.4 Modelling of factors associated with antibiotic prescription

Analysis was conducted to investigate factors that are associated with antibiotic prescribing (both total prescribing and prescribing deviating from clinical guidelines). Data collected as part of this study has a hierarchical structure in which patients (level 1, represented by i) exist in groups according to which GDP they are treated by (level 2, represented by j). It was important that this structure and lack of independence was represented in the analysis as the treatment received by two patients treated by the same dentist is likely to be more similar than the treatment received by two patients treated by two different GDPs. Therefore a multilevel modelling approach was used.

The models employed were two-level random intercepts logistic regression models. For discrete response multilevel models MLwiN uses quasi-likelihood methods to approximate this model into a continuous response multilevel model so that the Iterative Generalised Least Squares (IGLS) algorithm can be used. Two types of approximation (Marginal Quasi Likelihood (MQL) and Penalised Quasi Likelihood (PQL)) are available and either 1st order terms or up to 2nd order terms can be included. As recommended by the MLwiN user guide (Rasbash et al. 2012), within this analysis the 1st order MQL approximation was fitted first, followed by the 2nd order PQL. Conducting the approximations in this way capitalised on the stability of the 1st order MQL approximation whilst allowing the 2nd order PQL procedure to provide more accurate estimates (Leckie and Charlton 2013). The equation for this model is shown in Figure 2.4.

$$F^{-1}(\pi_{ij}) = \beta_{0j} + \beta_1 x_{ij} + u_j$$

Where F^{-1} is the link function (in this case logit); π_{ij} is the probability of a patient receiving an antibiotic; β_0 is the log-odds that $y = 1$ when $x = 0$ and $u = 0$; β_1 is effect on log-odds of a one-unit increase in x for individuals in the same group (also known as the cluster-specific effect of x); x_{ij} is the predictor variable and u_j is the level 2 residuals (or dentist-effect).

Figure 2.4 – Two-level, random intercepts logit model (Leckie and Charlton 2013)

Predictors were selected on the basis of existing literature (Palmer and Martin 1998, Palmer et al. 2000a, Seager et al. 2006), and where a plausible argument could be made for their inclusion. These predictor variables assessed were:

- Patient demographics (age, gender, NHS/private status).
- Clinical features (symptom duration, symptomatic tooth, signs and symptoms).
- Appointment features (patient refusal of operative treatment, shortage of clinical time and patient request for antibiotics).
- GDP demographics (gender, years since qualification, GDP postgraduate qualification status, GDP country of qualification, Wales Index of Multiple Deprivation 2011 (WIMD)³ category for practice location).

Univariate analysis was used as a screening tool to determine which predictors were to be entered into each of the models. Variables with a p-value of <0.1 on univariate analysis were entered in a forward stepwise manner into the two-level random intercept logit model. Where there was a significant association between variables these were entered as an interaction term. Within the total antibiotic prescribing model, the response variable was taken straight from the dataset where it was recorded in a binary form.

The antibiotic prescribing deviating from clinical guidelines model required the calculation of a new variable, '*Guideline incongruent antibiotic use*' (Table 2.1). Whether an antibiotic was given outside clinical guidelines was judged against SDCEP and FGDP(UK) criteria (Scottish Dental Clinical Effectiveness Programme 2011, Palmer et al. 2012) and required a determination of:

- Whether features of spreading infection or systemic involvement were present (defined as the presence of one of the following symptoms: diffuse swelling, cellulitis, lymphadenopathy, trismus, raised floor of mouth, dysphagia or elevated temperature OR diagnosis of acute apical abscess with systemic involvement) (as indicated in Sections 2 or 3 of the CRF).
- Whether local measures (defined as incision and drainage, subgingival debridement, extraction, restoration and/or pulp treatment) were attempted (as indicated in Section 3 of the CRF) OR if local measures had proved ineffective (defined as a positive response to '*patient unable to tolerate operative treatment*' or '*previous operative treatment failed*' or '*unable to achieve adequate local anaesthesia*' in Section 6 of the CRF).

³ WIMD'11 is the official measure of relative deprivation for small areas in Wales (Statistics for Wales, 2012)

	Spreading infection and/or systemic involvement = 0	Spreading infection and/or systemic involvement = 1
Local measures attempted = 0 AND Local measures proved ineffective = 0	Guideline incongruent antibiotic use = 1	Guideline incongruent antibiotic use = 1
Local measures attempted = 1 AND/OR Local measures proved ineffective = 1	Guideline incongruent antibiotic use = 1	Guideline incongruent antibiotic use = 0

Table 2.1 – Recoding table for ‘Prescribing outside guideline’ variable. If no antibiotic was prescribed during a consultation, ‘Prescribing outside guidelines’ = 0.

For each predictor, the modelling produced a co-efficient (β) and associated standard error (S.E) from which an odds ratio, 95% CI and p-value were reported. This format displays the change in the probability of the outcome associated with a one-unit change in each significant predictor variable, holding all other independent variables constant. An odds ratio of 1 implies the predictor has no effect on the outcome, an odds ratio of >1 indicates that cases with higher values of the predictor are more likely to receive an antibiotic and an odds ratio of <1 indicates a lower chance of receiving an antibiotic (Bland and Altman 2000).

2.8.3.4.1 *Measures of variance and model fit*

The proportion in variance attributable to dentist-level is described using the variance partition coefficient (VPC) (Figure 2.5). A VPC of 0 would indicate that none of the variance could be attributable to between-group effects. Conversely, a VPC of 1 would indicate no within-group differences. For multilevel random effects models VPC is equal to the ICC (ρ) (Rasbash et al. 2012).

Two values of VPC are given for each model – first for the simple (null) model which contains no predictors, and second for the model when all predictors have been included. These values provide an illustration of the impact controlling for the predictors can have, and the remaining between-dentist variance when the predictors have been included in the model (Rasbash et al. 2012).

$$\text{Variance partition coefficient (VPC)} = \frac{\text{Level 2 variance}}{\text{Level 2 variance} + \frac{\pi^2}{3}}$$

$$\text{VPC} = \frac{\sigma_u^2}{\sigma_u^2 + \frac{\pi^2}{3}}$$

Where σ_u^2 is the level 2 (between dentist) variance.

Figure 2.5 – Method for calculating the variance partition coefficient (VPC) (Rasbash et al. 2012).

Comparison of model fit was calculated using Monte-Carlo Markov Chain (MCMC) estimation in MLwiN (Rasbash et al. 2012), which facilitated the calculation of a Deviance Information Criterion (DIC). Decrease of DIC between the null and full models indicates a better fit of model is achieved by the addition of explanatory variables (Rasbash et al. 2012).

2.9 Study approvals, monitoring and funding

2.9.1 Ethics, NHS and Local Health Board approvals

The study was reviewed and given a favourable ethical opinion by the London Central Proportionate Review Committee (ref: 12/LO/1213) (Appendix XII). It was the opinion of the committee that, due to the anonymous nature of the data collected, it was not necessary to obtain individual patient consent.

Cardiff University was sponsor for the study (ref: SPON1109-12). The study was approved by the National Institute for Social Care and Health Research Clinical Research Centre (NISCHR CRC) and by the R&D offices of all seven LHBs in Wales. Since practitioners, not individual patients were the unit of interest and no patients were recruited to the study, R&D offices did not require the submission of NHS Site-Specific Information.

2.9.2 Study name and logo

The acronym APICAL (Antibiotics and Primary Care Dental Problems) was used to aid communications clinicians and those involved with ethical and R&D approvals.



2.9.3 Monitoring

The research team (AC, NF, IGC and FW) met fortnightly to discuss the progress of the study and address any concerns that had arisen in the intervening period.

2.9.4 Funding

All three phases of APICAL were funded by a Wales School for Primary Care Research grant of £8,400 (grant number 504746). Practitioners were reimbursed for the time taken to complete study. They were paid £10 for every CRF completed, with the majority receiving the full £150 available.

2.10 Justification of methodology

2.10.1 Study design

Since the research questions were primarily descriptive, a cross-sectional design was selected as most appropriate. Cross-sectional studies are commonly conducted to estimate the prevalence of the outcome of interest (in this case antibiotic prescribing) for a given population (adults with an odontogenic infection or associated condition consulting a GDP) (Levin 2006). During the initial phases of this study a cohort design involving a patient recorded symptom diary to describe the recovery following different various treatments for acute dental conditions was also considered. This was subsequently rejected as it neither answered the research questions at hand nor was the optimal method of evaluating interventions (a randomised controlled trial).

Data collection can be conducted prospectively or retrospectively. Consideration was given to conducting a retrospective analysis of patient records held in general dental practice. This would have had the advantage of minimising observer bias that may be introduced during prospective cross-sectional studies. However, three disadvantages were identified with regard to retrospective data collection. First, it may have been necessary to gain informed consent from patients to access their records which could have resulted in poor recruitment. Secondly, there is no one universal system for patient records used in primary dental care; some practices still operate paper-based systems, whilst computerised practices may use one of a number of different patient management systems. Large scale retrospective data collection would therefore have required the development of computer algorithms to extract patient records or time-consuming hand-searching. However, by far the most important reason why retrospective data collection was not selected was because of the lack of detailed information that may be recorded in clinical notes. In a retrospective study conducted within the emergency dental service, only 65% of patients had a clinical diagnosis recorded, (Tulip and Palmer 2008). In addition it was considered highly unlikely that GDPs would record when patient management was affected by availability of clinical time. For this reason data were collected prospectively.

The amount of information to be collected on the CRF was extensively discussed by the research team; too little and there would be insufficient data to conduct analysis to gain perspective on the research question, too much and it risked overwhelming clinicians and could lead to poor rates of return. Therefore a double-A4 sided CRF design was selected.

3. Observation Study of the Management of Acute Dental Conditions by General Dental Practitioners in Wales – Results

3.1 Introduction

This chapter presents the results of the observation study of the management of acute dental conditions by general dental practitioners (GDPs) in Wales. The methods underlying this study are described in Chapter 2.

Section 3.2 describes the recruitment of GDPs and data collection; Section 3.3 presents the characteristics of GDPs and patients included in the study and Sections 3.4 and 3.5 present the results related to the primary and secondary outcomes.

3.2 Recruitment of practitioners

Practitioners were recruited between October 2012 and February 2013. Recruitment of practitioners began as soon as R&D approval was received for the Local Health Board (LHB). Response to the invitation to participate exceeded expectation and, as a result, the LHBs where recruitment began first (Cwm Taf Health Board and Cardiff and Vale University Health Board) are somewhat over-represented within the sample (Table 3.1).

Two hundred practitioners were sent brief written information about the study and invited to participate. In total 60 practitioners expressed an interest in learning more about the study and 45 returned consent forms and were sent study packs (Table 3.1).

Local Health Board (LHB)	Date recruitment began	Number of invitations sent (n=200)	Number of practitioners expressing interest (n=60)	Enrolled practitioners (n=45)	Dropout (no data returned) (n=3)
Cwm Taf HB	1 st Oct '12	35	11	11	0
Cardiff and Vale UHB	5 th Oct '12	45	15	11	0
Betsi Cadwaladr UHB	5 th Oct '12	43	11	8	1
Aneurin Bevan HB	24 th Oct '12	23	5	3	0
ABM UHB	2 nd Nov '12	28	10	5	0
Powys LHB	8 th Nov '12	10	3	2	0
Hywel Dda LHB	29 th Nov '12	16	5	4	2

Table 3.1 - Recruitment figures per LHB

3.2.1 Return of data collection booklets

Data collection occurred between October 2012 and June 2013. The flow of data collection is shown in Figure 3.1. Of the 45 enrolled practitioners, 3 did not return all 3 booklets despite 2 email or telephone reminders (depending on preferred method of contact). At least one drop out was known to be due to the dentist leaving the practice.

The data collection process was closely monitored to maximise booklet return. Practitioners who had either not returned their first booklet, or who had had a delay of more than four weeks since the return of the previous booklet were contacted by email to ensure they had sufficient study booklets and to resolve any queries regarding data collection. All practitioners received a mid-study newsletter to inform them about the progress of the study and to encourage ongoing participation. In total 118 case report form (CRF) booklets were eventually returned containing details of 590 clinical encounters. Of these, 9 CRFs were incomplete and 13 related to patients under the age of 18, leaving 568 which met the inclusion criteria and were suitable for analysis.

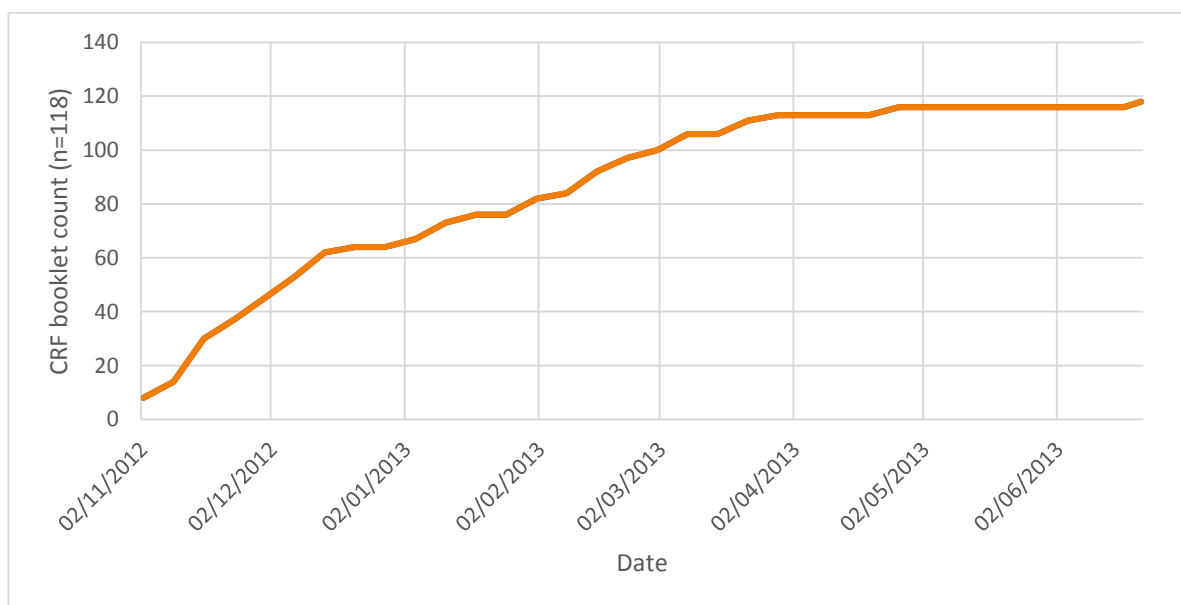


Figure 3.1 – CRF booklet return

3.3 Descriptive analysis

3.3.1 Description of participating clinicians

A total of 42 clinicians participated in the study (Table 3.2). Just over half the sample was male (54.76%), and the mean time since primary dental qualification was 14.31 years (SD 10.27). All

but four GDPs had received their primary dental qualification in the UK (90.47%) and just over a quarter held postgraduate qualifications such as MFDS, MJDF or an MSc (28.57%). The majority of clinicians worked less than 10 sessions per week (a session being one morning or afternoon), with the mean number of sessions worked per week being 7.95 (SD 2.31). Just over three quarters of clinicians (78.57%) reported spending 50% or more of their time engaged in the provision of NHS care.

Characteristic	GDPs (n=42)
Male gender (%)	23 (54.76%)
Mean time since qualification (years) (SD)	14.31 (10.27)
Primary dental qualification from a UK institution (%)	38 (90.48%)
Postgraduate qualifications (%)	12 (28.57%)
Number of sessions worked per week (%)	
4 or less	5 (11.90%)
5 or more	37 (88.10%)
Proportion of clinical treatment provided under an NHS contract (%)	
Less than 50%	9 (21.43%)
50% or more	33 (78.57%)
Involvement in 1000 Lives Plus Antimicrobial Prescribing Audit	
Already completed	5 (11.9%)
Currently completing	19 (45.2%)
No involvement	18 (42.9%)
Wales Index Multiple Deprivation'11 Rank	
10% most deprived ranks (ranks 1-190)	5 (11.9%)
10-20% most deprived ranks (ranks 191-380)	10 (23.8%)
20-30% most deprived ranks (ranks 381-570)	17 (40.5%)
30-50% most deprived ranks (ranks 571-950)	6 (14.3%)
50% least deprived ranks (ranks 951-1896)	4 (9.5%)

Table 3.2 – Characteristics of participating GDPs

3.3.2 Description of patients

Participating clinicians recorded information about 568 adult patients with pulpal, apical and periodontal conditions. Patients' ages ranged from 18 to 92, with a mean age of 46.10 years (SD 17.74). Just over half the sample (52.64%) were female. The majority of patients reported symptoms of 7 days or less duration (80.63%), although considerable variation existed within the sample (SD 22.1 days). The majority of patients were treated under an NHS contract (75.88%), the remainder receiving their treatment privately. Pathologies of maxillary incisors and canines represented a higher proportion of the sample than mandibular incisors and canines, whilst problems with mandibular premolars and molars outnumbered maxillary premolars and molars. Mandibular third molars were responsible for 13.91% of all attendances (Table 3.3).

Pain was the most commonly recorded presenting symptom (95.25%), followed by facial swelling (49.11%) of which 77.42% was reported as localised and 22.58% as diffuse. Less commonly recorded signs included purulent discharge or a draining sinus (17.78%), lymphadenopathy (11.09%), trismus (9.15%), fever (5.11%) and dysphagia (2.82%). Mucosal ulceration and cellulitis were relatively uncommon findings, reported in 1.58% and 1.23% of cases respectively. There were no recorded instances of raised floor of the mouth (Table 3.4).

The most common clinical diagnoses recorded were irreversible pulpitis (19.36%), symptomatic apical periodontitis (16.02%), periodontal abscess or periodontal-endodontic lesion (13.91%), acute apical abscess (with no systemic involvement) (13.73%), pericoronitis (12.68%) and chronic apical abscess (12.15%). Less frequently recorded diagnoses included acute apical abscess (with systemic involvement) (5.99%), reversible pulpitis (5.63%) and cystic lesions (0.53%). In total, 47.89% of diagnoses were related to apical pathologies (such as symptomatic apical periodontitis and apical abscesses), 26.59% to periodontal pathologies (including pericoronitis), 24.99% to pulpitis and 0.53% to cystic lesions which could be apical or periodontal in origin (Table 3.5).

Characteristic	Patients (n=568)
Mean age (years) (SD)	46.10 (17.74)
Male gender (%)	269 (47.36%)
Median duration of symptoms (days) (IQR)	4.00 (3.00 – 7.00)
Registration status (%)	
NHS	431 (75.88%)
Private	137 (24.12%)
Affected tooth (%)	
Permanent upper incisors and canines	64 (11.27%)
Permanent lower incisors and canines	24 (4.23%)
Upper premolars	89 (15.67%)
Lower premolars	52 (9.15%)
Permanent upper first and second molars	104 (18.31%)
Permanent lower first and second molars	133 (23.42%)
Upper third molars	20 (3.52%)
Lower third molars	79 (13.91%)
Retained deciduous teeth	3 (0.53%)

Table 3.3 – Characteristics of patients, duration of symptoms and affected teeth

Clinical sign or symptom	Frequency (n=568)	Proportion of patients where clinical sign or symptom was recorded (%)
Pain	541	95.25
Swelling		
Localised	216	38.03
Diffuse	63	11.09
Purulent discharge or draining sinus	101	17.78
Lymphadenopathy	63	11.09
Trismus	52	9.15
Fever	29	5.11
Dysphagia	16	2.82
Mucosal ulceration	9	1.58
Cellulitis	7	1.23
Raised floor of mouth	0	0.00

Table 3.4 - Patient clinical signs and symptoms

Diagnosis	Frequency (n=568)	Proportion (%)
Reversible pulpitis	32	5.63
Irreversible pulpitis	110	19.36
Symptomatic apical periodontitis	91	16.02
Acute apical abscess		
with no spreading infection or systemic involvement	78	13.73
with spreading infection or systemic involvement	34	5.99
Chronic apical abscess	69	12.15
Periodontal abscess or periodontal-endodontic lesion	79	13.91
Pericoronitis	72	12.68
Cyst	3	0.53

Table 3.5 – Patient clinical diagnoses

3.4 Primary outcome

The proportion of patients consulting a GDP with an acute dental condition who receive a prescription for systemic antibiotics.

Systemic antibiotics were prescribed to 326 out of 568 patients (57.39% (95% CI 27.48% - 87.30%)). Therefore, assuming the absence of bias or confounding, it is possible to be 95 percent confident that the true percentage of patients with an acute dental problem who receive an antibiotic during a consultation with a GDP is between 27.48% and 87.30%.

The wide confidence interval arises due to substantial differences in the antibiotic prescribing behaviours amongst participating GDPs (ICC = 0.50). Antibiotic use ranged from one GDP who prescribed antibiotics to 1 out of 15 patients, to a GDP that prescribed an antibiotic for all 15 patients.

3.5 Secondary outcomes

3.5.1 Management of acute dental conditions

In total 39.96% (227/568) of patients received local measures only, 37.15% (211/568) were prescribed antibiotics only, 20.25% (115/568) received antibiotics and local measures, 0.18% (1/568) received analgesics only and 2.46% (14/568) received no treatment.

3.5.1.1 Reversible pulpitis

Of the 32 patients diagnosed with reversible pulpitis, 26 (81.25%) received local measures. Of the six patients that did not receive operative treatment: four received an antibiotic; one analgesia and the remaining one advice only (Table 3.6). Of the local measures employed, the most common was restoration without endodontic treatment (23/26, 88.46%).

3.5.1.2 Irreversible pulpitis

The majority of patients with irreversible pulpitis received local measures only (65/110, 59.09%) (with or without analgesics). Local measures with antibiotics was received by 28.18% (31/110) of patients and 10.00% of patients with irreversible pulpitis (11/110) received antibiotics as their only treatment. Three patients received no treatment (2.73%) (Table 3.6). Of the local measures employed, the most common was endodontic therapy (54/76, 71.05%), followed by exodontia (19/76, 25.00%).

3.5.1.3 Symptomatic apical periodontitis

Of the 91 patients diagnosed with acute apical periodontitis, 48 (52.75%) received operative treatment (either pulp therapy with restoration or extraction) with or without analgesics, 28 (30.77%) received just antibiotics, 13 (14.29%) antibiotics and local measures. The remaining two patients received just analgesics (Table 3.6). Of the local measures employed, the most common was endodontic therapy (31/61, 50.82%), followed by exodontia (28/61, 45.90%).

3.5.1.4 Acute apical abscess

With no evidence of spreading infection and/or systemic involvement

Over half of patients with acute apical abscess with no evidence of spreading infection or systemic involvement received antibiotics as part of the management of their condition (47/78, 60.26%). The majority of patients received antibiotics only (33/78, 42.31%), whilst a smaller number received antibiotics together with local measures (14/78, 17.95%). The remaining patients received local measures only (31/78, 39.74%) (Table 3.6). Of the local measures employed, the most common was exodontia (28/45, 62.22%), followed by endodontic treatment (13/45, 28.89%). A small number of patients underwent incision and drainage (5/45, 11.11%) (1 patient underwent both incision and drainage and endodontic treatment).

With evidence of spreading infection and/or systemic involvement

The majority of patients with acute apical abscess with spreading infection and/or systemic involvement received antibiotics as part of their management (32/34, 94.12%). Over half (18/32, 56.25%) of individuals prescribed antibiotics received no adjunctive local measures. A small proportion of patients received local measures alone (2/34, 5.88%) (Table 3.6). Of the local measures employed, the most common were incision and drainage (7/16, 43.75%), endodontic therapy (6/16, 37.50%) (one patient had both incision and drainage and endodontic therapy), followed by exodontia (4/16, 25.00%).

3.5.1.5 Chronic apical abscess

The most common treatment of chronic apical abscess was antibiotics alone (31/69, 44.93%), followed by local measures only (21/69, 30.43%), and the combined use of antibiotics and local measures (14/69, 20.29%). The remaining patients (3/69, 4.35%) received no active treatment (Table 3.6). Of the local measures employed, the most common was exodontia (18/35, 51.43%), closely followed by both endodontic treatment (8/35, 22.85%) and incision and drainage (8/35, 22.85%).

3.5.1.6 Acute periodontal conditions

Of the 79 patients diagnosed with periodontal abscess or combined periodontal-endodontic lesions, 32 (40.51%) received local measures only; 16 (20.25%) received antibiotics in conjunction with local measures and 28 patients (35.44%) received antibiotics only (Table 3.6). The most common operative interventions were exodontia (33/48, 68.75%) and root surface debridement (RSD) (14/48, 29.17%).

3.5.1.7 Pericoronitis

Of the 72 patients diagnosed with pericoronitis, 55 (76.39%) received an antibiotic only; 12 (16.67%) received antibiotics in conjunction with local measures and three patients (4.17%) received local measures only. Two patients received no treatment (2.78%) (Table 3.6). The most common operative intervention was irrigation of the operculum (recorded as RSD) (11/15, 73.33%).

	Reversible pulpitis (n=32)	Irreversible pulpitis (n=110)	Symptomatic apical periodontitis (n=91)	Acute apical abscess (no spreading infection or systemic involvement) (n=78)	Acute apical abscess (with spreading infection or systemic involvement) (n=34)	Chronic apical abscess (n=69)	Acute periodontal conditions (n=79)	Pericoronitis (n=72)
Local measures only	25	65	48	31	2	21	32	3
(%)	78.13	59.09	52.75	39.74	5.88	30.43	40.51	4.17
Local measures and antibiotics	1	31	13	14	14	14	16	12
%	3.13	28.18	14.29	17.95	41.18	20.29	20.25	16.67
Antibiotics only	4	11	28	33	18	31	28	55
%	12.50	10.00	30.77	42.31	52.94	44.93	35.44	76.39
Analgesics only	1	0	0	0	0	0	0	0
%	3.13	0	0	0	0	0	0	0
No treatment	1	3	2	0	0	3	3	2
%	3.13	2.73	2.20	0.00	0.00	4.35	3.80	2.78

Table 3.6 - Treatment modalities provided for the most common clinical diagnoses

3.5.2 Antibiotic usage

3.5.2.1 Types of antibiotic

Amoxicillin was the most frequently prescribed antibiotic (191/326, 58.59%) followed by metronidazole (111/326, 34.04%). Small numbers of patients were prescribed erythromycin (17/326, 5.21%), co-amoxiclav (5/326, 1.53%), and clindamycin (1/326, 0.31%).

3.5.2.2 Adjunctive or sole treatment

The majority of antibiotics (230/326, 70.55% (95% CI 60.20% - 80.90%)) were used alone, without the provision of local measures (such as exodontia or endodontic treatment), whilst the remaining antibiotics were provided in conjunction with operative treatment (96/326, 29.45% (95% CI 19.10 – 39.80)).

3.5.2.3 Antibiotic usage by clinical signs and symptoms

High proportions ($\geq 85.00\%$) of patients recorded as affected by diffuse swelling, lymphadenopathy, trismus, fever, dysphagia or cellulitis received an antibiotic as part of their management. High proportions (76.24% and 77.78% respectively) of patients with purulent discharge or a draining sinus, and mucosal ulceration were also prescribed an antibiotic. In comparison 57.80% of patients with pain and 58.80% of patients with localised swelling were prescribed an antibiotic (Table 3.7).

Clinical sign or symptom	Frequency (n=568)	Frequency of antibiotics (n=326)	Proportion of patients positive for clinical signs or symptom prescribed antibiotics (%)
Pain	541	312	57.67
Swelling			
Localised	216	127	58.80
Diffuse	63	56	88.89
Purulent discharge or draining sinus	101	77	76.24
Lymphadenopathy	63	61	96.83
Trismus	52	49	94.23
Fever	29	28	96.55
Dysphagia	16	16	100.00
Cellulitis	7	6	85.71
Mucosal ulceration	9	7	77.78

Table 3.7 - Antibiotic use per clinical sign or symptom

3.5.2.4 Antibiotic usage by clinical diagnosis

Of the 326 antibiotic courses prescribed during the study, 20.55% (67/326) were for pericoronitis, 14.42% (47/326) were for acute apical abscess with no spreading infection or systemic involvement, 13.80% (45/326) were for a chronic apical abscess, 12.88% (42/326) were for irreversible pulpitis and 12.58% (41/326) were for symptomatic apical periodontitis. Smaller numbers of antibiotics were prescribed for periodontal abscesses (33/326, 10.12%), acute apical abscess with evidence spreading infection or systemic involvement (32/326, 9.82%), combined periodontal-endodontic lesions (11/326, 3.37%), reversible pulpitis (5/326, 1.54%) and cystic lesions (3/326, 0.09%) (Table 3.8).

Clinical diagnosis	Frequency of clinical diagnosis (n=568)	Frequency of antibiotics (n=326)	Proportion of presenting cases prescribed an antibiotic (%)	Proportion of total antibiotics prescribed (%)
Irreversible pulpitis	110	42	38.18	12.88
Symptomatic apical periodontitis	91	41	45.05	12.58
Acute apical abscess				
<i>with no systemic involvement</i>	78	47	60.26	14.42
<i>with systemic involvement</i>	34	32	94.12	9.82
Pericoronitis	72	67	93.06	20.55
Chronic apical abscess	69	45	65.22	13.80
Periodontal abscess	56	33	58.93	10.12
Reversible pulpitis	32	5	15.63	1.53
Combined periodontal-endodontic lesion	23	11	47.83	3.37
Cystic lesions	3	3	100	0.09

Table 3.8 - Frequency of antibiotic prescribing per clinical diagnosis, showing proportion of total antibiotic use per condition

Amoxicillin was most frequency prescribed for pulpal and apical pathologies such as acute apical abscess (52/191, 27.2%); symptomatic apical periodontitis (33/191, 17.3%); chronic apical abscess (32/191, 16.8%) and irreversible pulpitis (29/191, 15.2%). In contrast, metronidazole was most commonly used in the management of periodontal pathologies such as pericoronitis (43/111, 38.7%) and acute periodontal conditions (28/111, 25.2%) (Figure 3.2).

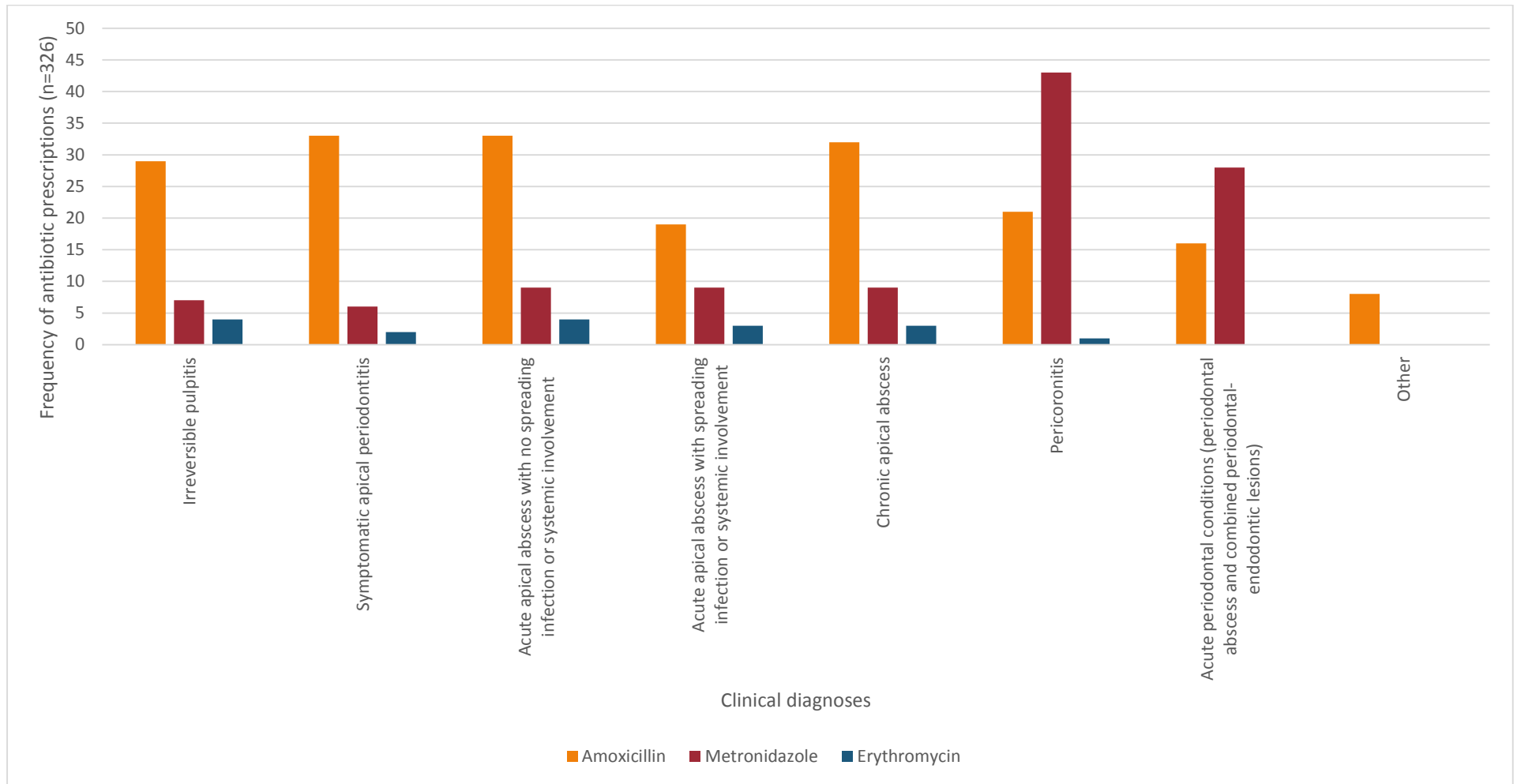


Figure 3.2 – Usage of three most commonly prescribed antibiotics by clinical diagnosis

3.5.2.5 Recommended use of antibiotics

The majority of antibiotics were provided for immediate use (298/326, 91.41%), with smaller amounts provided for the patient to take if their condition deteriorated (22/326, 6.75%) or if local measures failed to relieve symptoms (5/326, 1.53%). No antibiotics were provided prophylactically against infective bacterial endocarditis.

3.2.2.6 Post hoc analysis of differences between antibiotics prescribed for NHS and private patients

A post-hoc analysis of differences between antibiotics prescribed for NHS and private patients was conducted. Whilst there were no significant differences in the type of antibiotic prescribed to NHS and private patients ($p=0.106$), private patients were more likely to receive delayed prescriptions than NHS patients ($p=0.000$) (Table 3.9). Private patients also received longer courses of antibiotics than NHS patients ($p=0.000$) (Figure 3.3).

	For immediate use (n=298)	Delayed use — to take if symptoms worsen (n=22)	Delayed use — to take if treatment does not relieve symptoms (n=5)
NHS patients (n=234)	234	7	3
Private patients (n=64)	64	15	2

Table 3.9 – Post hoc analysis of recommended use of antibiotics by NHS or private status of patients

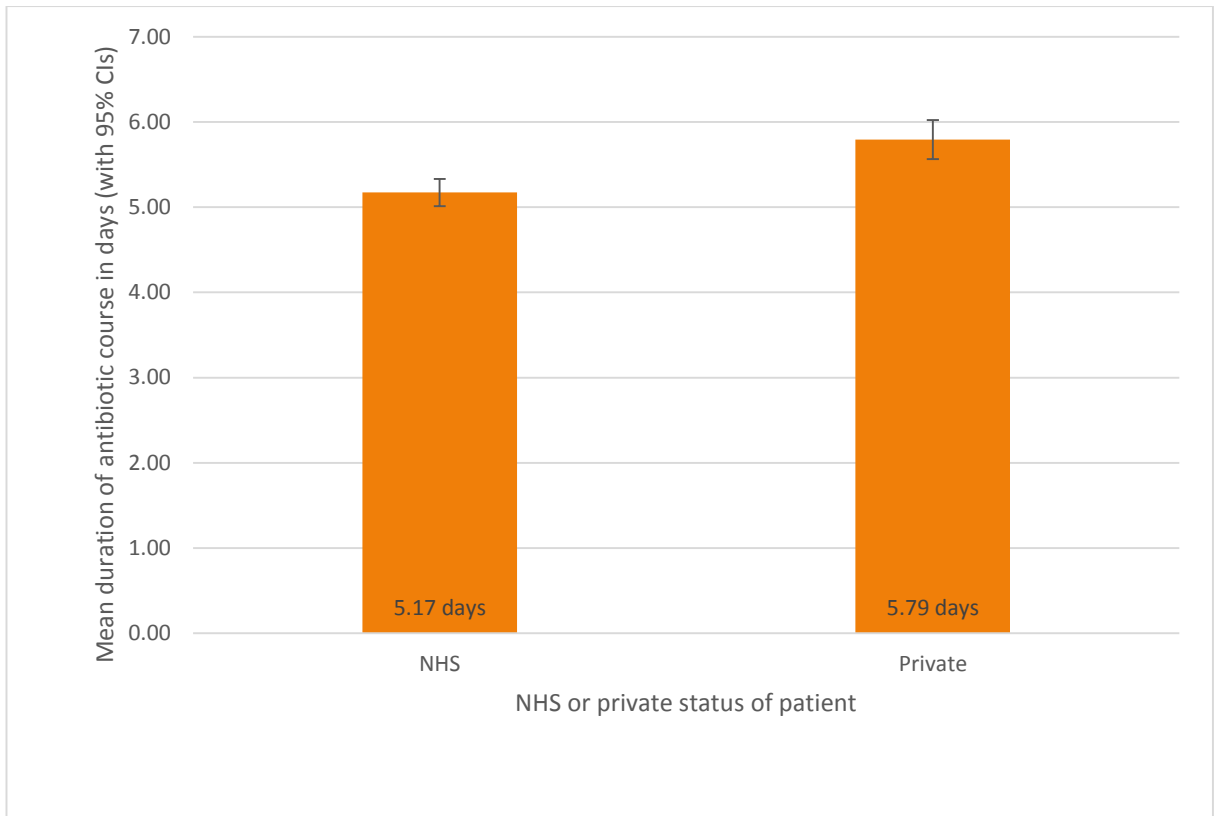


Figure 3.3 – Post hoc analysis of mean duration of antibiotic course between NHS and private patients

3.5.3 Compliance with clinical guidelines for antibiotic usage

3.5.3.1 Type, dose, duration and frequency of antibiotics prescribed

Analysis of the most commonly prescribed antibiotics, demonstrated wide variation in the dose, frequency and duration of antibiotic courses prescribed; 31.41% of amoxicillin prescriptions, 0.90% of metronidazole, 64.71% of erythromycin and 40% of co-amoxiclav prescriptions fell outside the recommendations of either the SDCEP, FGDP(UK) or BNF (Table 3.10). Nearly a fifth of prescriptions (64/326, 19.63%) were for seven days or longer duration.

	Antimicrobial Prescribing for General Dental Practitioners, 2nd Ed. (Palmer et al. 2012)	Drug Prescribing for Dentistry, 2nd Ed. (Scottish Dental Clinical Effectiveness Programme 2011)	British National Formulary, 64th ed. (Joint Formulary Committee 2012)	Frequency prescriptions within current study made according to guidelines
Amoxicillin (n=191)	250mg or 500mg, every 8 hours, up to 5 days	250mg or 500mg, every 8 hours, usually 5 days (3 in some conditions)	250mg or 500mg, every 8 hours, 5 days (3 in some conditions)	131 (68.59%)
Metronidazole (n=111)	200mg, every eight hours, for three days	200mg, every eight hours, for 3 days	200mg, 250mg, 400mg or 500mg, every 8 hours, up to 7 days	110 (99.10%)
Erythromycin (n=17)	Not recommended by guideline	250mg, every six hours, for 5 days	Not recommended by guideline	6 (35.29%)
Co-amoxiclav (n=5)	Not recommended by guideline	250/125 or 500/125, every 8 hours, for 5 days	Not recommended by guideline	3 (60.00%)
Clindamycin (n=1)	Not recommended by guideline	150mg, every 6 hours, for 5 days	Not recommended by guideline	1 (100.00%)
Other antibiotics recommended in guideline, not prescribed as within this study	Clarithromycin, 250mg, every twelve hours, for up to 5 days Azithromycin, 500mg, every twenty-four hours, for 2-3 days	Phenoxymethylpenicillin, 500mg, every 6 hours, for 5 days Clarithromycin, 250mg, every twelve hours, for 7 days	N/A	N/A

Table 3.10 – Table comparing dose, frequency and duration of course of the antibiotics prescribed against guidelines published by the Faculty of General Dental Practice (UK) (Palmer et al. 2012), Scottish Dental Clinical Effectiveness Programme (2011) and British National Formulary (Joint Formulary Committee 2012)

3.5.3.2 Indications for antibiotic use

Appropriate use of antibiotics in the treatment of acute dental conditions, as defined by SDCEP and FGDP(UK) clinical guidelines, is limited to situations where:

- There is evidence of spreading infection and/or systemic involvement: diffuse facial swelling, lymphadenopathy, fever, dysphagia, cellulitis, sublingual swelling or trismus.
- Local measures (such as exodontia, endodontic treatment or incision and drainage of a swelling) are also attempted

- Where definitive treatment has to be delayed due to referral to specialist services or in situations where local measures have been ineffective (Palmer et al. 2012, Scottish Dental Clinical Effectiveness Programme 2011)

Only a small proportion of antibiotics (62/326, 19.02% (95% CI 11.36% - 26.68%) were provided in accordance with SDCEP and FGDP(UK) guidelines. The antibiotics which fell outside of the guidelines did so because: there was no signs of spreading infection or systemic involvement (34/326, 10.43% (95% CI 7.09% - 13.77%)); no local measures were provided and there was no indication that either treatment had to be delayed or local measures had failed (106/326, 32.52% (95% CI 25.23% - 39.81%), or neither of these conditions were met (124/326, 38.04% (95% CI 27.81% - 48.27%)).

3.5.4 Appointment features which influenced treatment

Appointment features which influenced treatment were recorded by GDPs in '*Section 6 – Non-clinical factors influencing treatment*' of the CRF (Appendix X). GDPs could mark none, one or more than one appointment feature which influenced treatment per consultation. A total of 272 appointment features were recorded in 215 out of 568 consultations (37.85%). Antibiotics were prescribed in 90.69% of consultations (195/215) where an appointment feature was recorded, compared to 37.11% of consultations (131/353) where no such appointment feature was recorded. This difference was statistically significant ($X^2=156.910$, d.f. 1, $p<0.0001$). The association of appointment features and antibiotic prescribing is shown in Table 3.11.

Appointment feature	Frequency of consultations with appointment feature where antibiotic was not prescribed	Frequency of antibiotic prescription in consultations with appointment feature	P-value*
Patient declined operative treatment (n=61)	7	54	0.000
Patient unable to tolerate operative treatment (n=37)	3	34	0.000
Previous operative treatment failed (n=30)	6	24	0.010
Insufficient time to perform operative treatment (n=73)	6	67	0.000
Unable to achieve adequate local anaesthesia (n=23)	1	22	0.000
Patient requested antibiotics (n=48)	0	48	0.000

Table 3.11 – Association of appointment features with antibiotic prescribing. *Fischer’s exact test

3.5.5 Analgesic use

Compared to antibiotics, prescribing of analgesics was low (25/568, 4.4%). However, analgesic prescribing was highly clustered to a small number of practitioners with three GDPs prescribing 68.0% of all analgesics within the study.

3.5.6 Modelling of factors associated with antibiotic prescription

3.5.6.1 All antibiotic prescribing

Patient, practice and appointment features that were associated with antibiotic prescribing with a p-value of ≤ 0.1 on univariate analyses (Table 3.12) were entered forward in a stepwise fashion, into a two-level random intercepts logit model. In the case of categorical variables (such as

'Involvement in 1000 Lives Plus Antimicrobial Prescribing Audit') if a difference significant at $p \leq 0.1$ was present between two categories, all categories were included in the model.

Predictor	P-value on univariate analysis
Patient age (years), per increase of 1 year from 18 years	0.06
Gender (base = male)	0.02
Symptom duration (days)	0.04
Patient's NHS/private status (base = NHS)	0.33
Symptoms (base = not present)	
<i>Pain</i>	0.47
<i>Localised swelling</i>	<0.001
<i>Diffuse swelling</i>	<0.001
<i>Cellulitis</i>	0.02
<i>Lymphadenopathy</i>	<0.001
<i>Purulent discharge or draining sinus</i>	0.002
<i>Trismus</i>	<0.001
<i>Fever</i>	0.006
<i>Dysphagia</i>	*
<i>Mucosal ulceration</i>	0.05
Appointment features influencing treatment (base = not present)	
<i>Patient declined operative treatment</i>	<0.001
<i>Previous operative treatment failed</i>	<0.001
<i>Insufficient time to perform operative treatment</i>	<0.001
<i>Unable to achieve adequate local anaesthesia</i>	<0.001
<i>Patient requested antibiotics</i>	*
Practitioner gender (base = male)	0.03
Years since qualification, per increase of 10 years	0.23
Place of primary dental qualification (base = UK)	0.09
Postgraduate qualification status (base = no postgraduate qualifications)	0.37
Involvement in 1000 Lives Plus Antimicrobial Prescribing Audit (base = not taking part)	
<i>Already completed</i>	0.39
<i>Currently completing</i>	0.49
WIMD'11 Rank, per increase of 200 ranks	0.48

* Unable to calculate due to perfect correlation

Table 3.12 – Univariate analysis to determine the predictors entered into the multilevel model for antibiotic prescribing

Table 3.13 presents the results (odds ratios) for the multilevel logistic regression model predicting whether a patient with an acute dental problem will receive an antibiotic. The sample used in the model is 558 patients treated by 42 GDPs. The 10 patients for which there was

missing data with respect to patient age, gender or duration of symptoms were excluded from the model. The vast majority of the predictors in the model fail to reach statistical significance and those that did were associated with wide confidence intervals. However, this may be at least in part attributable to the relatively modest sample size.

Patient characteristics: Female patients were more likely to be prescribed an antibiotic during a consultation than male patients (OR 1.99 (95% CI 1.03 – 3.85)), whilst patient age and duration of symptoms did not significantly predict the likelihood of an antibiotic being prescribed. If a localised swelling was present the odds of an antibiotic being prescribed were 6.12 (95% CI 2.87 – 13.03), compared to if this feature was not present. The odds of an antibiotic being prescribed when a diffuse swelling was noted were 12.11 (95% CI 2.56 – 57.19), 41.18 (95% CI 6.42 – 264.03) for lymphadenopathy and 9.42 (95% CI 1.42 – 62.57) for trismus. Cellulitis, purulent discharge or draining sinus, fever and mucosal ulceration all failed to reach statistical significance in the final model.

Appointment features influencing treatment: the odds of a patient who declined operative treatment receiving an antibiotic were 71.88 (95% CI 16.05 – 321.95) that of patients who did not decline operative treatment. Similarly, the odds of an antibiotic being prescribed when previous operative treatment had failed was 19.43 (95% CI 4.29 – 88.07), GDP reported insufficient time to perform operative treatment 28.99 (95% CI 8.29 – 101.44) and if a GDP was unable to achieve adequate local anaesthesia 30.88 (95% CI 1.57 – 607.41).

GDP characteristics: within the full model neither practitioner gender nor place of qualification proved significant predictors of antibiotic prescribing.

The variance partition coefficient (VPC) is 0.49 in the null model and 0.61 once predictors were added. This indicates that 61% of the residual variance in the full model is due to differences in antibiotic prescribing behaviour at the dentist-level. Significant differences in prescribing behaviour still existed following the fitting of the model ($p = <0.001$).

The Bayesian Deviance Information Criterion (DIC) is smaller in the full model (311.63) than in the empty model (533.81) suggesting that a better model fit is achieved following the addition of explanatory variables.

	Regression coefficient (β)	Standard error (S.E) of β	Odds Ratio (EXP(β))	95% CI Low	95% CI High	P-value	
Patient characteristics (level i)	Patient age in years (base = 18 years)						
	Per 1 year increase in age	0.01	0.01	1.01	0.99	1.02	0.631
	Patient gender (base = male)						
	Female	0.69	0.34	1.99	1.03	3.85	0.042
	Duration of symptoms (base = 1 day)						
	Per 1 day increase in duration	-0.02	0.01	0.98	0.97	1.0016	0.087
	Signs and symptoms (base = not present)						
	Localised swelling	1.81	0.39	6.12	2.87	13.03	<0.001
	Diffuse swelling	2.49	0.79	12.11	2.56	57.19	0.002
	Cellulitis	-0.01	1.81	0.99	0.03	34.66	0.999
	Lymphadenopathy	3.72	0.95	41.18	6.42	264.03	<0.001
	Purulent discharge or draining sinus	0.08	0.41	1.08	0.48	2.42	0.854
	Trismus	2.24	0.97	9.42	1.42	62.57	0.020
Fever	2.74	1.43	15.49	0.94	254.89	0.055	
Mucosal ulceration	1.31	1.62	3.72	0.16	88.09	0.416	
Appointment features (level i)	Appointment features (base = not recorded)						
	Patient declined operative treatment	4.53	0.79	92.30	19.70	432.46	<0.001
	Previous operative treatment failed	2.97	0.77	19.43	4.29	88.07	<0.001
	Insufficient time to perform operative treatment	3.60	0.68	36.74	9.73	138.78	<0.001
	Unable to achieve adequate local anaesthesia	3.43	1.52	30.88	1.57	607.41	0.024
Practitioner characteristics (level j)	Practitioner gender (base = male)						
	Female	-0.15	0.83	0.86	0.17	4.35	0.854
	Place of primary dental qualification (base = UK)						
	Non-UK	2.82	1.81	16.71	0.48	579.20	0.200
Model intercept and measures of variance	Intercept	-2.27	0.73	0.10	0.02	0.44	0.002
	Practitioner-level residual variance						
	Null model	3.19	0.86				<0.001
	Full model	5.07	1.45				<0.001
	Variance partition coefficient (VPC)						
	Null model	0.49					
	Full model	0.61					
	Bayesian Deviance Information Criterion (DIC)						
Null model	533.81						
Full model	311.63						

Table 3.13 - Odds ratio and residual variance for two-level logistic regression model predicting antibiotic prescribing

3.5.6.2 Antibiotic prescribing deviating from clinical guidelines

Patient, practice and appointment features that were associated with inappropriate antibiotic prescribing with a p-value of ≤ 0.1 on univariate analyses (Table 3.14) were entered forward in a stepwise fashion into a two-level random intercepts logit model. In the case of categorical variables if a difference significant at $p \leq 0.1$ was present between two categories, all categories were included in the model.

Predictor	P-value on univariate analysis
Patient age (years), per increase of 1 year from 18 years	0.805
Gender (base = male)	0.032
Symptom duration (days)	0.074
Patient's NHS/private status (base = NHS)	0.486
Symptoms (base = not present)	
<i>Pain</i>	0.631
<i>Localised swelling</i>	<0.001
<i>Diffuse swelling</i>	0.410
<i>Cellulitis</i>	0.430
<i>Lymphadenopathy</i>	0.041
<i>Purulent discharge or draining sinus</i>	0.060
<i>Trismus</i>	0.001
<i>Fever</i>	0.040
<i>Dysphagia</i>	0.069
<i>Mucosal ulceration</i>	0.740
Appointment features influencing treatment (base = not present)	
<i>Patient declined operative treatment</i>	<0.001
<i>Insufficient time to perform operative treatment</i>	<0.001
<i>Patient requested antibiotics</i>	<0.001
<i>Patient unable to tolerate operative treatment</i>	<0.001
<i>Unable to achieve adequate local anaesthesia</i>	0.014
<i>Previous operative treatment failed</i>	0.033
Practitioner gender (base = male)	0.637
Years since qualification, per increase of 10 years	0.821
Place of primary dental qualification (base = UK)	0.170
Postgraduate qualification status (base = no postgraduate qualifications)	0.284
Involvement in 1000 Lives Plus Antimicrobial Prescribing Audit (base = not taking part)	
<i>Already completed</i>	0.770
<i>Currently completing</i>	0.550
WIMD'11 Rank, per increase of 200 ranks	0.933

Table 3.14 - Univariate analysis to determine the predictors entered into the multilevel model

for antibiotic prescribing deviating from clinical guidelines

Table 3.15 presents the results (odds ratios) for the multilevel logistic regression model predicting whether a patient with an acute dental problem will receive an antibiotic not indicated by the SDCEP or FGDP(UK) guidelines.

Patient characteristics: The longer a patient had experienced symptoms, the lower their likelihood of a patient receiving an antibiotic in a situation not indicated by the clinical guidelines. A one day increase in symptom duration was associated with a 15% reduction in the odds of receiving an antibiotic (OR 0.85 (95% 0.76 - 0.94). This size of the effect of symptom duration differed between male and female patients. This is evidenced by the positive interaction term between gender and symptom duration. The positive interaction term when the female dummy variable is used indicates that the effect of symptom duration on inappropriate prescribing is significantly stronger in male patients. This interaction is presented graphically in Appendix XIII. Once these predictors were added to the model no significant differences between male and female patients remained. With regard to clinical signs and symptoms the presence of a localised swelling or fever were both significant predictors of an antibiotic being prescribed out of line with clinical guidelines.

Appointment features influencing treatment: The presence of appointment features such as limited clinical time or patient refusal of treatment were the strongest predictors of antibiotic prescribing outside clinical guidelines. The odds of a patient who declined operative treatment receiving an inappropriate antibiotic were 59.86 (95% CI 14.15 – 253.30). Patients who were reported to be unable to tolerate operative treatment had odds of 42.99 (95% CI 7.57 – 244.10) of receiving an antibiotic where guidelines indicated one was not required. In cases when previous operative treatment had failed, a patient had odds of 4.88 (95% 1.52 – 15.66) of receiving an antibiotic that was not indicated. Similarly if a GDP reported insufficient time to perform operative treatment the odds an inappropriate antibiotic were 27.28 (95% CI 10.12 – 73.53). The odds of a patient for whom local anaesthesia could not be achieved receiving an antibiotic out of line with guidelines were 9.07 (95% CI 1.83 – 44.98). Patients who requested an antibiotic had odds of 7.45 (95% CI 1.56 – 35.45) of receiving one inappropriately compared to a patient who had not.

The proportion of residual variance at the GDP-level is 0.40 in the null model and 0.50 once predictors are added. This indicates that there is large variation in the antibiotic prescribing behaviours of GDPs specifically in relation to congruence with clinical guidelines. Even after patient and practitioner characteristics and appointment features are controlled, significant differences ($P = 0.001$) exist between GDPs.

The DIC is smaller in the full model (388.12) than in the empty model (624.89) suggesting that a better model fit is achieved following the addition of explanatory variables.

	Regression coefficient (β)	Standard error (S.E) of β	Odds Ratio (EXP(β))	95% CI Low	95% CI High	P-value	
Patient characteristics (level i)	Patient gender (base = male)						
	Female	-0.29	0.39	0.75	0.35	1.61	0.459
	Duration of symptoms (base = 1 day)						
	Per 1 day increase in duration	-0.17	0.05	0.85	0.76	0.94	0.001
	Signs and symptoms (base = not present)						
	Localised swelling	1.29	0.32	3.62	1.94	6.75	<0.001
	Lymphadenopathy	-0.02	0.48	0.98	0.39	2.49	0.964
	Purulent discharge or draining sinus	0.43	0.36	1.54	0.76	3.11	0.232
	Trismus	0.65	0.52	1.92	0.69	5.29	0.209
	Fever	-2.32	0.76	0.10	0.02	0.44	0.002
Dysphagia	1.69	0.93	5.42	0.87	33.81	0.070	
Appointment features (level i)	Patient declined operative treatment	4.09	0.74	59.86	14.15	253.30	<0.001
	Patient unable to tolerate operative treatment	3.76	0.89	42.99	7.57	244.10	<0.001
	Previous operative treatment failed	1.59	0.60	4.88	1.52	15.66	0.008
	Insufficient time to perform operative treatment	3.31	0.51	27.28	10.12	73.53	<0.001
	Unable to achieve adequate local anaesthesia	2.21	0.82	9.07	1.83	44.98	0.007
	Patient requested antibiotics	2.01	0.80	7.45	1.56	35.45	0.018
Interaction terms	Gender*duration of symptoms term (bases: gender = male; duration of symptoms: 1 day)						
	Female.duration of symptoms	0.16	0.05	1.18	1.06	1.31	0.002
Model intercept and measures of variance	Intercept	-1.53	0.48	0.22	0.08	0.56	0.001
	Practitioner-level residual variance						
	Null model	2.19	0.59				<0.001
	Full model	3.29	0.93				<0.001
	Variance partition coefficient (VPC)						
	Null model	0.40					
	Full model	0.50					
	Bayesian Deviance Information Criterion (DIC)						
Null model	624.89						
Full model	388.12						

Table 3.15 - Odds ratio and residual variance for two-level logistic regression model predicting guideline incongruent antibiotic prescribing

3.6 Chapter summary

This chapter has described the management of adult patients with acute dental conditions by GDPs in Wales, specifically with regard to the use of antibiotics in these conditions.

Over half of the patients in the study were prescribed a systemic antibiotic, with over a quarter of all antibiotics prescribed for inflammatory conditions such as pulpitis and apical periodontitis. There were wide variations in the dose, frequency and duration of antibiotic courses prescribed, and over a fifth of prescriptions were for seven days duration or greater. Over three quarters of antibiotics were prescribed in situations where clinical guidelines recommended their use was not indicated.

The likelihood of a patient receiving an antibiotic during a consultation for an acute dental problem was influenced by: their gender; whether swelling, lymphadenopathy and trismus were present; whether they were unwilling or unable to accept operative treatment; if previous operative treatment had failed; if adequate local anaesthesia could not be obtained and if a GDP reported having insufficient time to perform operative treatment.

The likelihood of a patient being prescribed an antibiotic in a situation contradictory to clinical guidelines was influenced by: the reported duration of symptoms the effect of which differed by patient gender; whether a localised swelling or fever was present; if the patient was unwilling or unable to accept operative treatment; if previous operative treatment had failed; if adequate local anaesthesia could be obtained, if a GDP reported having insufficient time to perform operative treatment and if the patient requested an antibiotic.

Discussion of the main findings, interpretation of findings in the context of other published work, strengths and limitations of the study, and the implications for practice, policy and further work are addressed in Chapter 9.

4. Retrospective Longitudinal Cohort Study of Dental Consultations in UK General Medical Practice – Materials and Methods

4.1 Introduction

As outlined in Section 1.5.2, patients may seek treatment for oral and dental problems from their general medical practitioner (GMP). Patients who visit their GMP complaining of tooth-related problems are thought to have a higher likelihood of being prescribed a systemic antibiotic compared to individuals who consult with a dentist for a similar problem (Anderson et al. 2000).

Despite concern within the general medical profession that attendances for dental problems are increasing (Bint 2008), there has been little investigation of the issue within the last 10 years. During this time there has been considerable change within primary care dental services in the UK, following the introduction of the new Dental Contract in April 2006. The new contract led to the re-organisation of some dental services, which may have resulted in changes in access to NHS dental services.

This study aims to describe the frequency of consultations for dental problems in primary medical care in the UK and to explore the types of management patients attending with dental problems receive from GMPs. The following chapter outlines the materials and methods of this retrospective longitudinal cohort study of dental consultations in UK general medical practice. Results from this study are presented in Chapter 5.

4.2 Research questions

The following research questions formed the basis for the analysis.

4.2.1 Descriptive

- What are the characteristics of the population of patients who consult a GMP for a dental problem? Did these characteristics change between 2001 and 2011?
- What is the incidence of consultations for dental problems and have rates in England and Wales changed since the introduction of the new Dental Contract in 2006?

- How are dental problems managed in general medical practice? In particular, which antibiotics and analgesics are prescribed, and how often?

4.2.2 Analytical

- What are the predictors of antibiotic and analgesic prescribing for dental problems in general medical practice?
- What are the predictors of consultation for a subsequent episode of dental problems within a two-year period? Is there an association between the treatment patients receive for a dental problem in general medical practice and their rate of tooth-related problem in the future?

4.3 Study design

This study was a retrospective longitudinal cohort study of dental consultations in UK general medical practice using routinely collected data from primary care medical records gathered between 2001 and 2011. It has descriptive and analytical elements (hypothesis generating and hypothesis testing) which differ in certain respects and will therefore be described separately.

4.3.1 Data source

This study used data from the UK Clinical Practice Research Datalink (CPRD), the world's largest validation computerised database of anonymised longitudinal medical records for primary care (Williams et al. 2012). This resource was formerly known as the General Practice Research Database (GPRD). Data comprise approximately 4 billion records on 14 million patients and registered with 660 primary care practices spread throughout the UK. It contains data on approximately 7% of the UK population, and is broadly representative of patients' and practices' characteristics in the UK (Campbell et al. 2013). Records are derived from a widely used GP software system (VISION) and contain complete prescribing and coded diagnostic and clinical information as well as information on tests requested, laboratory results and referrals made at or following on from each consultation (Figure 4.1). CPRD is used worldwide for research by the pharmaceutical industry, clinical research organisations, regulators, government organisations and academic institutions (Tate et al. 2014).

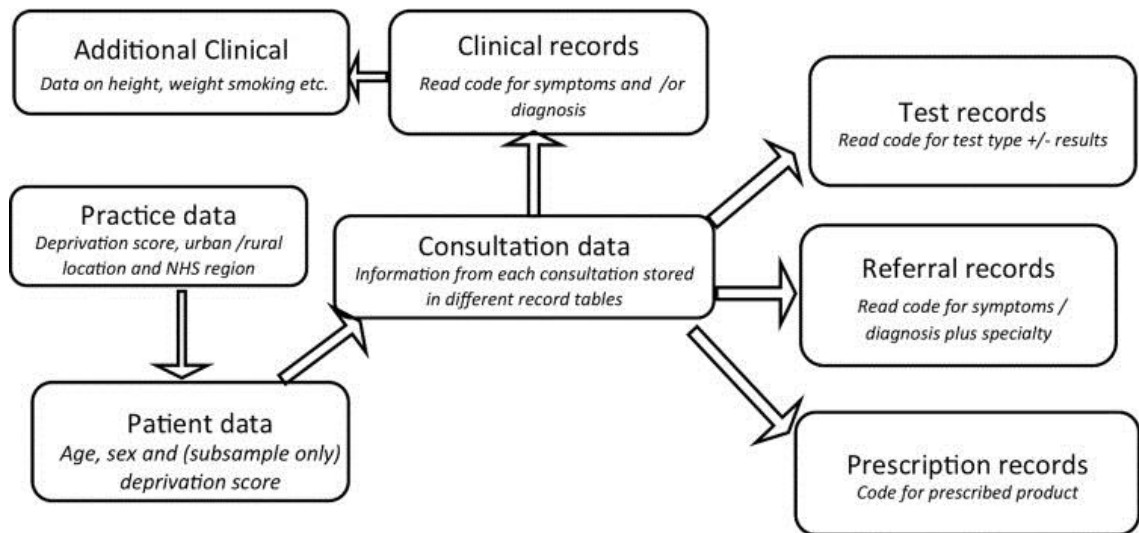


Figure 4.1 – Overview of data held within CPRD (Tate et al. 2014).

4.3.2 Extraction criteria

Clinical diagnoses are coded in the Clinical Practice Research Datalink with Read Codes. Dental consultations that occurred between 2001 and 2011 (inclusive) were identified by a diagnostic, examination or referral Read Code (Appendix XIV). The selected Read Codes related to structures and pathologies of the teeth and the periodontium. Read Codes which related to non-dental oral or dental problems such as salivary gland or oral soft tissue disease were excluded.

CPRD administrators conduct ongoing data checks on all practices and data quality assurance processes are undertaken as part of data processing. Patients are flagged as ‘research-acceptable’ for use in research by a process that identifies and excludes patients with non-contiguous follow-up or patients with poor data recording. Both of these features may be indicative of errors within the patient’s record which can introduce inaccuracies within subsequent analysis (Strom et al. 2013). Each practice is assigned an ‘up-to-standard’ date from which practice data is of research quality. Therefore, from this larger dataset of dental consultations, ‘research-acceptable’ consultations from practices that were ‘up-to-standard’ at the time of consultation were extracted.

Included consultations met the following conditions:

Consultation level

- Valid dental Read code (Appendix XIV)

Patient level

- Patient flagged as having acceptable quality data
- Valid gender
- Valid birth year with no events prior to birth
- Age \leq 115 at last collection date
- First registration date must be on or after birth date
- Current registration date must be valid and on or after birth date and on or after first registration date
- Permanent registration
- Transfer out date must: exist if there is a transferred out reason; have a transferred out reason recorded; be on or after the first registration date; be on or after the current registration date
- Censor date⁴ must be after index date

Practice level

- 'Up-to-standard' date must be on or before index date

4.3.3 Data extraction

Study data were extracted by a third-party 'nominated user', and sent to the researchers in flat-file format. Data related to the identified dental consultations were extracted from the following CPRD linked tables:

- Clinical (contains medical history events)
- Consultation (contains information relating to the type of consultation as entered by the GMP from a pre-determined list)
- Patient (contains basic patient demographics and patient registration details for the patients)
- Practice (contains details for practices, including region and collection information)
- Therapy (contains details of all prescriptions on the GMP system)

⁴ The censor date is the earliest of: the date the patient transferred out of the practice; their date of death; or the last collection date of the practice.

These data were then linked by *Patient Identifier (patid)*, *Practice Identifier (pracid)* and *Consultation Identifier (consid)* variables to form a flat data file. Subsequently records pertaining to a single consultation were identified and aggregated into one record with unique identifiers *patid* and *consid*. Data were then cleaned against the inclusion criteria described above. A random sample of 20 records was checked to confirm they related to a tooth-related attendance.

4.3.4 Definitions

The following definitions are used to describe dental attendances at general medical practices.

Consultation – a single patient-clinician interaction in a primary care setting.

Episode – a consultation or group of consultations judged to represent one period of dental problems. Consultations with less than 30 days separation will be considered part of the same episode.

Reconsultation – when a patient has a further episode of dental problems for which they consult the same general medical practice.

Patient-years - the amount of person-time at risk. For example, 100 patients followed for 10 years would be 1000 patient-years.

4.4 Descriptive elements of the study

4.4.1 Outcomes

- A description of the characteristics of patients consulting for a dental problem in general medical practice.
- A description of the rate of consultations for dental problems per 1000 patient-years 2004-2011: annual rate and by 10-year age groups and gender.
- A description of consultation rate 2004-2011, considered in the context of the introduction of the new Dental Contract in England and Wales in 2006.
- Trends in the use of systemic antibiotics and analgesics, 2001-2011.

4.4.2 Study population

4.4.2.1 Inclusion criteria

All 'research-acceptable' consultations from practices that were 'up-to-standard' at the time of consultation that had a diagnostic Read Code indicating a dental problem between the 1st January 2001 and 31st December 2011 (inclusive).

4.4.2.2 Sample size

In a previous study of the General Practice Morbidity Database for Wales conducted in 1996, authors reported that an average of 0.32% of all consultations were for oral/dental problems (SD = 0.14) of which 44.2% were for specifically-dental concerns (Anderson 1999). Therefore, since tooth-related attendances comprise only a tiny proportion of all consultations, an inclusive sample of all dental consultations 2001-2011 was extracted. This allowed age and gender specific rates to be calculated against the full population of CPRD. Preliminary application of the selection criteria to the November 2012 CPRD Primary Care Dataset revealed approximately 320,000 eligible consultations.

4.4.3 Descriptive analysis

Patient and consultation characteristics are described using mean (and standard deviation (SD)), median (and interquartile range (IQR)) and range. Frequency of consultation by day, month and year are also described. In order to account for different month lengths, proportions are adjusted using scaling factors. Results are presented in frequency tables and graphs where appropriate.

Consultation rates were calculated using practice denominator data. Summary statistics of the total number of patients per practice by age and gender were averaged to obtain a value for a mean number of registered patients per year. Incidence rates were produced by age, gender and year using age and gender specific denominators. Whilst the dental consultation data covers the study period 2001-2011, due to administrative difficulties denominator data is only available between 2004 and 2011 and therefore it is only possible to calculate rates within this period.

To describe the changes that occurred in consultation rate for dental problems that may be related to the introduction of the new NHS Dental Contract in England and Wales in 2006, consultation rates before and after 2006 in these countries are compared to similar periods in Scotland and Northern Ireland.

Types of antibiotic and analgesics prescribed are described using mean (and SD), median (and IQR) and range and presented in frequency tables and graphs with 95% confidence intervals. Trends in antibiotic and analgesic prescribing are also stratified by 10-year age group. Differences in the prescribing of antibiotics and analgesics are also described.

4.5 Hypothesis generating and hypothesis testing elements of the study

4.5.1 Outcomes

The following outcome measures were utilised.

4.5.1.1 Hypothesis generation

- A description of patient, practice and appointment factors associated with antibiotic prescribing during a dental consultation.
- A description of patient, practice and appointment factors associated with analgesic prescribing during a dental consultation.

4.5.1.2 Hypothesis testing

- An assessment of whether an association exists between antibiotic prescribing for dental problems and a further consultation for a tooth-related problem within a two-year period. **This is the outcome on which the sample size was calculated.**

Hypothesis: There is an association between prescription for systemic antibiotic during a consultation for a dental problem and a further consultation for a tooth-related problem within a two-year period.

Null Hypothesis: There is no association between prescription for systemic antibiotic during a consultation for a dental problem and a further consultation for a tooth-related problem within a two-year period.

- An assessment of whether an association exists between analgesic prescribing for dental problems and a further consultation for a dental problem within a two-year period.

Hypothesis: There is an association between prescription for systemic analgesic during a consultation for a dental problem and a further consultation for a tooth-related problem within a two-year period.

Null Hypothesis: There is no association between prescription for systemic analgesic during a consultation for a dental problem and a further consultation for a tooth-related problem within a two-year period.

The overall hypothesis being tested is that receiving antibiotics or analgesics for dental consultations may reinforce patients' belief that general medical practice is an appropriate place to access care for acute dental problems. This in turn may lead individuals to visit their GMP during subsequent episodes of dental problems. A follow-up period of two years was selected as this would allow sufficient time for the outcome under investigation (a further consultation) to occur, indicating a behaviour change had occurred. This analysis is not intended to measure re-consultation rates for the same dental problem.

4.5.2 Study population

4.5.2.1 Inclusion criteria

All 'research-acceptable' consultations from practices that were 'up-to-standard' at time of consultation that had a diagnostic Read Code indicating a dental problem between the 1st January 2001 and 31st December 2011 (inclusive).

For the hypothesis testing analysis the dataset was censored to remove episodes in which the final consultation is less than 2 years from the end of the data collection period as these had inequitable opportunity to achieve the response outcome (e.g. consultations on or after 01/01/2009 or consultations where censor date was less than 2 years after initial consultation).

4.5.2.2 Sample size calculation

The outcome used for the sample size calculation for this portion of the analysis was: an assessment of whether an association exists between antibiotic prescribing for dental problems and a further consultation for a tooth-related problem within a two-year period.

In the absence of other literature on the subject we conservatively estimated that 10% of patients would have a subsequent consultation for a tooth-related problem in a two-year period. Furthermore, there was no pre-existing indications of the effect antibiotic prescribing may have on the likelihood of future consultations for dental problems in the two-year follow-up period. Therefore estimates were based on a previous randomised controlled trial conducted in primary care in which immediate prescribing of antibiotics for a viral sore throat increased the rate of consultation for a similar problem by a hazard ratio of 1.39 over the subsequent year (Little et al. 1997). As such, a meaningful change in consultation rates during a two-year period within this study was judged to be 4% (from 10% to 14%).

Within the current study, 1,383 consultations were required in each group (received antibiotics vs. did not receive antibiotics) in order to provide a 90% power of chance of detecting a change in subsequent consultation proportion of 4% (from 10% to 14%) at a significance of 5% level. Since we anticipated two-thirds of patients would receive antibiotics the total sample size required is 4,149 (Pocock 1983).

4.5.3 Analysis

Data collected as part of CPRD has a hierarchical structure in which episodes (level 1) exist in groups according to the patient they relate to (level 2), which are subsequently grouped by practice (level 3) (Figure 4.2). It is important that this structure and lack of independence is represented in the analysis. The multilevel model also accounts for a repeated measures design where one patient may consult on several different occasions.

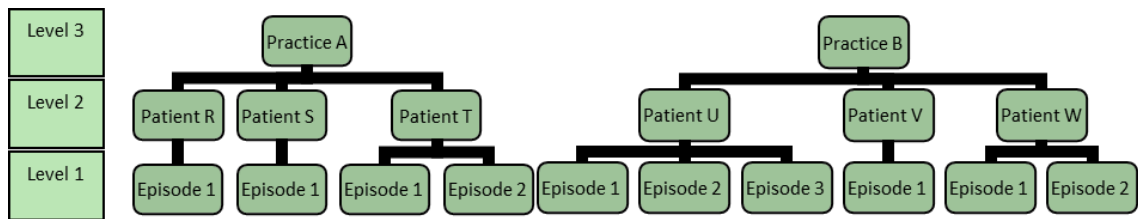


Figure 4.2 - Diagrammatic representation of the proposed multilevel model

Three models were constructed as part of the hypothesis generating and hypothesis testing component of the analysis. They were three-level, random intercept, logistic regression models with antibiotic prescription, analgesic prescription, or further consultation for a dental problem as binary outcomes. For discrete response multilevel models MLwiN uses quasi-likelihood methods to approximate this model into a continuous response multilevel model so that the Iterative Generalised Least Squares (IGLS) algorithm was used (Leckie and Charlton 2013). Within all analyses, consultations with less than 30 days separation were considered the same episode.

Predictors were selected on the basis of existing literature (Anderson et al. 1999) and where a plausible argument could be made for their inclusion. The predictor variables included in each of the models are described in Section 4.5.3.1 and 4.5.3.2.

Univariate analysis was used as a screening tool to determine which predictors were entered into each of the models. Variables with a p-value of <0.1 following univariate analysis were entered in a forward, stepwise manner into the model. Where there was a significant association between variables these were entered as an interaction term.

For each predictor, the modelling produced a co-efficient (β) and associated standard error (S.E). The co-efficient is log-odds that a consultation (i) by patient (j) in practice (k) results in an antibiotic is a function of variables at three levels and random patient-level (u_{0jk}) and practice-level effects (v_{0k}). The odds ratio describes the effect of the predictor on the likelihood of an antibiotic/analgesic being prescribed or the likelihood of a patient having a subsequent consultation for dental problems within two years. P-values calculated using Chi-square methods are also presented. The proportion of variance attributable to the patient- and practice-level is described using the variance partition coefficient (VPC).

4.5.3.1 Hypothesis generating

Response variable

The binary response variable was whether a patient was prescribed one of the following medications during a consultation for a dental problem:

Model 1: A systemic preparation of one of the following antibiotic classes: penicillins; cephalosporins; clindamycin; macrolides; metronidazole and tinidazole; quinolones; sulphonamides and trimethoprim; tetracyclines.

Model 2: A systemic preparation of an opioid, non-opioid or compound analgesic.

Predictor variables

- Consultation characteristics: patient age; number of previous episodes for dental problems within dataset; day of the week (Monday to Friday only); month of the year.
- Patient characteristics: patient gender.
- Practice features: country.

4.5.3.2 Hypothesis testing

Outcome variable

The binary outcome variable was whether patients have a subsequent consultation for a dental problem within the time period: >30 days and ≤ 730 days (2 years).

Predictor variable

The categorical predictor variable was whether a systemic antibiotic, analgesic, both or neither were prescribed during the initial (or index) consultation for a dental problem.

Co-variates

- Consultation characteristics: patient age; whether this was the first consultation within the dataset or not.
- Patient characteristics: patient gender.
- Practice features: country.

4.6 Analytical software

Analysis was performed using statistical software SPSS 20. Multilevel modelling was completed using MLwiN 2.28 (Rasbash et al. 2013).

4.7 Study approvals

The study protocol was reviewed and approved by the CPRD Independent Scientific Advisory Committee (ref: 14_144R). The CPRD dataset was obtained under the licence held by Cardiff University.

5. Retrospective Longitudinal Cohort Study of Dental Consultations in UK General Medical Practice – Results

5.1 Introduction

This chapter presents the results of the longitudinal cohort study of dental consultations in UK general medical practice held by the Clinical Practice Research Datalink (CPRD). The methods used in this study are described in Chapter 4. The descriptive analysis presented within Section 5.2 illustrates the characteristics of patients consulting a general medical practitioner (GMP) for a dental problem and changes in the rate of dental consultation 2004-2011. The use of systemic antibiotic and analgesics by GMPs in the management of dental problems is then described in Section 5.3. Section 5.4 aims to generate hypotheses regarding the factors predictive of antibiotic and analgesic prescribing during a dental consultation. Section 5.5 presents the outcomes of hypothesis testing, exploring the associations between antibiotic and analgesic prescribing and subsequent consultations for a further episode of dental problems within two years.

5.1.1 Description of dataset

Within the cleaned dataset there were 326,130 consultations relating to 307,996 unique episodes experienced by 255,259 patients who attended at one of 638 general practices between 1st January 2001 and 31st December 2011 (inclusive).

5.2 Descriptive analysis

5.2.1 Characteristics of dental consultations in general medical practice

During the period 2001-2011 inclusive, there were on average of 29,648 dental consultations across all CPRD practices per year. The majority of the practices contributing to CPRD are from England and this is reflected in the fact that the majority of consultations within the dental dataset occurred in England (81.27%), with smaller proportions arising in Wales (9.18%), Scotland (7.14%), and Northern Ireland (2.41%).

5.2.1.1 Age

The age range of patients consulting for a dental problem was <1 to 106 years. The mean age at consultation was 41.2 years (SD 21.7 years). Over two thirds (234,494/326,130, 71.90%) of patients were of economically-productive age (18-65 years) at the time of consultation. A breakdown of frequency of dental consultation per 10 year age bracket is shown in Figure 5.1.

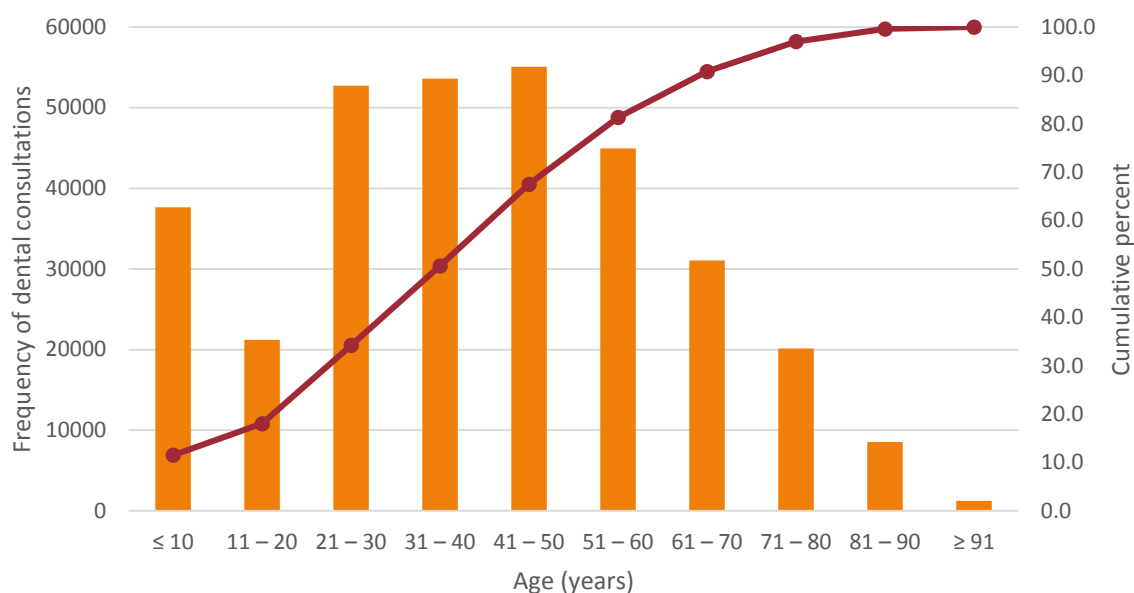


Figure 5.1 – Consultation frequency and cumulative frequency of dental consultations by age group.

5.4.1.2 Gender

Less than half (44.60% (95% CI 44.43% - 44.77%)) of dental consultations were made by male patients. The proportion of male patients was greatest amongst patients 10 years or younger (59.24% (95% CI 52.36% - 53.37%)) and lowest in the two oldest age groups (81-90 years (38.10% (95% CI 37.07% - 39.13%)) and ≥ 91 years (27.47% (95% CI 24.99% - 29.95%)) (Figure 5.2).

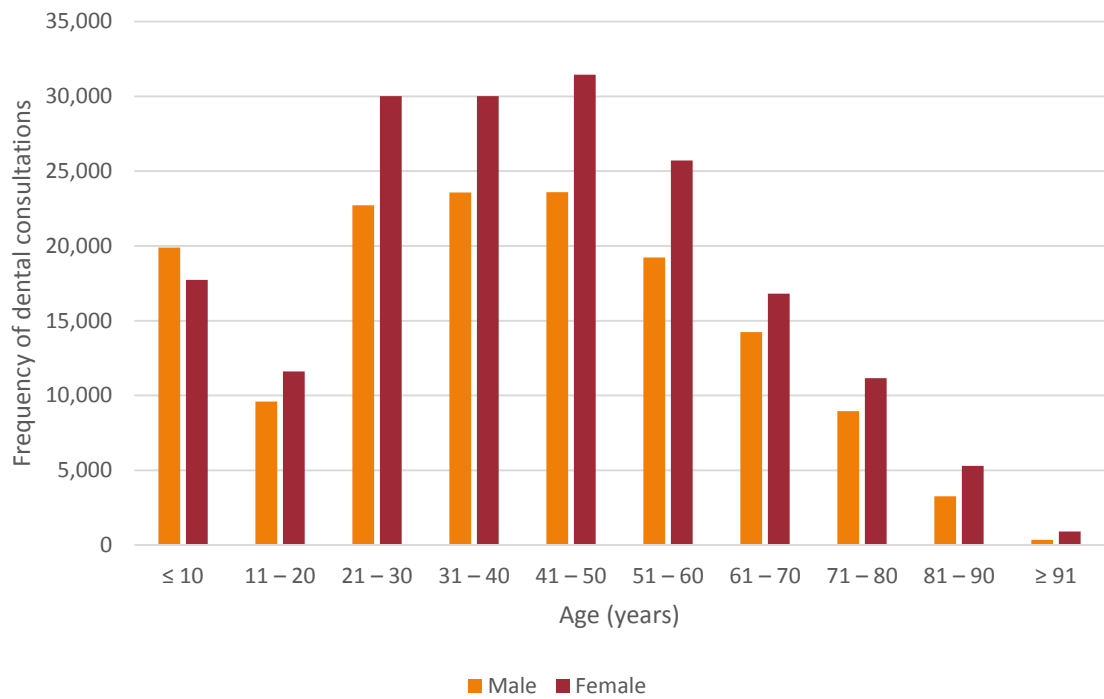


Figure 5.2 – Consultations made by male and female patients, by age group.

5.4.1.3 Identifying Read Code

Of the 177 dental Read Codes identified prior to data extraction the three most common within the dataset were ‘*Dental abscess*’ (36.39% (95% CI 36.22% – 36.56%)), ‘*Dental symptoms*’ (14.72% (95% CI 14.60% - 14.85%)) and ‘*Toothache*’ (10.64% (95% CI (10.53% - 10.75%))). The frequency of these and other common dental Read Codes are displayed in Table 5.1.

Read Code	Definition	Frequency (n=326,130)	Proportion (%)	95% Confidence Interval (%)	
				Lower	Upper
J025000	Dental abscess	118,681	36.39	36.22	36.56
191..11	Dental symptoms	48,008	14.72	14.60	14.85
1912	Toothache	34,699	10.64	10.53	10.75
J031.11	Gingivitis	21,670	6.64	6.56	6.73
J007.00	Teething syndrome	17,146	5.26	5.18	5.34
J024.11	Dental infection	16,652	5.11	5.03	5.18
1923.11	Sore gums - symptom	10,280	3.15	3.09	3.21
191..00	Tooth symptoms	6,038	1.85	1.80	1.90
J05y.11	Toothache	4,819	1.48	1.44	1.52
J010.00	Dental caries	4,308	1.32	1.28	1.36
1928	Bleeding gums	3,667	1.12	1.09	1.16
191Z.00	Tooth symptom NOS	3,641	1.12	1.08	1.15
J027.11	Gumboil	3,139	0.96	0.93	1.00
J05z.00	Dental diseases and conditions NOS	3,050	0.94	0.90	0.97
8H7F.00	Referred to dentist	2,509	0.77	0.74	0.80
191..12	Teeth symptoms	2,433	0.75	0.72	0.78
J031.00	Chronic gingivitis	2,318	0.71	0.68	0.74
J083z11	Infection mouth	2,246	0.69	0.66	0.72
2552	O/E - gingivitis	1,865	0.57	0.55	0.60
1923	Sore gums	1,779	0.55	0.52	0.57
	Other Read Codes	17,182	5.26	4.68	6.40

Table 5.1 – Frequency of Read Codes within the cleaned dataset. Read Codes with less than 0.5% are not presented.

5.4.1.4 Episodes of dental problems

During the study period the majority of patients consulted for only one episode of dental problems (82.88% (95% CI 82.74% - 82.74%)). However there were a population of patients (n=3,260) who attended for five or more episodes during the 11-year study period (Table 5.2).

Episode	Frequency (n=307,996)	Proportion (%)	95%		Cumulative Frequency (n=307,996)	Cumulative Percentage (%)	95%	
			Confidence Interval				Confidence Interval	
			Lower	Upper			Lower	Upper
1 st	255,259	82.88	82.74	83.01	255,259	82.88	82.74	82.74
2 nd	36,345	11.80	11.69	11.91	291,604	94.68	94.60	94.60
3 rd	9,654	3.13	3.07	3.20	301,258	97.81	97.76	97.76
4 th	3,478	1.13	1.09	1.17	304,736	98.94	98.91	98.91
≥5 th	3,260	1.06	1.02	1.09	307,996	100.00	100.00	100.00

Table 5.2 – Episode frequency and cumulative frequency.

5.2.1.5 Dental consultations by day, week and month

The majority of dental consultations occurred on a weekday (94.94% (95% CI 94.86% - 95.01%)), with Monday and Friday consultations being more frequent than Tuesday, Wednesday or Thursday consultations (Table 5.3). Following adjustments for different length of month, there are minor differences in consultation frequency by month, with May having the smallest proportion of consultations (8.09% of all consultations (95% CI 8.00% - 8.19%)) and September the highest (8.71% of all consultations (95% CI 8.61% - 8.80%)) (Table 5.4). The highest number of dental consultations were recorded in 2008 and the lowest in 2001 (Table 5.5).

Day	Frequency (n=326,130)	Proportion (%)	95% Confidence Interval (%)	
			Lower	Upper
Sunday	5,285	1.62	1.58	1.66
Monday	71,628	21.96	21.82	22.11
Tuesday	61,035	18.71	18.58	18.85
Wednesday	56,617	17.36	17.23	17.49
Thursday	56,479	17.32	17.19	17.45
Friday	63,855	19.58	19.44	19.72
Saturday	11,231	3.44	3.38	3.51

Table 5.3 – Frequency of dental consultations per day of the week.

Month	Frequency (n=326,130)	Proportion (%)	95% Confidence Interval		Adjusted proportion (%)	95% Confidence Interval	
			Interval			Interval	
			Lower	Upper		Lower	Upper
Jan	27,007	8.28	7.94	8.38	8.13	8.04	8.22
Feb	24,794	7.60	7.29	7.69	8.19	8.10	8.29
Mar	27,796	8.52	8.43	8.62	8.37	8.27	8.46
Apr	26,092	8.00	7.91	8.09	8.12	8.02	8.21
May	26,886	8.24	8.15	8.34	8.09	8.00	8.19
Jun	27,426	8.41	8.31	8.50	8.53	8.44	8.63
July	27,855	8.54	8.45	8.64	8.39	8.29	8.48
Aug	27,042	8.29	8.20	8.39	8.14	8.05	8.24
Sep	27,984	8.58	8.48	8.68	8.71	8.61	8.80
Oct	28,010	8.59	8.49	8.92	8.43	8.34	8.53
Nov	27,228	8.35	8.25	8.67	8.47	8.38	8.57
Dec	28,010	8.59	8.49	8.68	8.43	8.34	8.53

Table 5.4 – Frequency of dental consultations per month. Adjusted proportions account for different month lengths.

Year	Frequency (n=326,130)	Proportion (%)	95% Confidence Interval	
			Low	High
2001	21,752	6.67	6.58	6.67
2002	23,788	7.29	7.20	7.29
2003	25,962	7.96	7.87	7.96
2004	29,696	9.11	9.01	9.11
2005	31,947	9.80	9.69	9.80
2006	33,246	10.19	10.09	10.19
2007	33,579	10.30	10.19	10.30
2008	34,027	10.43	10.33	10.43
2009	32,588	9.99	9.89	9.99
2010	30,779	9.44	9.34	9.44
2011	28,766	8.82	8.72	8.82

Table 5.5 – Frequency of dental consultations per year.

5.2.2 Rates of dental consultation

5.2.2.1 Annual rate

During the period 2004 to 2011, the average rate of dental consultation ranged between 6.49 and 7.40 per 1000 patient-years. Across the entire study period the average rate of dental consultations was 7.02 per 1000 patient-years.

However, rates of dental consultations within individual practices varied more dramatically, ranging between <0.01 consultations per 1000 patient years to 47.29 consultations per 1000 patient years.

As seen in Figure 5.3, the rate of dental consultation increased between 2004 and 2006. Rates stabilised between 2006 and 2008 and then there was gradual reduction in dental consultations per 100,000 patient-years between 2008 and 2011 (Table 5.6 and Figure 5.3).

5.2.2.2 Rate of dental consultations by gender

Throughout the study period, female consultation rate for dental problems was consistently higher than male consultation rate (Table 5.6 and Figure 5.3). This difference equated to approximately 1.4 consultations per 1000 patient-years

5.2.2.3 Rate of dental consultations by age group

Consultation rates for dental problems were highest amongst patients aged 21-30 years. Patients 31-40, 41-50 and 51-60 years also had higher rates of consultation than the population average. The groups with the lowest consultations rates were patients aged 71-80, 81-90 and ≥91 years. Trends in dental consultation by age broadly match the overall trend (Table 5.7 and Figure 5.4).

Year	Total Population					Male					Female				
	Frequency of dental consultations	Population	Dental consultations (per 1000 patient-years)	95% CIs		Frequency of dental consultations	Population	Consultation rate (per 1000 patient-years)	95% CIs		Frequency of dental consultations	Population	Consultation rate (per 1000 patient-years)	95% CIs	
				Lower	Upper				Lower	Upper				Lower	Upper
2004	29,696	4,397,599	6.75	6.68	6.83	13,167	2,183,529	6.03	5.93	6.13	16,529	2,214,070	7.47	7.35	7.58
2005	31,947	4,512,931	7.08	7.00	7.16	14,331	2,240,687	6.40	6.29	6.50	17,616	2,272,244	7.75	7.64	7.87
2006	33,246	4,563,046	7.29	7.21	7.36	14,930	2,266,167	6.59	6.48	6.69	18,316	2,296,879	7.97	7.86	8.09
2007	33,579	4,613,042	7.28	7.20	7.36	14,891	2,291,114	6.50	6.40	6.60	18,688	2,321,928	8.05	7.93	8.16
2008	34,027	4,597,802	7.40	7.32	7.48	15,267	2,282,164	6.69	6.58	6.80	18,760	2,315,638	8.10	7.99	8.22
2009	32,588	4,593,828	7.09	7.02	7.17	14,396	2,279,226	6.32	6.21	6.42	18,192	2,314,602	7.86	7.75	7.97
2010	30,779	4,527,683	6.80	6.72	6.87	13,721	2,245,289	6.11	6.01	6.21	17,058	2,282,394	7.47	7.36	7.59
2011	28,766	4,435,151	6.49	6.41	6.56	12,751	2,195,024	5.81	5.71	5.91	16,015	2,240,127	7.15	7.04	7.26

Table 5.6 - Rate of dental consultations 2004-2011, total study population and by gender

Year	Age group (years)										
	≤10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	≥90	
2004	6.89	3.80	9.08	7.51	7.66	7.03	6.18	5.50	4.67	3.73	
2005	6.70	4.17	9.70	7.87	8.04	7.45	6.38	6.15	4.82	3.57	
2006	6.95	4.30	10.04	8.03	8.31	7.38	6.78	6.27	5.29	3.82	
2007	6.55	4.30	9.76	8.35	8.24	7.53	6.77	6.58	5.31	3.94	
2008	6.41	4.23	10.06	8.38	8.33	7.87	6.84	6.76	6.01	4.57	
2009	6.33	3.78	9.36	7.81	8.04	7.97	6.66	6.60	5.57	4.73	
2010	5.97	3.54	8.77	7.64	7.50	7.86	6.67	6.40	5.23	3.90	
2011	5.90	3.28	8.58	7.13	7.41	7.34	6.21	5.72	4.92	5.28	
Total	6.46	3.93	9.42	7.84	7.94	7.55	6.56	6.25	5.23	4.19	

Table 5.7 - Rate of dental consultations per 1000 patient-years by age group, 2004-2011

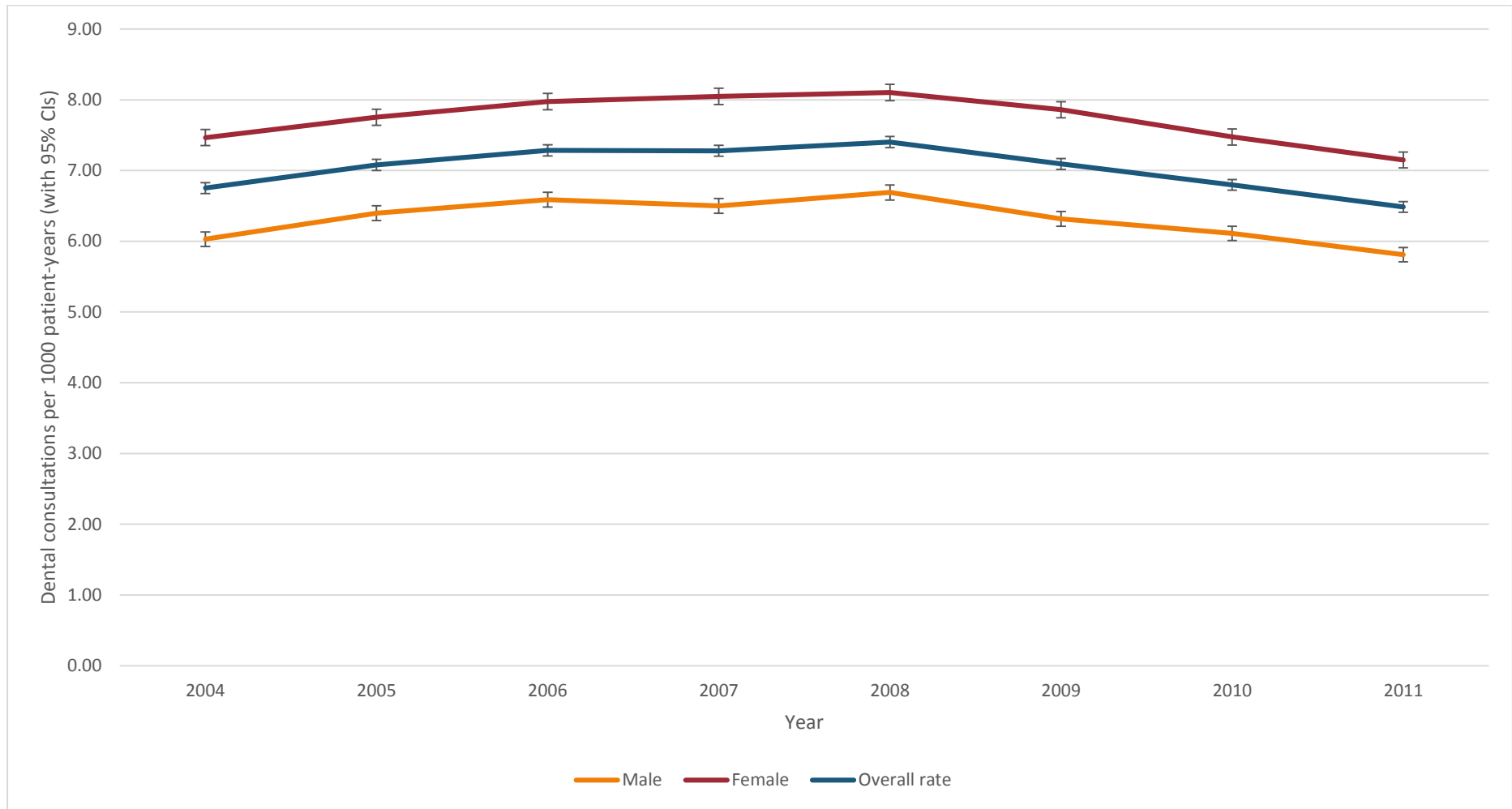


Figure 5.3 - Dental consultations per 1000 patient-years, total and by gender, 2004-2011

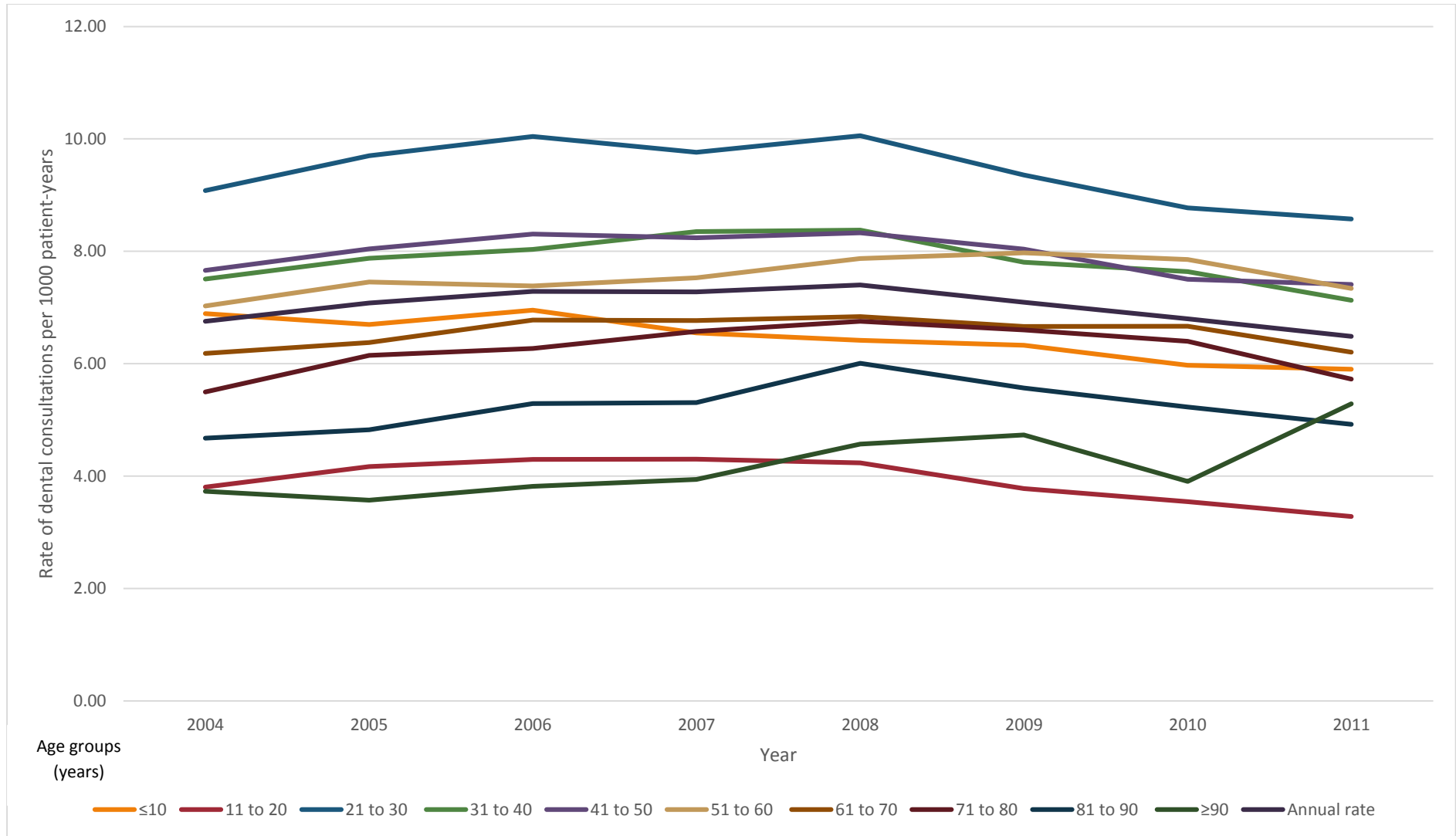


Figure 5.4 - Rate of dental consultations per 1000 patient-years by age group, 2004-2011.

5.2.2.4 The change of NHS dental contract in 2006 in England and Wales

Dental consultation rates per 1000 patient-years for the four constituent UK countries 2004 – 2011 are shown in Figure 5.5. Throughout the study period, practices in England and Wales had consistently had higher rates of dental consultation than those in Scotland and Northern Ireland. Within England, rates of dental consultation displayed a small year-on-year increase between 2004 and 2006. Between 2006 and 2008 rates of dental consultation stabilised, before a slight downward trend is seen between 2008 and 2011. Rates of dental consultation in Wales show more variability; increasing between 2004 and 2006 before steadily decreasing from 2006 to 2011. In comparison, rates in Scotland increased between 2004 and 2008 and then decreased until 2011. Rates of dental consultation in Northern Ireland remain relatively stable between 2004 and 2009 and then decrease between 2009 and 2011.

Confidence intervals surrounding rates of dental consultation in Wales, Scotland and Northern Ireland are considerably wider than those surrounding English estimates. This is because the number of contributing practices outside England are relatively small. Between 2004 and 2011 there were 437 English practices collecting CPRD data compared to 63 to 65 in Scotland, 45-49 in Wales, and 21-22 in Northern Ireland. The implications of this are discussed in Chapter 9.

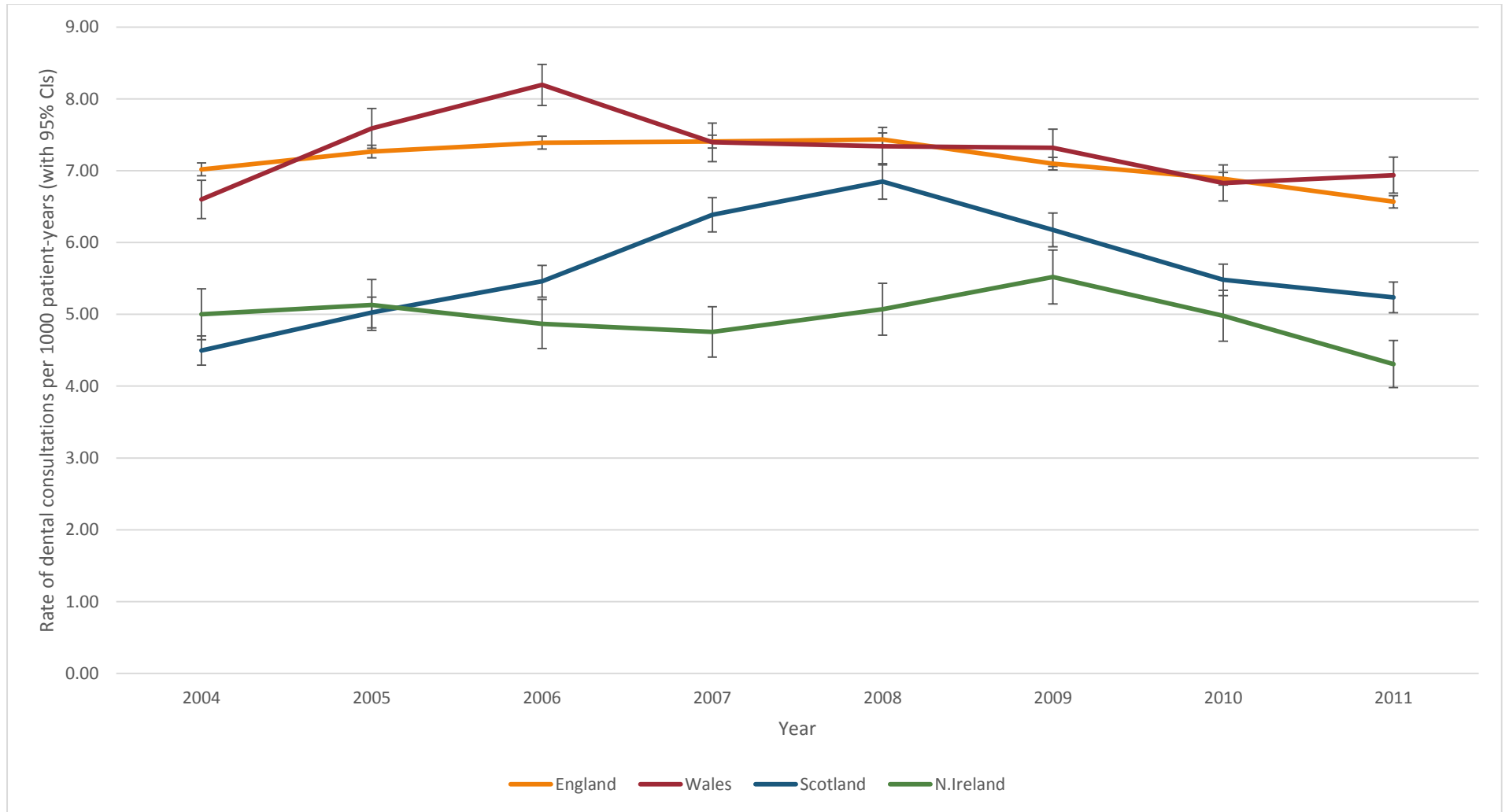


Figure 5.5 - Rate of dental consultations per 1000 patient-years per practice, grouped by country.

5.3 The use of systemic antibiotics and analgesics in the management of dental problems by general medical practitioners

Two thirds of dental consultations (215,161/326,130, 65.97%) during the study period 2001 to 2011 resulted in a prescription for a systemic antibiotic or analgesic (Table 5.8). Of the 215,161 consultations resulting in an antibiotic or analgesic, 69.58% were for an antibiotic only, 14.83% were for an analgesic only and 15.57% were for both an analgesic and antibiotic.

Therapy	Frequency (n=326,130)	Proportion (%)	95% Confidence Interval (%)	
			Lower	Upper
No antibiotic or analgesic	110,969	34.03	33.86	34.03
Antibiotic only	149,729	45.91	45.74	45.91
Analgesic only	31,927	9.79	9.69	9.79
Antibiotic and analgesic	33,505	10.27	10.17	10.27

Table 5.8 – Frequency of antibiotic and analgesic therapies by general medical practitioners

When analysed by patient age at consultation, the predominant therapy for patients aged ≤ 10 years and those aged ≥ 81 years was neither an antibiotic nor analgesic. In comparison, consultations for patients aged 11-80 were most likely to result in an antibiotic only. Use of analgesics, either alone or with an antibiotic made up less than a third of consultations in all age groups (Figure 5.6).

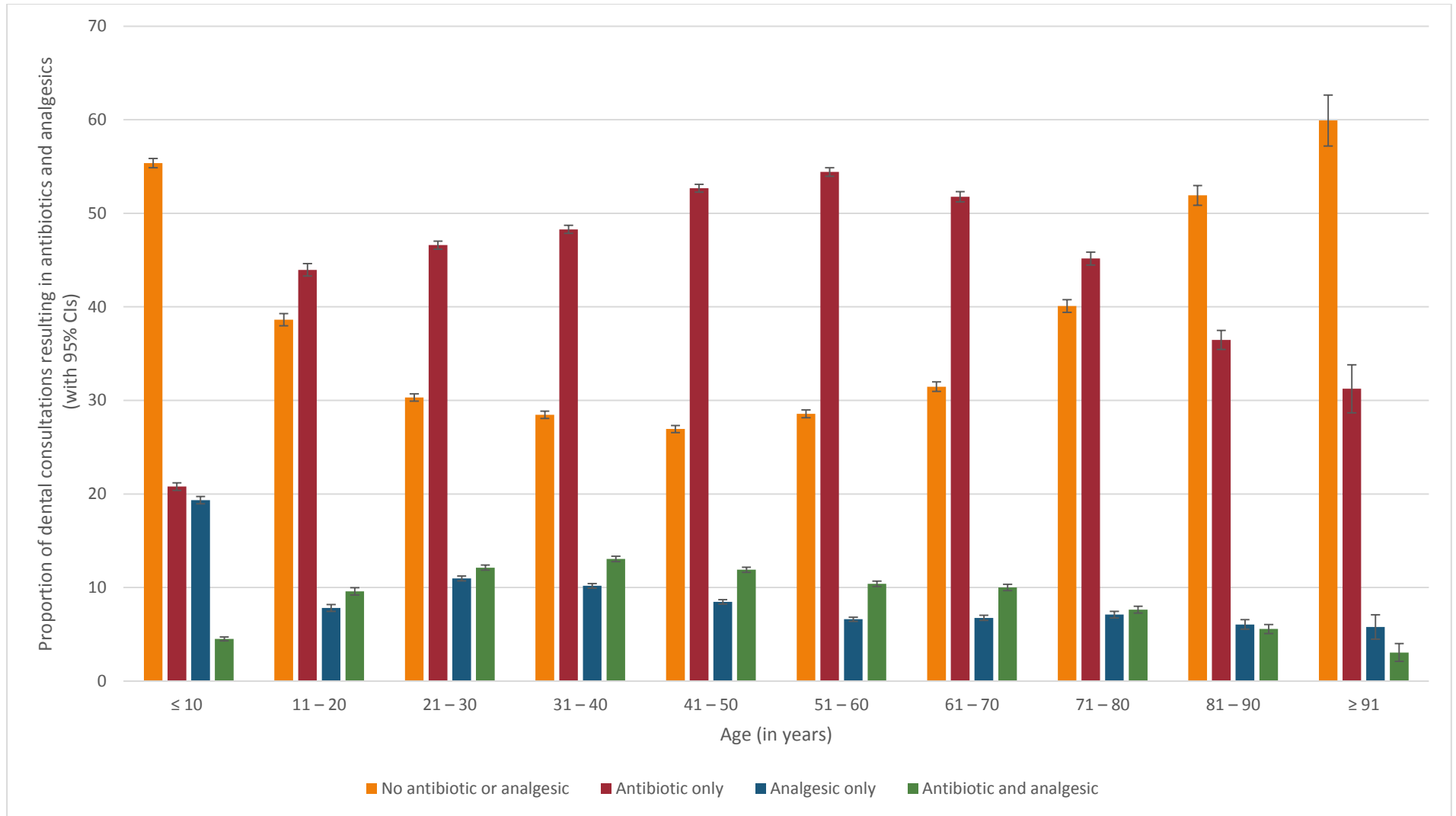


Figure – 5.6 Use of antibiotic and analgesic therapies by age group.

5.3.1 Antibiotic prescriptions

In total, 183,234 of the 326,130 consultations (56.18% (95% CI 56.01% – 56.35%)) resulted in a prescription for an antibiotic. In the majority of consultations resulting in an antibiotic, a single antibiotic item was prescribed (92.07% (95% CI 91.95% – 92.51%)), whilst in a minority of instances two or more antibiotic items were prescribed (7.93 (95% CI 7.49% – 8.05%)). The total number of systemic antibiotic items prescribed was 197,756.

During the study period the proportion of dental consultations that resulted in an antibiotic increased from 52.74% (95% CI 52.07 – 53.41) in 2001 to 58.01% (95% CI 57.48 – 58.50) in 2007 before decreasing to 54.23% (95% CI 53.65 – 54.81) in 2011 (Table 5.9 and Figure 5.7).

Figure 5.7 also presents the proportion of dental consultations resulting in an antibiotic per year, per constituent country. The proportion of dental consultations resulting in an antibiotic remained relatively stable in England and Scotland between 2001 and 2011. In comparison, the proportion of consultations in which an antibiotic was prescribed increased in Wales and Northern Ireland during this period. In Northern Ireland this increase stabilised in 2004, whilst in Wales antibiotic use has remained roughly the same since 2006. From 2004 onwards, consultations in England and Wales were more likely to result in an antibiotic than those in Scotland or Northern Ireland.

The most commonly prescribed antibiotics were penicillins (69.85% (95% CI 69.64 – 70.05)), followed by metronidazole and tinidazole (16.97% (95% CI 16.80 - 17.13)), macrolides (9.13% (95% CI 8.99 – 9.24)) and cephalosporins (2.39% (95% CI 2.32 – 2.45)). Tetracyclines, quinolones, sulphonamides and trimethoprim, and clindamycin each made up less than 1% of all antibiotics prescribed (Table 5.10).

Trends of use of the four principal antibiotic classes between 2001 and 2011 are presented in Figure 5.8. Penicillins have consistently comprised approximately 70% of all antibiotics prescribed for dental problems. In comparison, the proportion of metronidazole and tinidazole increased from 13.36% in 2001 to 19.19% in 2011. Prescriptions of macrolides made up 10.84% of all dental antibiotics in 2001, but by 2011 this had decreased to 8.25%. Similarly, the proportion of cephalosporins decreased from 3.09% in 2001 to 1.17% in 2011.

Year	Frequency of consultations resulting in an antibiotic (n=183,234)	Frequency of dental consultations (n=326,130)	Proportion of dental consultations resulting in an antibiotic (%)	95% Confidence Interval	
				Lower	Upper
2001	11,471	21,752	52.74	52.07	53.41
2002	12,869	23,788	54.10	53.46	54.73
2003	14,270	25,962	54.96	54.35	55.57
2004	16,802	29,696	56.58	56.01	57.14
2005	18,421	31,947	57.66	57.12	58.20
2006	19,146	33,246	57.59	57.06	58.12
2007	19,479	33,579	58.01	57.48	58.50
2008	19,446	34,027	57.15	56.62	57.68
2009	18,383	32,588	56.41	55.87	56.95
2010	17,346	30,779	56.36	55.80	56.91
2011	15,601	28,766	54.23	53.65	54.81

Table 5.9 Proportion of dental consultations resulting in an antibiotic per year 2001-2011

Type of antibiotic	Frequency (n=197,756)	Proportion (%)	95% Confidence Interval (%)	
			Lower	Upper
Penicillins	138,127	69.85	69.64	70.05
Metronidazole and tinidazole	33,551	16.97	16.80	17.13
Macrolides	18,026	9.12	8.99	9.24
Cephalosporins	4,717	2.39	2.32	2.45
Tetracyclines	1,656	0.84	0.80	0.88
Quinolones	1,025	0.52	0.49	0.55
Sulphonamides and trimethoprim	428	0.22	0.20	0.24
Clindamycin	224	0.11	0.10	0.13

Table 5.10 - Frequency of antibiotic type prescribed

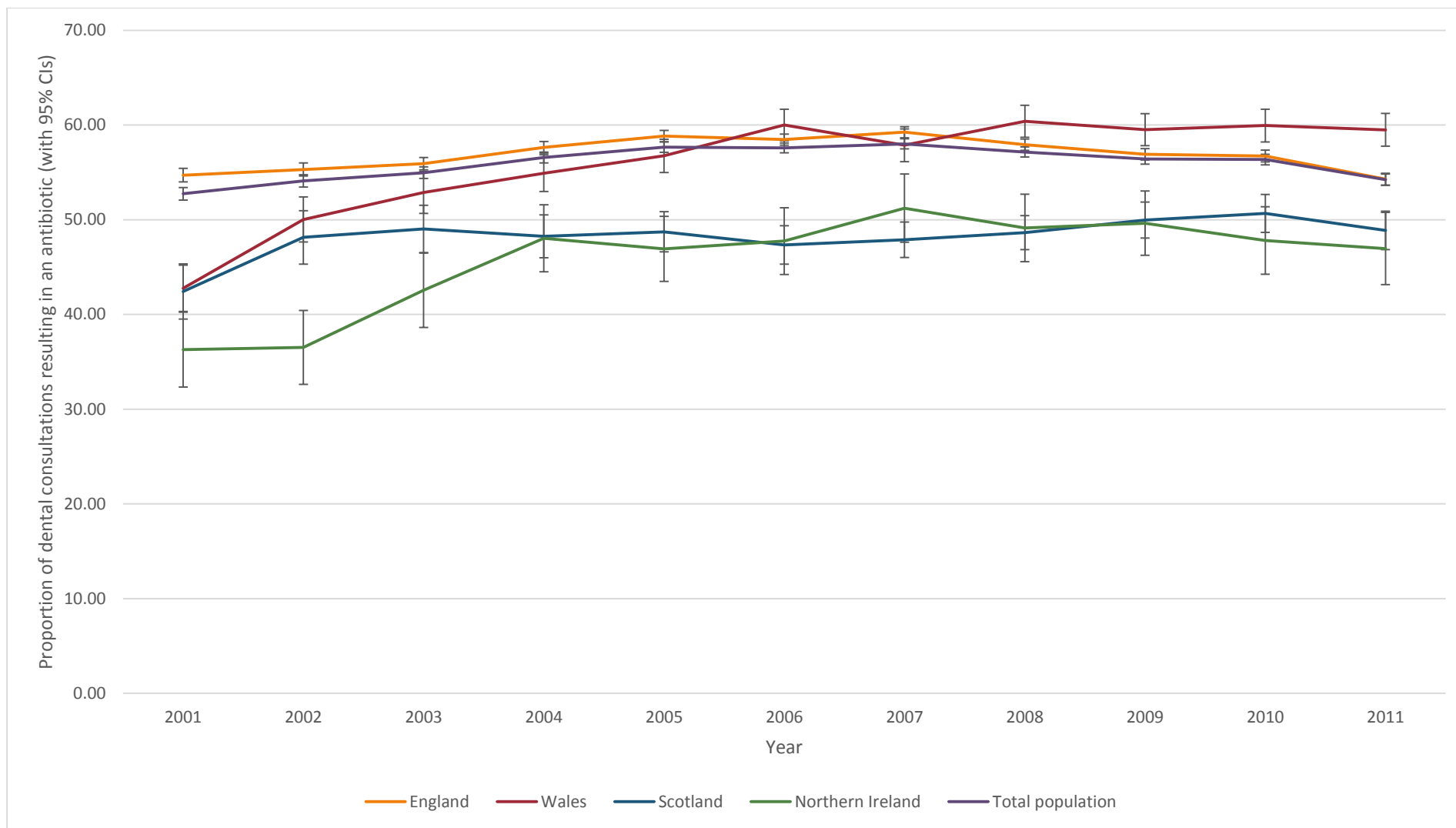


Figure 5.7 - Graph showing proportion of dental consultations resulting in an antibiotic for the total population and per country, 2001-2011.

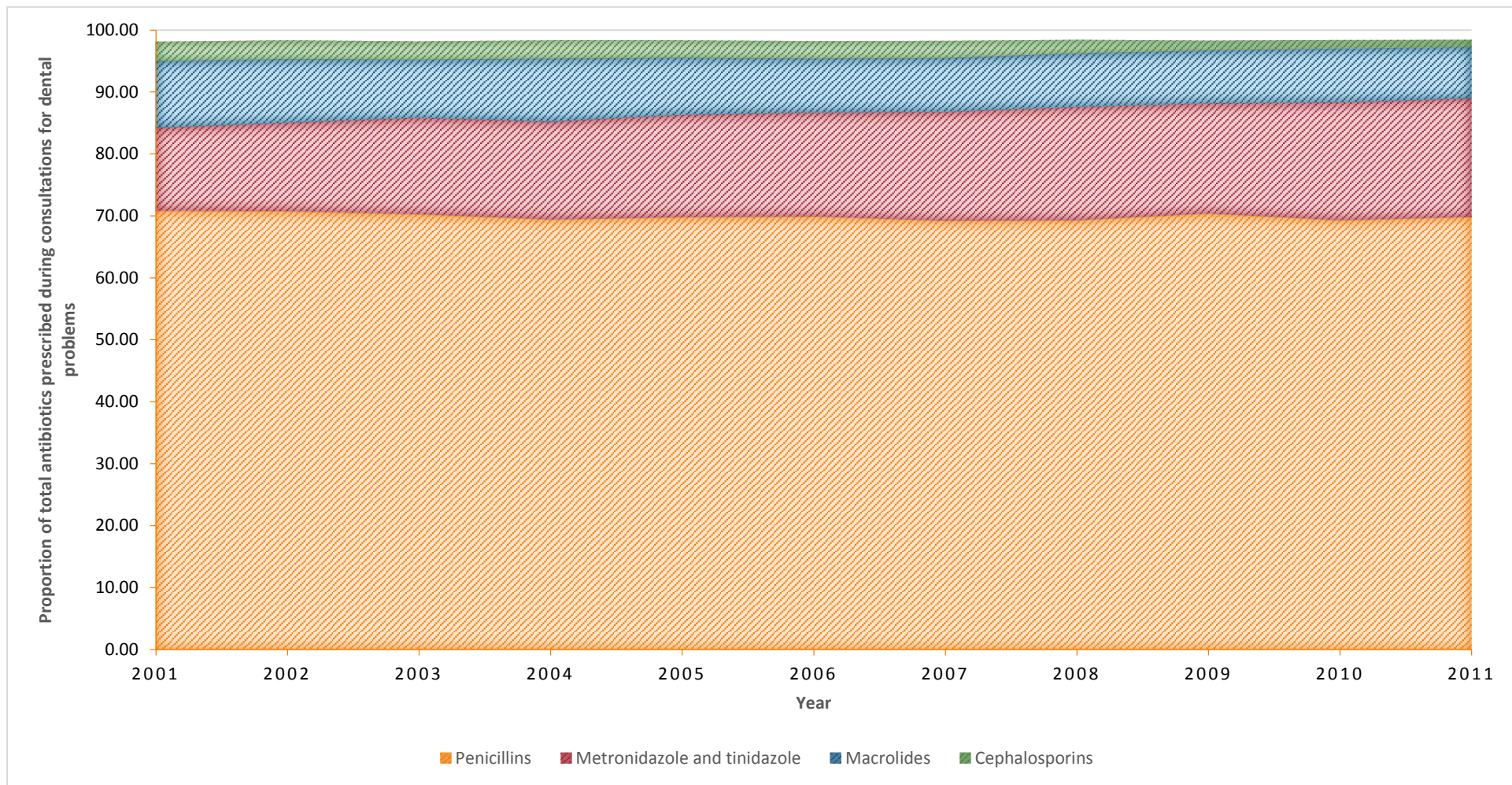


Figure 5.8 - Proportions of the four major types of antibiotic prescribed during consultations for dental problems, 2001-2011.

5.3.2 Analgesic prescriptions

Within the study period 2001 to 2011, 65,432 of the 326,130 consultations (20.06% (95% CI 19.93% – 20.20%)) resulted in a prescription for an analgesic. In the majority of instances where an analgesic was prescribed, a single item was provided (87.53% (95% CI 87.28% – 88.88%)), whilst in a minority of consultations two or more analgesic items were prescribed (12.47% (95% CI 12.22% – 12.72%)). The total number of systemic analgesic items prescribed was 74,179.

Within the study period, the proportion of dental consultations resulting in an analgesic increased from 18.65% (95% CI 18.13% – 19.16%) in 2001 to 21.51% (95% CI 21.04% – 21.99%) in 2011 (Table 5.11 and Figure 5.9).

Figure 5.9 also presents the proportion of dental consultations resulting in an analgesic per year by constituent country. The proportion of dental consultations resulting in an analgesic gradually increased in England and more markedly increased in Wales during the study period. In Scotland, the proportion of consultations where an analgesic is prescribed decreased slightly between 2001 and 2005 (although these proportions are associated with wide confidence intervals) and then subsequently increased between 2005 and 2011. Between 2001 and 2004, the proportion of dental consultations resulting in an analgesic was considerably higher in Northern Ireland than in England, Scotland and Wales. Between 2001 and 2008, the proportion of dental consultations in Northern Ireland where an analgesic is prescribed decreased, before increasing again between 2008 and 2011.

The most commonly prescribed analgesics were opioid-paracetamol compounds (38.78% (95% CI 38.43% - 39.13%)) followed by non-steroidal anti-inflammatories (NSAIDs) (27.92% (95% CI 27.61% -28.25%)), paracetamol (16.21% (95% CI 15.94% -16.48%)), opioids (14.49% (95% CI 14.24% -14.74%)) and aspirin (2.54% (95% CI 2.44% - 2.66%)). Opioid-NSAID, opioid-aspirin and aspirin-paracetamol compounds made up less than 1% of all analgesics prescribed (see Table 5.12).

Changes in the analgesics most commonly prescribed during dental consultations between 2001 and 2011 are presented in Figure 5.10. Between 2001 and 2011 the proportion of all analgesics that are opioid/paracetamol preparations decreased from 40.30% in 2001 to 37.38% in 2011. A similar trend is seen for paracetamol prescriptions, which made up 22.77% of analgesics in 2001 but only 15.70% in 2011. Conversely, the proportion of NSAID and opioid-only prescriptions increased from 23.44% to 27.62% (NSAIDs) and from 11.35% to 17.27% (opioids) during the

study period. Prescriptions for aspirin comprised approximately 2% of all analgesics prescribed during dental consultations.

Year	Frequency of consultations resulting in an analgesic (n= 65,432)	Frequency of dental consultations (n=326,130)	Proportion of dental consultations resulting in an analgesic (%)	95% Confidence Interval	
				Lower	Upper
2001	4,056	21,752	18.65	18.13	19.16
2002	4,555	23,788	19.15	18.65	19.65
2003	4,978	25,962	19.17	18.70	19.65
2004	5,595	29,696	18.84	18.40	19.29
2005	6,286	31,947	19.68	19.24	20.11
2006	6,650	33,246	20.00	19.57	20.43
2007	6,732	33,579	20.05	19.62	20.48
2008	7,074	34,027	20.79	20.36	21.22
2009	6,706	32,588	20.58	20.14	21.02
2010	6,611	30,779	21.48	21.02	21.94
2011	6,189	28,766	21.51	21.04	21.99

Table 5.11 - Proportion of dental consultations resulting in an analgesic per year, 2001-2011.

Type	Frequency (n=741,79)	Proportion (%)	95% Confidence Intervals	
			Lower	Upper
Opioids/Paracetamol	28,766	38.78	38.43	39.13
NSAIDs	20,718	27.92	27.61	28.25
Paracetamol	12,023	16.21	15.94	16.48
Opioids	10,748	14.49	14.24	14.74
Aspirin	1,890	2.54	2.44	2.66
Opioids/NSAIDs	16	0.02	0.01	0.04
Opioids/Aspirin	16	0.02	0.01	0.04
Aspirin/Paracetamol	<5*	N/A	N/A	N/A

Table 5.12 - Frequency of analgesic type prescribed.*In order to prevent the identification of individual patients, values for cells containing less than or equal to 5 individuals will not be published.

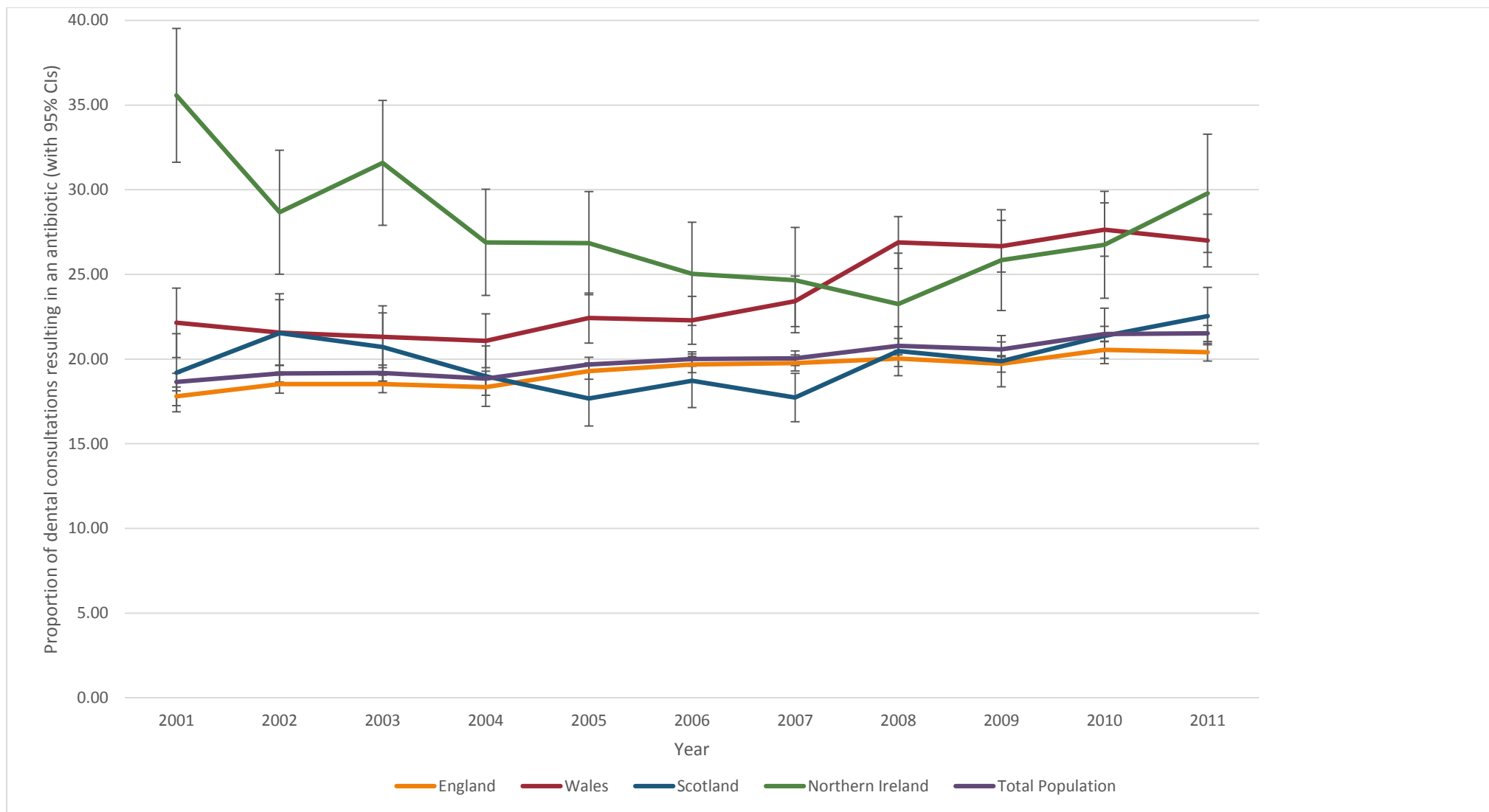


Figure 5.9 - Graph showing proportion of dental consultations resulting in an analgesic for the total population and per country, 2001-2011

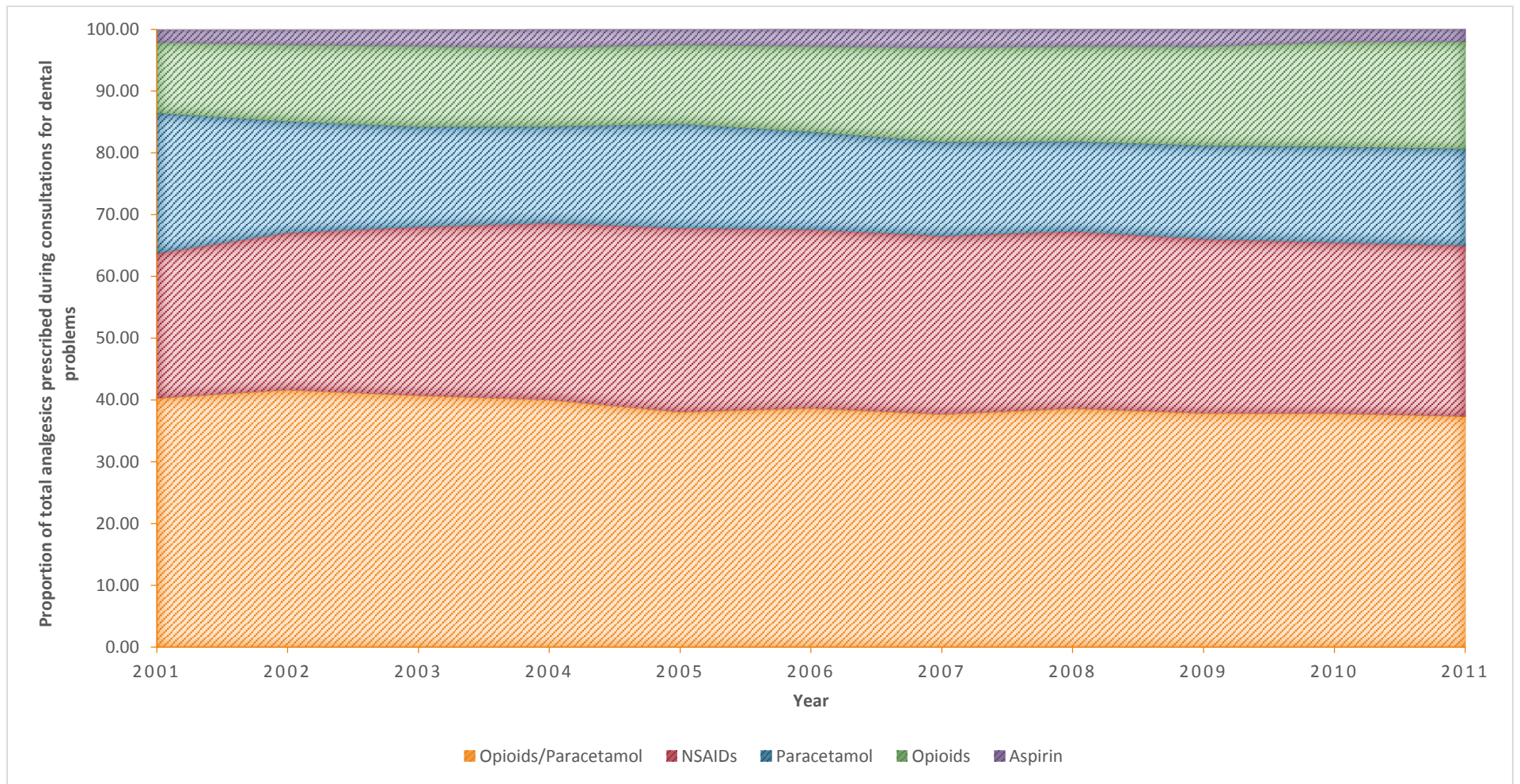


Figure 5.10 - Proportions of the five major types of analgesic prescribed during consultations for dental problems, 2001-2011.

5.4 Hypothesis generation

5.4.1 Factors associated with antibiotic prescribing for dental conditions

Just over half of all dental consultations within the dataset resulted in an antibiotic (Table 5.13).

Patient, practice and appointment features associated with antibiotic prescribing with a p-value of ≤ 0.1 on univariate analyses (Table 5.14) were entered into a forward, stepwise, three-level, random intercepts, logit model. In the case of categorical variables (such as country, weekday or month) if a difference significant at $p \leq 0.1$ was present between two categories, all categories were included in the model.

Outcome	Frequency (n=326,130)	Proportion (%)	95% Confidence Interval	
			Lower	Upper
Antibiotic prescribed	183,234	56.18	56.01	56.35
No antibiotic prescribed	142,896	43.82	43.65	43.99

Table 5.13 - Frequency of antibiotic prescribing outcome

Predictor	Z Value	P-value on univariate analysis
Patient age (years)		
<i>age ^ 1</i>	76	<0.001
<i>age ^ 2</i>	79	<0.001
Gender(base = male)		
	1.43	0.08
Country (base = England)		
<i>Scotland</i>	2.18	0.01
<i>Wales</i>	0.125	0.45
<i>Northern Ireland</i>	2.40	0.008
Episode number (base = 1st episode)		
	34.20	<0.001
Weekday (base = Wednesday)		
<i>Monday</i>	6	<0.001
<i>Tuesday</i>	0.5	0.31
<i>Thursday</i>	0.04	0.48
<i>Friday</i>	12.24	<0.001
<i>Saturday</i>	23.83	<0.001
<i>Sunday</i>	51.835	<0.001
Month (base = January)		
<i>Feb</i>	0.97	0.17
<i>Mar</i>	0.91	0.18
<i>April</i>	2.25	0.01
<i>May</i>	0.71	0.24
<i>June</i>	0.19	0.42
<i>July</i>	2.45	0.007
<i>Aug</i>	1.45	0.07
<i>Sep</i>	0.89	0.19
<i>Oct</i>	0.42	0.34
<i>Nov</i>	0.95	0.17
<i>Dec</i>	11.63	<0.001

Table 5.14 - Univariate analysing determining the predictors entered into the multilevel model for antibiotic prescribing

The final multilevel logistic regression model fitted, with all variables included is presented in Table 5.15 with associated odds ratios, 95% CIs and p-values.

Patient age and gender, practice country, episode number, weekday of consultation, month of consultation and rate of dental consultations during year of consultation were all significant predictors of whether a consultation for a dental problem would result in a prescription for an antibiotic. Patient age was included as a polynomial variable as it has an inverse parabolic association with antibiotic prescribing, with younger and older patients being significantly less likely to be prescribed an antibiotic than patients of middle age. Female patients were marginally

less likely to receive an antibiotic than their male counterparts (OR 0.93 (95% CI 0.92-0.95)). The odds of a patient receiving an antibiotic within a consultation during a subsequent episode of dental problems within the study period was 1.12 (95% CI 1.11 – 1.13) per episode (i.e. the odds of receiving an antibiotic during the 3rd episode of dental problems was 1.25 that of a consultation during a first episode). Consultations that occurred in practices in Scotland were significantly less likely to result in an antibiotic than consultations in England. There was no significant differences between England and Wales or England and Northern Ireland.

There were no significant differences between the odds of an antibiotic being prescribed during a consultation occurring on a Wednesday than consultations on Tuesdays or Thursdays. Consultations on Mondays and Fridays however were more likely to result in antibiotic prescription than those on Wednesdays. In comparison, consultations on weekends (Saturdays or Sundays) were significantly less likely to have an antibiotic prescribed. When month of consultation was considered, January consultations were no more or less likely to result in an antibiotic than consultations in February, March, June, October or November whilst consultations in April, May, July, August and September were all slightly more likely to result in antibiotics than January consultations (ORs 1.04 – 1.06). However, in comparison, the odds of an antibiotic being prescribed during a consultation in December was 1.22 (95% CI 1.18 – 1.27) that of a January consultation.

Adding the co-variables to the model led to some improvement in model fit, reducing residual variance at practice-level by 10.71% and patient-level by 15.00%. The relative sizes of the practice- and patient-level variances in both empty and populated models indicate that antibiotic prescribing is substantially more clustered within practices than within patients.

		Regression coefficient (β)	Standard error (S.E) of β	Odds ratio (EXP(β))	95% CI low	95% CI high	P-value
Consultations characteristics (level i)	Patient age (years)						
	Per 1 year increase in age^1	0.08	0.00	1.08	1.08	1.08	<0.001
	Per 1 year increase in age^2	0.00	0.00	1.00	1.00	1.00	<0.001
	Episode number (base = 1 st episode)						
	Per 1 unit increase in episode number	0.11	0.00	1.12	1.11	1.13	<0.001
	Day of the week (base = Wednesday)						
	Sunday	-2.67	0.05	0.07	0.06	0.08	<0.001
	Monday	0.08	0.01	1.08	1.05	1.10	<0.001
	Tuesday	0.00	0.01	1.00	0.97	1.02	0.852
	Thursday	0.00	0.01	1.00	0.97	1.02	0.711
	Friday	0.14	0.01	1.15	1.12	1.17	<0.001
	Saturday	-0.55	0.02	0.58	0.55	0.60	<0.001
	Month of consultation (base = January)						
	Feb	0.02	0.02	1.02	0.99	1.06	0.245
	Mar	0.03	0.02	1.03	1.00	1.07	0.083
	Apr	0.06	0.02	1.06	1.02	1.10	0.001
	May	0.04	0.02	1.04	1.01	1.08	0.018
	Jun	0.01	0.02	1.01	0.98	1.05	0.456
	Jul	0.05	0.02	1.05	1.02	1.09	0.004
	Aug	0.04	0.02	1.04	1.01	1.08	0.025
Sep	0.04	0.02	1.04	1.00	1.08	0.035	
Oct	0.02	0.02	1.02	0.99	1.06	0.177	
Nov	0.03	0.02	1.03	1.00	1.07	0.069	
Dec	0.20	0.02	1.22	1.18	1.27	<0.001	
Patient characteristics (level j)	Patient gender (base = male)						
	Female	-0.07	0.01	0.93	0.92	0.95	<0.001
Practice characteristics (level k)	Country (base = England)						
	Wales	0.00	0.08	1.00	0.86	1.16	0.999
	Northern Ireland	-0.13	0.11	0.88	0.71	1.10	0.604
	Scotland	-0.18	0.07	0.84	0.73	0.96	0.009
Model intercept and measures of variance	Intercept	-1.27	0.06	0.28	0.25	0.32	<0.001
	Patient-level residual variance						
	Null model	0.20	0.01				<0.001
	Full model	0.17	0.01				<0.001
	Practice-level residual variance						
	Null model	0.28	0.02				<0.001
Full model	0.25	0.02				<0.001	

Table 5.15 - Predictors of antibiotic prescribing using a three-level regression model. The model includes 326,130 consultations by 255,259 patients at 638 practices.

5.4.2 Factors associated with analgesic prescribing for dental conditions

Just over a fifth of all dental consultations within the dataset resulted in an analgesic (Table 5.16).

The same procedure to that described in Section 5.4.1 was followed during construction of the analgesic prescribing model. One notable difference was that patient-age was not entered as polynomial as it has a linear association with analgesic prescribing. The results of the univariate analysis are shown in Table 5.17.

Outcome	Frequency (n=326,130)	Proportion (%)	95% Confidence Interval	
			Lower	Upper
Analgesic prescribed	65,432	20.06	19.93	20.20
No analgesic prescribed	260,698	79.94	79.80	80.07

Table 5.16 - Frequency of analgesic prescribing outcome

Predictor	Z Value	P-value on univariate analysis
Patient age in years	31.24	<0.001
Gender(base = male)	5.46	<0.001
Country (base = England)		
<i>Scotland</i>	0.86	0.19
<i>Wales</i>	4.60	<0.001
<i>Northern Ireland</i>	4.18	<0.001
Episode number (base = 1 st episode)	22.50	<0.001
Weekday (base = Wednesday)		
<i>Monday</i>	3.40	<0.001
<i>Tuesday</i>	0.95	0.17
<i>Thursday</i>	0.34	0.37
<i>Friday</i>	0.04	0.48
<i>Saturday</i>	18.8	<0.001
<i>Sunday</i>	26.20	<0.001
Month (base = January)		
<i>Feb</i>	0.65	0.26
<i>Mar</i>	1.70	0.04
<i>April</i>	2.11	0.02
<i>May</i>	2.53	0.006
<i>June</i>	1.86	0.03
<i>July</i>	2.18	0.01
<i>Aug</i>	1.47	0.07
<i>Sep</i>	1.67	0.05
<i>Oct</i>	0.23	0.41
<i>Nov</i>	0.68	0.25
<i>Dec</i>	0.27	0.40

Table 5.17 - Univariate analysis determining the predictors entered into the multilevel model for analgesic prescribing

The final multilevel logistic regression model fitted, with all variables included is presented in Table 5.18 with associated odds ratios, 95% CIs and p-values.

Patient age and gender, practice country, episode number, weekday of consultation and month of consultation were all significant predictors of whether a consultation for a dental problem

would result in a prescription for an analgesic. Older patients were less likely to be prescribed an analgesic, the odds being 0.99 (95% CI 0.99 - 0.99) per increase in year. Female patients were more likely to receive an antibiotic than their male counterparts (OR 1.06 (95% CI 1.04 – 1.08)). The odds of a patient receiving an analgesic within a consultation during a subsequent episode of dental problems within the study period were 1.10 (95% CI 1.08 – 1.11) per episode (i.e. the odds of receiving an analgesic during the 3rd episode of dental problems was 1.21 that of a consultation during a first episode). Whilst consultations that occurred in practices in Wales and Northern Ireland were significantly more likely to result in an analgesic than consultations in England, there was no significant difference between England and Scotland.

There were no significant differences between the odds of an analgesic being prescribed during a consultation occurring on a Wednesday than a consultation on a Tuesday, Thursday or Friday. In comparison, consultations on Mondays, Sundays and Saturdays were all less likely to result in an analgesic prescription than those occurring on Wednesdays.

When month of consultation was considered, January consultations were no more or less likely to result in an analgesic than consultations in February, March, August, September, October, November or December. However, consultations in April, May, June and July were all less likely to result in analgesic than January consultations (ORs 0.94 to 0.96).

Adding the co-variates to the model led to some improvement in model fit, reducing residual variance at practice-level by 23.53% and patient-level 8.33%. The relative sizes of the practice- and patient-level variances in both empty and populated models indicate that analgesic prescribing is substantially more clustered at the practice- than patient-level.

		Regression coefficient (β)	Standard error (S.E) of β	Odds ratio (EXP(β))	95% CI low	95% CI high	P-value
Consultations characteristics (level i)	Patient age (years)						
	Per 1 year increase in age	-0.01	0.00	0.99	0.99	0.99	<0.001
	Episode number (base = 1 st episode)						
	Per 1 unit increase in episode number	0.09	0.01	1.10	1.08	1.11	<0.001
	Day of the week (base = Wednesday)						
	Sunday	-2.34	0.09	0.10	0.08	0.12	<0.001
	Monday	-0.05	0.02	0.95	0.92	0.98	<0.001
	Tuesday	-0.02	0.02	0.98	0.96	1.01	0.318
	Thursday	-0.01	0.02	0.99	0.96	1.02	0.696
	Friday	0.00	0.02	1.00	0.97	1.03	0.924
	Saturday	-0.55	0.03	0.58	0.54	0.61	<0.001
	Month of consultation (base = January)						
	Feb	0.01	0.02	1.01	0.97	1.06	0.510
	Mar	-0.04	0.02	0.96	0.92	1.00	0.061
	Apr	-0.05	0.02	0.95	0.91	1.00	0.028
	May	-0.06	0.02	0.94	0.90	0.99	0.008
	Jun	-0.04	0.02	0.96	0.92	1.00	0.039
	Jul	-0.05	0.02	0.95	0.91	0.99	0.020
	Aug	-0.04	0.02	0.97	0.92	1.01	0.114
	Sep	0.02	0.02	1.02	0.98	1.07	0.239
Oct	-0.01	0.02	0.99	0.95	1.03	0.566	
Nov	-0.03	0.02	0.97	0.93	1.02	0.248	
Dec	-0.01	0.02	0.99	0.95	1.03	0.475	
Patient characteristics (level j)	Patient gender (base = male)						
	Female	0.06	0.01	1.06	1.04	1.08	<0.001
Practice characteristics (level k)	Country (base = England)						
	Scotland	0.05	0.05	1.05	0.94	1.16	0.437
	Wales	0.28	0.06	1.32	1.18	1.47	<0.001
	Northern Ireland	0.34	0.09	1.41	1.19	1.66	<0.001
Model intercept and measures of variance	Intercept	-1.27	0.06	0.28	0.25	0.32	<0.001
	Practice level residual variance						
	Null model	0.48	0.01				<0.001
	Full model	0.44	0.01				<0.001
	Patient level residual variance						
	Null model	0.17	0.01				<0.001
Full model	0.13	0.01				<0.001	

Table 5.18 - Predictors of analgesic prescribing using a three-level regression model. The model includes 326,130 consultations by 255,259 patients at 638 practices.

5.5 Hypothesis testing

5.5.1 An assessment of whether an association exists between the prescription of antibiotics or analgesics for dental problems and further consultation for a tooth-related problem within a two-year period.

Reconsultation for a subsequent episode of dental problems within two-years occurred in 11.94% of cases (Table 5.19). Within the censored dataset, in 32.97% of consultations neither an antibiotic nor analgesic was prescribed, in 46.89% an antibiotic alone was prescribed, in 9.38% an analgesic only was prescribed and in 10.76% of consultations both an antibiotic and an analgesic were prescribed (Table 5.20). These proportions are broadly similar to those of the total dataset (Table 5.8) although there are slightly higher proportions of antibiotic use and marginally lower rates of analgesic use within the censored dataset.

Outcome	Frequency (n=242,684)	Proportion (%)	95% Confidence Interval	
			Lower	Upper
Consultation for further episode within two years	28,982	11.94	11.80	12.08
No consultation for further episode within two years	213,702	88.06	87.92	88.20

Table 5.19 - Frequency of outcome for subsequent consultation for a further episode of dental problems within two years.

Therapeutic modality of index episode	Total frequency (n=242,684)	Frequency of a subsequent episode within two years. (n=28,982)	Proportion of index episodes followed by a subsequent episode within two years (%)	95% Confidence Interval	
				Lower	Upper
Neither antibiotic nor analgesic	80,007	6,457	8.07	7.88	8.26
Antibiotic only	113,803	15,142	13.31	13.11	13.50
Analgesic only	22,756	2,950	12.96	12.53	13.40
Antibiotic and analgesic	26,118	4,433	16.97	16.52	17.43

Table 5.20 - Proportion of index episodes with reconsultation within two years by therapeutic modality of index episode.

The same procedure described in Section 5.4.1 was followed during construction of the model determining the predictors of further consultation. The results of the univariate analysis are presented in Table 5.21.

Predictor	Z Value	P-value on univariate analysis
Patient age in years		
<i>age ^ 1</i>	28.11	<0.001
<i>age ^ 2</i>	34.00	<0.001
Gender (base = male)		
	7.60	<0.001
Country (base = England)		
<i>Scotland</i>	0.28	0.40
<i>Wales</i>	0.09	0.46
<i>Northern Ireland</i>	1.59	0.06
Therapeutic modality (base = no analgesic, no antibiotic)		
<i>Antibiotic only</i>	21.76	<0.001
<i>Analgesic only</i>	13.50	<0.001
<i>Antibiotic and analgesic</i>	18.04	<0.001

Table 5.21 - Univariate analysing determining the predictors entered into the multilevel model for reconsultation.

The final multilevel logistic regression model fitted, with all variables included is shown below and presented in Table 5.22 with associated odds ratios, 95% CIs and p-values.

The model indicates that there are statistically significant associations between a patient receiving an antibiotic or analgesic, or both, from a GMP during an episode of dental pain and the rate of subsequent consultations for a similar problem within two-years. The odds of a patient who received an antibiotic only reconsulting is 1.65 (95% CI 1.56 – 1.75, $p < 0.001$) that of a patient who received neither an antibiotic nor an analgesic. The odds of a patient reconsulting who received an analgesic only is 1.78 (95% CI 1.63 – 1.94) that of a patient who received neither an antibiotic nor an analgesic. The odds of a patient who received both an antibiotic and an analgesic reconsulting is almost double (OR 1.97 (95% CI 1.63 – 1.94, $p < 0.001$)) that of a patient who received neither medication. Therefore, it is possible to reject both null hypotheses and conclude that, within the population studied, there are associations between prescription for systemic antibiotics or analgesics during a consultation for a dental problem and a further consultation for a tooth-related problem within a two-year period.

Patient age and gender are also significant predictors of whether a patient will attend a further consultation for a tooth-related problem within a two-year period. Patient age demonstrates a parabolic association with likelihood of further consultation; with the youngest and oldest

patients being less likely to reconsult within two-years than patients in middle-age ($p < 0.001$). Female patients are more likely than male patients to have a further consultation within two years (OR 1.16 (95% CI 1.09 – 1.23)).

Within the model no significant differences between reconsultation rates within English, Welsh, Scottish and Northern Irish practices were detected.

There was a significant interaction terms between gender and therapeutic modality. The odds ratios for 'female.antibiotic only' and 'female.analgesic only' are negative, indicating that the effects of receiving an antibiotic or analgesic only on the probability of reconsultation is weaker in female patients than in male.

Adding the co-variates to the model reduced the residual variance at patient-level but increased the variance at practice level. However a considerable amount of patient-level variance persists even after the model is fitted suggesting that there are large differences between patients regarding their decision to reconsult and there may be factors that predict reconsultation that were not routinely collected within the CPRD.

		Regression coefficient (β)	Standard error (S.E) of β	Odds ratio (EXP(β))	95% CI low	95% CI high	P- value
Consultations characteristics (level i)	Patient age (years)						
	Per 1 year increase in age ¹	0.02	0.00	1.02	1.02	1.02	<0.001
	Per 1 year increase in age ²	0.00	0.00	1.00	1.00	1.00	<0.001
	Therapy provided (base = no antibiotic, no analgesic)						
	Antibiotic only	0.50	0.03	1.65	1.56	1.75	<0.001
	Analgesic only	0.58	0.04	1.78	1.63	1.94	<0.001
Antibiotic and analgesic	0.68	0.04	1.97	1.82	2.13	<0.001	
Patient characteristics (level j)	Patient gender (base = male)						
	Female	0.15	0.03	1.16	1.09	1.23	<0.001
Practice level characteristics (level k)	Country (base = England)						
	Scotland	0.09	0.07	1.09	0.94	1.26	0.237
	Wales	0.02	0.08	1.02	0.88	1.19	0.786
	Northern Ireland	-0.02	0.12	0.98	0.78	1.24	0.893
Interaction terms	Gender*therapy interaction term (bases: gender = male; therapy = no antibiotic, no analgesic)						
	Female.Antibiotic only	-0.08	0.04	0.92	0.86	0.99	0.034
	Female.Analgesic only	-0.23	0.06	0.79	0.71	0.89	<0.001
	Female.Antibiotic and analgesic	-0.03	0.05	0.97	0.88	1.07	0.570
Model intercept and measures of variance	Intercept	-3.02	0.04	0.05	0.05	0.05	<0.001
	Practice level residual variance						
	Null model	0.17	0.01				<0.001
	Full model	0.22	0.02				<0.001
	Patient level residual variance						
	Null model	1.78	0.04				<0.001
Full model	1.95	0.04				<0.001	

Table 5.22 - Predictors of further consultation for a tooth-related problem within a two-year period using a three-level regression model. This model is based on 256,168 episodes of dental problems, in 204,152 patients who attended 610 practices.

5.5 Chapter summary

This chapter has sought to describe consultations for dental problems in general medical practice in the UK using a retrospective longitudinal cohort of consultation records held within CPRD. Between 2004 and 2008 rates of dental consultation per 1000 patient-years increased, and subsequently decreased from 2008 to 2011. Rates of consultation are highest amongst working age individuals and higher in female patients than male. Antibiotics were prescribed in approximately half of all dental consultations, and analgesics in approximately one fifth.

The most commonly prescribed antibiotics were penicillins, followed by metronidazole and tinidazole, macrolides and cephalosporins. Prescriptions for penicillins make up approximately 70% of all antibiotics prescribed during a consultation for a dental problem. The most commonly prescribed analgesics were opioid-paracetamol compounds, followed by NSAIDs, paracetamol, opioids and aspirin.

The likelihood of a patient receiving an antibiotic during a consultation for dental problems in general medical practice is influenced by their age, gender, number previous consultation for dental problems, day of the week and month of the year of consultation and the country in which they consult. The likelihood of a patient receiving an analgesic during a consultation for dental problems is influenced by their age, gender, number of previous consultations for dental problems, day of the week and month of the year of consultation and country in which they consult.

There are strong suggestions that, within the population studies, there was an association between prescriptions for systemic antibiotics or analgesics during a consultation for a dental problem and a further consultation for a tooth-related problem within two years. The likelihood of reconsultation is also partly influenced by patient age and gender.

Discussion of the main findings, interpretation of findings in the context of other published work, strengths and limitations of the study and the implications for practice, policy and further work are addressed in Chapter 9.

6. Qualitative Methods

6.1 Introduction and research questions

The remaining work within the thesis seeks to gain a deeper understanding of the process of managing acute dental problems in primary care, with a specific focus on the decision to prescribe an antibiotic. Specifically, it will seek to address the following research questions:

- How do primary care clinicians (GDPs and GMPs) make treatment decisions when a patient attends with an acute dental condition?
- What influences how a primary care clinician manages a patient with an acute dental condition?
- What are the specific influences on the antibiotic prescribing behaviours of primary care clinicians with respect to acute dental conditions?
- What are the attitudes towards the use of antibiotics in the management of dental problems amongst primary care clinicians?

These questions were addressed using qualitative methodology and semi-structured interviews with GDPs and GMPs about their experiences, attitudes and patterns of behaviour during consultations for dental problems. The two phases were conducted concurrently, although sampling strategies and recruitment methods differed.

Sections 6.2 and 6.3 describe the philosophical perspectives underlying the research and description of the methods used. Sections 6.4 and 6.5 describe the specific objectives, sampling methods and development topic guides employed in the GDP and GMP interviews respectively. Section 6.6 considers GDP and GMP interviews together, outlining data collection, management and analysis processes that were undertaken. Section 6.7 is a justification of the selected methodology and Section 6.8 is a reflexive account of the interviewing process.

6.2 Philosophical perspectives

What exists and how do we come to know about it?

There is no single, accepted way of conducting qualitative research. Instead, how qualitative researchers conduct their studies depends upon a range of factors: their beliefs about the nature of the social reality and what can be known about it (ontology), the nature of knowledge and how it can be acquired (epistemology), the research questions, participants, the audience for

the research, and the position and environment of the researchers themselves. A researcher's ontological and epistemological viewpoint relates to their research paradigm, the overall framework for how they view reality, and this may invariably inform methodological choices (Hesse-Biber and Leavy 2011).

“By setting out clearly the interrelationship between what a researcher thinks can be researched (ontological position) linking it to what we can know about it (her epistemological position) and how to go about acquiring it (her methodological approach), you can begin to comprehend the impact your ontological position can have on what and how you decide to study.” (Grix 2010 p. 67)

Following the Age of Enlightenment the first social researchers asserted that the social world should be studied objectively, in terms of invariant laws, just like the natural world. This belief is the basis of a paradigm known as *positivism* and was a major influence in social research throughout the twentieth century. Positivism represented a thesis of the unity of science according to which all sciences can be integrated into a single natural system. Positivists were described as ontological ‘realists’, believing that an external reality exists independent of our beliefs or understanding and epistemologically objectivist, believing that:

- Only those phenomena which are observable can be counted as knowledge.
- Knowledge is developed inductively through the accumulation of verified facts.
- Hypotheses are derived deductively from scientific theories to be tested empirically (the scientific method) (Ritchie and Lewis 2003).

However the positivist paradigm received widespread criticism in the late twentieth century and was largely rejected by researchers who argued that its approach ignored the complex, subjective experience of the individual. In addition, since humans have free will, their behaviour cannot always be explained by reference to conformity to a particular social law (Macionis 2005). It was from this criticism that *interpretivism* arose. In stark contrast to positivism, the main tenet of interpretivism, or *relativism*, is that research can never be objectively observed from the outside, rather it must be observed from inside through the direct experience of the people. The interpretivist paradigm can be also called the *anti-positivist* paradigm because it rejects the premise that social phenomena exist independently, but rather are constructed and reconstructed by individuals. The epistemological assumptions of interpretivism are:

- Knowledge is gained inductively to create a theory
- Knowledge arises from particular situations and is not reducible to simplistic interpretation

- Knowledge is gained through personal experience (Ritchie and Lewis 2003).

However, critics attack interpretivism because it tends to exemplify a common belief that it can provide a 'deeper' and more 'meaningful' understanding of social phenomena than that which is obtained from scientific data (Nudzor 2009).

The two paradigms presented above represent the two ends of the spectrum with regard to social research philosophy. In reality, few researchers staunchly subscribe to one or other school of thought. Hammersley (1992) has suggested a solution to this conflict is to find some middle ground between the two extremes and adopt a position of 'subtle realism'. Whilst subtle realism has received criticism from some authors for lacking a true ontological basis (Seale 1999), other parties, including this researcher, acknowledges a realist ontology (as described in positivism), in that a social world that exists independent from the human experience and whilst human ability to know this reality is imperfect, it is accessible to us via participants' interpretations (which may then be further interpreted by the researcher) (Duncan and Nicol 2004). Within this ontological perspective it is accepted that participants may have diverse perspectives on the social world but that external reality is itself diverse and multifaceted and participants' views are just a mirror of this richness (Cohen and Crabtree 2006). Subtle realism upholds a subjectivist epistemology (also found in interpretivism) founded on the assertion that we cannot separate ourselves from what we know. The investigator and the object of investigation are linked such that who we are and how we understand the world is a central part of how we understand ourselves, others and the world. So whilst truth is negotiated through dialogue, objective reality cannot be apprehended in a perfect way (Cohen and Crabtree 2006). Furthermore, unlike stances such as extreme relativism, subtle realism states that all research involves subjective perceptions and observations and concede that different methods will produce different pictures of the participant(s) being studied and as such, is compatible with the perspective of mixed methods research (Duncan and Nicol 2004).

6.3 Study design

This was a qualitative, semi-structured telephone interview study conducted in Wales, UK between July and October 2013. Participants were GPs and GMPs providing primary care services to adult patients in Wales.

6.4 GDP interviews

6.4.1 Objectives

The following specific objectives were formulated:

- To understand the processes involved in the management of acute dental conditions in primary dental care.
- To understand the factors (clinical and non-clinical) that influence how GDPs manage acute dental conditions.
- To understand the usage of antibiotics in the management of acute dental problems by GDPs.
- To understand the clinical and non-clinical influences on the antibiotic prescribing behaviours of dental practitioners providing general dental care.
- To understand the effect of perceived patient expectation on the decision to prescribe an antibiotic.
- To understand the opinions of GDPs regarding the effectiveness of antibiotics in the management of acute dental conditions.
- To describe levels of awareness regarding guidelines on the use of systemic antibiotics in dentistry.
- To understand the sources that inform GDPs' antibiotic prescribing behaviours.
- To understand the opinions of GDPs regarding antibiotic resistance and the wider usage of antibiotics in healthcare.
- To describe the attitudes of GDPs towards changing prescribing behaviours on an individual and profession-wide basis.

6.4.2 Sample

The sampling frame comprised of all GDPs who had participated in the observational study of APICAL (described in Chapters 2 and 3), who had expressed an interest in taking part in a telephone interview.

From those GDPs who expressed a willingness to take part in an interview, participants were selected initially using convenience sampling techniques (n=15), and this sample was later augmented using maximum variation (n=4) sampling on the basis of their location and length of time since qualification. Non-probabilistic sampling techniques were employed as the objectives

of the interviews were not to obtain a representative sample but to explore a wide range of perspectives and experience amongst GDPs.

Data collection, transcription and analysis was undertaken concurrently to examine the emergence of themes and at which point 'saturation' had been reached. Saturation is defined as 'data adequacy' and in practice is the process of collecting data until a theme is thoroughly described (Morse 1995). Whilst it is widely accepted that reaching saturation is key to excellent qualitative work (Morse 1995) and 'saturation point' is frequently referenced in reports of qualitative research, few authors explain the process by which it was reached. Furthermore, there are no published guidelines regarding how to assess data saturation in qualitative research. Within this study it was decided that it was not the quantity of data within each theme that determined when a theme was saturated but when the richness of data within a theme no longer appeared to be increasing with subsequent interviews. Therefore, the interview process ceased when the researcher felt that there was sufficient data to build a comprehensive and convincing insight into GDP behaviour. Saturation was judged by the researcher (AC) to be nearing after interview numbers seventeen and eighteen, and was reached after interview nineteen. At this point, the data and emerging themes were presented by the researcher to a member of the supervisory team with experience in qualitative research (FW), who examined the narrative and assessed the links between different themes and confirmed that data saturation had been reached. Should the narrative have proved insufficiently rich, then data collection would have continued until saturation was reached.

6.4.3 Inclusion criteria

Inclusion criteria for the observational study of APICAL are described in Section 2.5.1.

6.4.4 Recruitment

GDPs who had expressed interest in participating in Phase Two (n=28) were sent an information pack at the same time as their quantitative-phase study cheque. The pack included:

- A covering letter
- A study information leaflet (Appendix XV)
- A contact details and consent form (Appendix XVI)
- Prepaid return envelope

Participants were informed they would receive £60 reimbursement. Practitioners who returned their consent form were then contacted to arrange a mutually convenient interview time (n=19). Those who did not return their consent form were assumed to no longer be interested in participating and were not contacted again (n=9).

6.4.5 Topic guide

The aim of the topic guide was to provide the basic 'skeleton', onto which the clinician's narrative could be attached. For ease of use the topic guide had the same chronology as a clinical appointment, with questions about practice structure, appointment systems and history taking at the beginning, and a greater focus on treatments and reflection towards the middle and end. The topic guide was however, flexible and from the outset of each interview participants were encouraged to speak at tangents, should the impulse arise.

An initial topic guide was prepared prior to beginning data collection (Appendix XVII). This was informed by the scientific literature, topic guides from other studies, initial results from the observational study of GDPs, and clinical experiences of the research team. In the early stages of interviewing, the topic guide went through several iterations during which questions were added and subsequently revised as a result of previous interviews (Appendix XVIII). Prompts were added to the topic guide to encourage elaboration by participants. Examples of how questions changed are shown below:

Some revisions were minor and used to enhance the clarity of the question.

OLD : *'Can you tell me about when you might use antibiotics to treat a patient with dental pain?'*

NEW: *'Can you think of an example of a situation when you might prescribe antibiotics to a patient with an acute dental condition?'*

Some questions became more specific to add to the richness of data within an existing theme.

OLD : *'Can you think of any factors that might influence your management of patients with dental pain?'*

NEW: *'What would you do if you only had a short appointment to treat a patient with dental pain?'*

But similarly, some questions also became less structured and more tailored to encouraging participants to discuss their experiences:

OLD : 'Have you been on any courses about antibiotic prescribing?'

NEW: '*How do you keep up-to-date with new information about antibiotics?*'

[Prompts included: '*Have you been on any courses where antibiotic prescribing has been discussed?*' '*Do you remember reading anything recently about antibiotics in dentistry?*']

6.5 GMP interviews

6.5.1 Objectives

From the research questions the following specific objectives were formulated:

- To produce an account of the beliefs and attitudes of GMPs towards the treatment of dental problems in general medical practice.
- To describe GMPs' knowledge about the management of dental problems.
- To understand the beliefs held by GMPs as to why patients with dental problems consult at a medical practice.
- To understand factors which influence the management of dental problems by GMPs.
- To understand GMPs' attitudes to the use of antibiotics in the management of dental problems in general medical practice.
- To produce a description of the influences on antibiotic prescribing behaviour for dental problems amongst GMPs
- To describe levels of awareness regarding guidelines on the use of systemic antibiotics for dental problems.

6.5.2 Sample

The sampling frame comprised of all fully qualified GMPs working in Wales. A database of all GMPs working in Wales as of October 2012 was compiled from the NHS Health in Wales Directory (NHS Wales 2012).

Since little is currently known about the attitudes of GMPs towards the management of dental problems by GMPs, maximum variation sampling techniques were utilised. This technique was chosen with the aim of identifying important common patterns amongst clinicians that cut across variations such as length of practicing career, practice location and patient socioeconomic

demographic, whilst developing multiple perspectives on the problems surrounding the management of dental problems in general medical practice.

At the onset of data collection, a sample of GMPs that exhibited maximum variation on the basis of characteristics anticipated to be relevant to study objectives was selected. These characteristics were:

- Practice locality (based on the 2011 Rural-Urban Classification for small area geographies (Office for National Statistics 2013a))
- Level of local deprivation (obtained from the Welsh Index of Multiple Deprivation (WIMD) 2011 (Statistics for Wales 2011) , the official measure of relative deprivation for small areas in Wales)
- Length of time since qualification (based on the General Medical Council online register (General Medical Council 2010)).

Data collection continued until a descriptive saturation was reached. It was initially anticipated that approximately 20 GMPs would be conducted. This was assessed using the process described in section 6.4.2 and was reached after the seventeenth interview.

6.5.3 Inclusion criteria

A practitioner will be eligible for inclusion if:

- They are a practicing GMP in Wales.
- They had completed their general practice specialty training or equivalent.

6.5.4 Recruitment

One hundred and seventy purposively sampled GMPs were sent a letter of invitation (Appendix XIX) outlining the study, a reply form and a prepaid envelope. GMPs who expressed an interest in participating (n=42) were sent a study pack containing:

- Study information (Appendix XX)
- Contact details and a consent form (Appendix XXI)
- A prepaid return envelope

Participants were informed they would receive £60 to thank and reimburse them for their time. Practitioners who returned their consent form (n=18) were then contacted to arrange a mutually convenient interview time. Those who did not return their consent form were contacted once more by either telephone or email. Those that did not return their consent form following this were not contacted again.

6.5.5 Topic guide

Similar to the GDP interviews, a topic guide was prepared prior to data collection (Appendix XXII). Similar to the topic guide in Section 6.4.5, it roughly followed the chronology of a standard consultation. As little demographic data were known about participants, these were used to open the interview. As the responses were often fact-based and easy for participants to answer, they also served as a good 'warm-up' for rest of the interview.

The main body of questions varied between experience and behaviour questions, '*What kind of advice do you provide to patients with dental problems?*'; opinions and values questions, '*What would you say are your opinions towards seeing patients who attend with a dental problems?*', and knowledge questions, '*Patients who see an NHS dentist may have to pay a contribution to the cost of their care. Were you aware of this?*'. However, it should be noted that the schedule was not standardised nor replicated identically for each interviewee. The nature of maximum variation sampling meant that some GMPs had specific characteristics that required supplementary questioning, such as a practitioner who worked in area of particularly low NHS dental provision or a GMP who had previously worked in an Oral and Maxillofacial Surgery department. Throughout the interviews questions were added, changed or removed as theories emerged and developed (Appendix XXIII). The interviews were loosely conversational but focused around key predetermined themes, with opportunities for the interviewer to prompt and probe to enable deeper exploration of a concept or idea. In this way the interviews became 'a conversation with a purpose'.

6.6 Data collection, management and analysis

This section concerns aspects of the data collection, management and analysis that are common to both GDP and GMP interviews.

6.6.1 Interview procedure

Interviews were arranged either by email or telephone. Participants were free to choose when the interview took place, with many electing for times outside standard office hours. Interviews were all conducted by the researcher from a quiet room with no disturbances. Audio recording equipment was used to record the interview.

At the start of the interview practitioners were asked to give verbal consent that they:

- Still wished to participate in the interview
- Understood the study information and had the opportunity to ask questions and had these questions answered satisfactorily
- Understood that their participation was voluntary and that they could withdraw at any time with no implications for their legal rights
- Agreed to the interview being recorded
- Agreed for the information contained within the interview to be processed in an anonymous way.

6.6.2 Analysis

Interview transcripts were examined using theoretic thematic analysis, a method for identifying, analysing and reporting patterns (themes) within data. Whilst widely used, the processes involved in thematic analysis are often poorly described (Braun and Clarke 2006). In an attempt to promote the transparency and rigour amongst qualitative researchers undertaking thematic analysis, Braun and Clarke have produced a guide identifying six phases of thematic analysis which primarily informed this work (Braun and Clarke 2006). The phases of which are described below:

1. Data familiarisation
2. Generating initial coding
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the report

6.6.2.1 Data familiarisation

Interviews were audio recorded with the exception of one GDP interview where the recording equipment failed. In this case additional field notes were made when the failure was detected (<30 minutes after the interview finished). No notes were recorded during the interview other than memos of additional questions/probes to ask each participant. This encouraged active listening on the part of the interviewer. 'Fieldnotes' were made at the end of each interview in the form of an Interview Diary in which observations were noted and emerging themes documented. The Interview Diary was written throughout the study and serves as a record of the personal development of the researcher in the acquisition, development and deployment of qualitative interviewing skills.

Interviews were transcribed in full within 3 weeks of the interview date by either the researcher (AC) or an experienced transcriber. The researcher then checked all transcripts along with the audio recording to ensure they were a faithful record of the interview, and to aid familiarisation.

6.6.2.2 Generating initial coding

Once immersed in the dataset, the researcher began recording instances where she recognised a pattern or an interesting feature within the dataset. Each new pattern or feature was designated as a code, given a name and entered into the code record. A code was defined as 'the most basic segment, or element, of the raw data or information' (Boyatzis 1998). On each subsequent occasion the pattern or feature was encountered, it was recorded as belonging to the same code and past interviews were assessed again as to whether they too had sections of data compatible with the code. The final code records, with associated descriptions, are shown in Appendix XXIV. At this point, the dataset and associated coding were inputted into the Computer-Assisted Qualitative Data Analysis software (CAQDAS) package, NVivo 8. The three main advantages of CAQDAS packages are speed (i.e. of handling large amounts of data); rigour (i.e. demonstration of cases through counting) and for team research (including the development of consistent coding across a team) (Seale 2010). Within this project, use of a CAQDAS package facilitated the rapid searching and retrieval of coded sections and the development of complex Boolean queries.

6.6.2.3 Searching, reviewing and defining themes

Once the dataset had been coded, the analysis was refocused at the broader level of themes. At this point, codes were be combined to create a theme. The data extracts for each theme were assessed, and the dataset re-read to ensure all data related to a theme are coded and that the themes accurately represent the dataset. Following this themes were 'defined and refined' and the reports (Chapters 7 and 8) written.

6.7 Justification of methods

6.7.1 Study design

A quantitative researcher may argue that the research questions proposed in Section 6.1 could be answered, at least in part, by quantitative methods such as surveys or questionnaires. However, the use of qualitative techniques allows an exploration of participants' interpretation of reality in a richness of description not afforded by quantitative methods.

To greater or less extents, qualitative interviewing, participant observation and focus groups are all methods by which the research questions could have been satisfied. Whilst the direct observation of clinicians would have provided a rich descriptive account of the management of patients with dental problems it would have been inefficient with respect to time, since consultations for acute dental problems may not be a daily, or even weekly (in the situation of GMPs) occurrence. Furthermore, since clinicians' behaviour may be influenced by implicit beliefs, pressures and motivations, observation techniques may ultimately require augmentation with interviewing to explore factors affecting clinical decision making. Participant observation in a clinical environment also raises issues of patient confidentiality.

Focus groups would have provided a dynamic forum for the identified and exploration of topics surrounding the presentation and management of acute dental problems in primary care. These may have been particularly useful as the research questions are largely unexplored in the literature to date. However, since this study was primarily interested in exploring individual decision making rather than collective attitudes, interviewing was selected as a more appropriate method of data collection. Furthermore, a number of the topics surrounding patient management and antibiotic prescribing are potentially professionally sensitive and participants may have withheld opinions they felt could be professionally unacceptable, such as refusal to treat patients with dental problems or the inappropriate use of antibiotics. Lastly, focus groups pose logistical challenges in terms of poor participant attendance, particularly when the

intended participants are professionals who often work fulltime and, in the cases of GDPs, are largely self-employed. Indeed difficulties in obtaining adequate participation of GDPs in focus groups have been previously reported (British Dental Association 2012).

Qualitative interviewing was therefore selected because it allowed participants to discuss their experiences in an environment where they could, if required, acknowledge such 'undesirable' behaviours and explain their motivations for acting in this way. Interviews also allowed the exploration of retrospective and hypothetical scenarios in a manner that was time-economical for both researcher and participant.

Qualitative interviewing techniques vary according to the level of structure imposed by the interviewer and the topic guide. Structure largely refers to the constraints, or lack thereof, placed on the replies of the participants and the freedom of the researcher to create appropriate questions within the interview. Interviews therefore tend to fall into one of three types:

- Structured
- Semi-structured
- Unstructured (Howitt 2010).

Structured interviews are, in effect, a questionnaire administered by the interviewer. Whilst quick and easy to process, they provide insufficient freedom for the exploration of new lines of inquiry and development of links between themes which may be required to address the research questions within this study. Their inflexible structure also fail to account for themes that may arise unexpectedly and do not allow participants to provide extended answers which may provide a wider perspective on the subject matter of the interview.

In stark comparison, during unstructured interviews the researcher engages in a conversation with the participant and generates questions in response to the participants' narrative. Consequently, each unstructured interview might generate data with different structures and patterns, the intention of which is to expose the researcher to unanticipated themes (Zhang and Wildemuth 2009). Whilst unstructured interviewing techniques may well have generated rich and detailed descriptions of particular phenomena, they could not be guaranteed to address all research questions sufficiently. Furthermore, on a practical level, unstructured interviews are often significantly longer than interviews conducted using other techniques and asking professionals to give up large amounts of time may have led to recruitment problems.

Therefore, since a balance must be struck between discussing predetermined topics and allowing interviewees to provide extended narratives, semi-structured interviews were selected as the most appropriate technique for use within this study. An interview guide was prepared;

but in the course of the interview, the researcher had a certain amount of room to adjust the sequence and content of the questions asked, adding questions if necessary based on the context of the participants' responses.

During the study design process, attention was paid as to whether interviews would be conducted face-to-face or by telephone. Face-to-face interviews have traditionally been held in greater esteem, primarily because telephone interviews were said to restrict the development of rapport and a 'natural' encounter between interviewer and interviewee (Rubin and Rubin 2012). However more recently, the value of telephone interviews within qualitative interviewing has been recognised, particularly when discussing sensitive topics (Sturges and Hanrahan 2004). The clear advantages of telephone interviewing within the context of this topic was its economy, both in terms of time and money, and that it allowed a wider geographical sampling of participants. However, it is important to recognise that whilst not inferior, telephone interviews may have different qualities to face-to-face interviews, there are often increased requests for clarification from interviewees in telephone interviews, less frequent vocalised acknowledgements given by the researcher and interviewees are more likely to enquire about the adequacy of their responses. Furthermore it is not possible to detect non-verbal cues elicited from participants and, in general, telephone-interviewers are shorter than face-to-face methods (Irvine et al. 2013).

6.7.2 Sampling

6.7.2.1 GDP interviews

Non-probabilistic sampling techniques were employed as the objectives of the interviews were not to obtain a representative sample but to explore a wide range of perspectives and experience amongst GDPs. Initially a convenience sample of responding GDPs were interviewed (n=15) and this was later augmented using maximum variation (n=4) sampling. Maximum variation sampling is a technique by which researchers attempt to study a phenomenon by seeking out settings or persons that represent the greatest differences in that phenomenon (Patton 2002). In this instance it was used to select practitioners with in excess of 20 years' experience, as these individuals had been underrepresented in the convenience sample and initial interviews with these experienced clinicians had provided insight into the changes that had occurred within the profession during the preceding two decades.

Within qualitative research the sample must be sufficiently large to assure that most or all of the issues that might be important are explored, but simultaneously, if the sample is too large data becomes repetitive and eventually, superfluous (Mason 2010). Morse suggests that the sample necessary will depend on: the scope of the study, with broader research questions taking longer to saturate; the nature of the topic and how well participants engage with talking about it; quality of the data and study design (Morse 2000). So whilst no target sample size was identified, experience within the research supervisory team led to a suggested estimate of in the region of 20 interviews to address the research questions.

6.7.2.2 GMP interviews

Maximum variation sampling techniques were also used to identify the GMP to be interviewed. Other purposive techniques that could have been used are homogenous, extreme, or typical case sampling. The first could have involved interviewing all GMPs working at a particular medical centre. Whilst this would have built up a strong perspective of the attitudes and behaviours within this particular practice, results would have been difficult to infer to other general practice environments.

In contrast, extreme case sampling seeks to sample the most divergent cases within a population, in this case either practitioners who hold intense views (either positive or negative) regarding the management of patients with dental problems, or GMPs in Wales seeing the highest or lowest numbers of patients with dental problems. The logic of extreme case sampling is that by understanding the phenomena experienced by individuals who represent one end of the spectrum of the topic being studied, this can be applied in a diluted form to more typical individuals (Patton 2002). However, with so little pre-existing knowledge on this topic, both defining and identifying extreme cases would have been difficult in this context. In a similar way, identifying typical cases, GMPs who represent 'average' examples in terms of their attitudes and management practices would have been comparably problematic.

6.7.3 Analysis

There are numerous ways of approaching the analysis of data derived from qualitative interviews. The choice of analysis method is guided by the scope of the research questions, the type of interviews employed, and, in certain cases, the researcher's epistemological orientation. There are methods that pay close attention to language and how it is being used in social interaction such as discourse analysis and ethnomethodology; those that are concerned with experience, meaning and language such as phenomenology and narrative methods; and those that seek to develop theory derived from data through a set of procedures and interconnected stages such as grounded theory. Many of these approaches are associated with specific disciplines and are underpinned by philosophical ideas which shape the process of analysis (Gale et al. 2013).

Methods such as discourse analysis, whilst useful in unstructured interviews or situations where natural talk exists (such as consultations) were unsuitable for a dataset arising from semi-structured interviews. Similarly, the semi-structured nature of the interviews produced few narratives (data with story-like qualities) suitable for narrative analysis. Other techniques, whilst suitable for semi-structured interviews, were not employed due to the nature of the research questions. For example, interpretative phenomenological analysis is concerned with how individuals experience phenomena, however its strong links with a phenomenological epistemology made it unsuitable for both the researcher and research questions which instead sought to identify patterns across the entire dataset. Furthermore, since the research questions were not orientated with regard to language as a social action, discourse analysis was not considered a suitable methodology.

The three methods most appropriate for addressing the research questions and semi-structured nature of the interviews were grounded theory, thematic analysis and framework analysis. Grounded theory is a qualitative research method that uses a systematic set of procedures to develop an inductive theory of well-developed categories (themes or concepts), systematically interrelated through statements of relationship to form a theoretical framework about a phenomenon (Strauss and Corbin 1998). This theory seeks to be transferable, rather than generalisable, in the sense that elements can be transferred to contexts with similar characteristics to the situation being studied. After consideration, grounded theory was rejected due to three main reasons: firstly, the 'contamination' of the researcher's perspective following intense immersion in the literature in the first year of study and her own experiences as a practicing primary care practitioner. Secondly, the enormous complexity of constructing theory to explain an immensely complicated behaviour such as antibiotic prescribing and thirdly, the emphasis of the research questions towards the identification, summarisation and

encapsulation of the influences, behaviours and attitudes in preference to the development of theory to explain the data.

Thematic analysis was selected as a more appropriate analysis method and has the advantages of being ontological and epistemologically 'free', accessible to researchers and readers relatively new to qualitative research and able to highlight both similarities and differences across the dataset. Thematic analysis is a search for themes that emerge as being important to the description of the phenomenon. (Daly et al. 2007) This method of analysis was selected for this study as it complemented the research questions by facilitating the detailed illustration of data, whilst allowing the investigation of divergent cases. It also allows comparisons to be made between the two datasets (GDPs and GMPs) should this arise.

Themes can be identified in one of two ways during thematic analysis: inductive 'data driven', or deductive 'analyst driven'. An inductive approach is characterised by themes that are strongly linked to the data themselves and resulting themes often bear little resemblance to the specific questions asked of participants. In contrast, deductive thematic analysis more closely follows pre-existing questions held by the researcher. Within this research a combination of inductive and deductive techniques were used.

Framework analysis is a content analysis method, similar to thematic analysis, which involves systematically summarising and classifying data into the 'thematic framework'. Its defining feature is the matrix output: rows (cases), columns (codes) and 'cells' of summarised data, providing a structure into which the researcher can systematically reduce the data, in order to analyse it by case and by code (Ritchie and Lewis 2003). The difference between this and grounded theory approaches is that the integrity and context of individual respondents' accounts is preserved through the analysis, rather than the deliberate attempt to fracture the data in order to open up new avenues for analysis. This makes it particularly suitable for policy- or practice-orientated research (Green and Thorogood 2004). Framework analysis would have been an excellent option for the analysis of the interview data gained within this study. However it was ultimately rejected in favour of thematic analysis by the researcher, as she considered the latter methods would allow greater interpretative creativity, thus maintaining the vividness of insight into the topics under investigation.

6.8 Reflexive account

Research interviews are a form of interaction jointly constructed by the interviewer and interviewee and therefore cannot be objective accounts (Garton and Copland 2010). From this perspective interviews are an interpretative practice, in which what is said is inextricably connected to where it is said, how it is said and, importantly, to whom it is said, with interviewer and interviewee jointly constructing the meaning of an interview (Holstein and Gubrium 2004). Therefore it is vital for the interviewer to 'highlight the baggage' they bring and the effects this has on the assembled meaning derived from the encounter.

6.8.1 GDP interviews

When the interviewer and interviewee are members of a similar group, be it professional, cultural, racial or gender there is a 'world-known-in-common' (Silverman 1997) or 'cocategorical incumbency' (Roulston et al. 2001). As a practicing dentist I have personal experience of managing patients with acute conditions and had pre-existing experiences of factors that can influence clinical decision-making. I made a conscious decision to disclose my profession to participants over presenting myself as a PhD student partly because I suspected it may help in the recruitment of participants, individuals being more likely to assist a member of their own group than an 'outsider' and partly because I felt it was ethical to do so. Furthermore I felt it important that dentists knew they could talk to me as they would to a colleague, without having to spend time explaining technical words or jargon used. However, I recognised that shared professional background was not a substitute to developing a relationship with participants and did not fail to neglect this during the course of the interviews.

On reflection, the shared professional identity led to a number of key features within the interviews: firstly, I probed sparingly about the technical aspects of dental treatments undertaken. In the following example I elected to probe about the impact of spending time on operative procedures rather than exploring why the extraction might take increased time:

“GDP - If, if one did, if one did have time, one might be more prepared to open teeth to drain, to achieve open drainage or attempt extractions. But, if teeth are heavily broken down, you know, extractions can take quite a while.

INT - And how might that impact on the rest of your day?

GDP- It, you know, gives you stress at the time, and yes, it can make the rest of your day quite, quite uncomfortable...”

GDP8, male, predominantly NHS, qualified >30 years

I felt that the shared knowledge of the dental world encouraged participants to explore tangents, particularly in relation their satisfaction with the profession and the systems governing NHS dentistry, in the way they might do with a colleague or dentist-friend. This resulted in rich descriptions of participants’ experiences:

“I think, I think dentistry has gone downhill rapidly since the introduction of this contract and I don’t think, you know getting off the subject of antibiotics now, when I was a young associate, I was sort of getting used to doing multiple crown and bridge work well they [young dentists], don’t want it now. They are coming in and looking for one crown because they are not going to provide six crowns on the National Health when they are getting the same payment for one. So the dental health of the nation has probably going to hit an all-time low really I think, it’s a sad time for dentistry...”

GDP26, female, predominantly NHS, qualified 20-30 years

It should also be noted that I already knew some of the GDPs who took part in this study. I do not feel this should be considered unusual as the local dental community is close-knit and I had worked in several general dental practices and dental hospital departments before and during this study. This familiarity ranged from close colleagues to professional- acquaintances I had met during professional development activities. However it should be noted that the majority of participants I had no pre-existing relationship with.

6.8.2 GMP interviews

I felt I came to the GMP interviews with a more limited understanding about ‘their world’, beyond my own experiences as a patient and as a primary care provider. There were more times when I had to probe for additional information because the GMP was using specialist language or contextual phrases with which I was unfamiliar.

“GMP- We tend, the patients tend to be quite demanding, according to the statistics we're the highest demanding practice in [COUNTY NAME]. We're, with morbidity we top of all the charts in morbidity league and we also have the highest consultation rate anywhere in [COUNTY NAME].

INT - What do you mean by demanding?

GMP- Yeah, you have people who are, who attend for trivia, which I daresay happens in all practices, but because of the nature of the morbidity of the area you also have people with chronic, quite significant chronic long term illnesses who obviously seek medical help because of their underlying problems.”

GMP14, male, qualified >30 years, urban practice

Perhaps more significant was the potential effect my profession may have had on the willingness of GMPs to express their opinions about the dental providers. During the interviews GMPs frequently voiced their frustrations with the access to local dental services although this was usually under the context of Local Health Board (LHB) provision, and only infrequently expressed disquiet specifically related to the dental profession themselves. Whether this is genuinely the attitudes of the clinicians interviewed or whether GMPs were providing answers they felt would be more socially desirable given an interviewer from the dental profession is difficult to determine and warrants further study. In hindsight, I maybe should have considered more carefully before disclosing my profession to this group of participants but prior to the study I anticipated a greater level of interprofessional contact between the professions than actually exists in practice.

7. The Use of Antibiotics in the Management of Acute Dental Conditions in General Dental Practice: a Qualitative Study - Results

7.1 Introduction

The cross-sectional study of general dental practitioners (GDPs) described in Chapters 2 and 3 facilitated the quantification of the use of systemic antibiotics in the management of acute dental conditions in general dental practice. However, in order to gain a deeper understanding of the factors that influence the management of patients with acute conditions a qualitative investigation was undertaken with a sample of 19 GDPs. The methodology underlying this study is described in Chapter 6.

The following chapter explores the beliefs and attitudes of GDPs towards the use of antibiotics and antimicrobial resistance and factors that influence the management of patients with acute dental conditions. It explores the three principal themes arising from the data: beliefs and attitudes towards antimicrobial use and resistance (Section 7.3); the influence of other individual, both colleagues and patients, on GDPs' management of patients with acute dental conditions (Section 7.4), and attitudes relating to time pressures, uncertainty, outcome expectancy and self-efficacy (Section 7.5).

Data related to GDPs' perceptions of antimicrobial use and resistance were subsequently published in an article in the British Dental Journal (Appendix XXV).

7.2 Sample

Thirty GDPs were approached to take part in this study of which nineteen were interviewed. Of these, 10 were male and the median number of years since graduation was 17. All but one qualified from dental schools in the UK and 5 had postgraduate qualifications such as MJDF/MFDS or MSc. All 7 Welsh Local Health Boards (LHBs) were represented in the sample and practitioners came from a mix of urban (14/19) and rural locations (5/19) (Office for National Statistics 2013a). Whilst most practitioners undertook both NHS and private work, 15 reported that they spent the majority of their time treating patients under the NHS. Six of the GDPs were also owner or joint-partner of their practice and the remaining thirteen were associate dentists (although one associate dentist was a former owner of their practice). Thirteen practitioners

worked in practices in areas which had Wales Index of Multiple Deprivation 2011 (WIMD '11) ranks indicating they served the 50% most deprived populations, whilst six were from practices which had WIMD '11 scores suggesting they served the 50% least deprived populations (Statistics for Wales 2011),.

Interviews lasted on average 25.6 minutes (SD 4.93 minutes). There was one instance where the recording device failed (GDP42).

Practitioner ID	Gender	Number of years since qualification	Postgraduate qualification	Predominantly NHS or private?	Practice owner or associate?	Practice location	Deprivation	1000 Lives Plus Antimicrobial Prescribing Audit
GDP3	Female	21-30 years	No	NHS	Owner	Rural – town and fringe	50% least deprived ranks	No
GDP4	Female	≤10 years	Yes	NHS	Associate	Urban – city and town	50% most deprived ranks	Yes – completed
GDP5	Male	≤10 years	Yes	NHS	Associate	Urban – city and town	50% most deprived ranks	Yes – currently completing
GDP6	Female	≤10 years	No	NHS	Associate	Urban – city and town	50% most deprived ranks	No
GDP8	Male	>30 years	No	NHS	Owner	Urban – city and town	50% most deprived ranks	Yes – currently completing
GDP10	Male	≤10 years	No	NHS	Associate	Urban – city and town	50% most deprived ranks	Yes – currently completing
GDP13	Female	≤10 years	No	NHS	Associate	Urban – city and town	50% most deprived ranks	No
GDP15	Female	10-20 years	No	NHS	Associate	Urban – city and town	50% least deprived ranks	No
GDP22	Male	10-20 years	No	NHS	Associate	Urban – city and town	50% least deprived ranks	Yes - completed
GDP23	Male	>30 years	Yes	Private	Associate	Urban – city and town	50% most deprived ranks	No
GDP24	Male	≤10 years	No	NHS	Associate	Urban – city and town	50% most deprived ranks	Yes – currently completing

Practitioner ID	Gender	Number of years since qualification	Postgraduate qualification	Predominantly NHS or private?	Practice owner or associate?	Practice location	Deprivation	1000 Lives Plus Antimicrobial Prescribing Audit
GDP26	Female	21-30 years	No	NHS	Owner	Rural – town and fringe	50% most deprived ranks	Yes – currently completing
GDP32	Female	11-20 years	No	Private	Associate	Urban – city and town	50% most deprived ranks	No
GDP33	Male	11-20 years	No	Private	Associate (former practice owner)	Urban – city and town	50% most deprived ranks	Yes – currently completing
GDP37	Male	>30 years	No	Private	Owner	Urban – city and town	50% least deprived ranks	No
GDP39	Female	21-30 years	Yes	NHS	Owner	Rural - town and fringe in a sparse setting	50% most deprived ranks	No
GDP42	Male	21-30 years	No	NHS	Owner	Rural - town and fringe in a sparse setting	50% most deprived ranks	Yes – currently completing
GDP58	Female	≤10 years	No	NHS	Associate	Rural – town and fringe	50% least deprived ranks	Yes – currently completing
GDP59	Male	21-30 years	Yes	NHS	Associate	Urban	50% least deprived ranks	Yes – currently completing

Table 7.1 – GDP characteristics

Number of years since qualification – since primary dental degree (determined from observational study demographic questionnaire)

Postgraduate qualification – whether the practitioner reported that they held a postgraduate qualification (such as MFDS/MJDF/MSc etc., from observational study demographic questionnaire)

Predominantly NHS or private – whether the practitioner reported spending more time engaged in NHS or private dentistry (from observational study demographic questionnaire)

Practice owner or associate – practice owner (also called principal, or provider-performer) or associate (from interview)

Practice location – determined by 2011 Rural-Urban Classification for Small Area Geographies, based on practice postcode

Local deprivation – determined from WIMD '11 ranks (Statistics for Wales 2011), based on practice postcode.

1000 Lives Plus Antimicrobial prescribing audit – whether practitioner taking part in this audit (from observational study demographic questionnaire and interview)

Explanation of participant identifiers

Participant ID, gender, predominantly NHS or private status, number of years since primary qualification

e.g. GDP24, male, predominantly NHS, qualified ≤10 years

7.3 Beliefs and attitudes towards antimicrobial use and resistance

7.3.1 Beliefs and attitudes and factors that influenced knowledge about antibiotic resistance

All clinicians were aware of antibiotic resistance, with many citing the example of methicillin-resistant *Staphylococcus aureus* (MRSA). There was an appreciation that prevalence of resistance was increasing and that this may present therapeutic problems during the management of infections. However, antimicrobial resistance was primarily considered a secondary care issue.

“It’ll be a problem for, for when patients actually have big systemic infections and problems, and they need antibiotics I’d say on a greater level than, for what someone might call a little minor problem such as toothache.”

GDP24, male, predominantly NHS, qualified ≤10 years

There were conflicting opinions as to whether antibiotic resistance occurred within odontogenic infections. Most of the clinicians interviewed had experienced antibiotic treatment failure and some attributed this to the presence of resistant bacteria, particularly in relation to amoxicillin. However other practitioners attributed poor clinical outcomes to the failure of operative treatment.

“I would say twenty years ago amoxicillin seemed to clear most swollen faces quite quickly, now I’m finding amoxicillin, it might work, but I’m using metronidazole and amoxicillin more often, in combination... I definitely worry more about a severe infection and it’s, a lot aren’t responding to amoxicillin and that’s the first choice.”

GDP23, male, predominantly private, qualified >30 years

All of the practitioners interviewed identified the link between antimicrobial prescribing and the increasing prevalence of resistance. Whilst many described how overprescribing could contribute to antibiotic resistance, there were varying levels of understanding about how antibiotic prescribing within dentistry could lead to the emergence of resistant strains.

“...some of them [bacteria] will occasionally mutate, so what that means is that their, sort of their DNA, their genetic makeup like we have, changes a bit. Sometimes these changes mean that the antibiotics that we can give you won’t work. And sometimes when antibiotics are given for the wrong reasons you can end up leaving some of these bacteria around, which then mutate, which then change which means that the next time we maybe give antibiotics the bacteria that mutated, that changed, are still with us.”

GDP5, male, predominantly NHS, qualified ≤10 years

“(Laughing) I don’t know too much about it to be honest. Erm... (tails off)”

GDP24, male, predominantly NHS, qualified ≤10 years

Clinicians’ perceptions of the extent to which prescribing by dentists contributed to antibiotic resistance varied between individuals. The majority of practitioners believed that whilst all antibiotic prescribing could theoretically lead to the emergence of resistance, the contribution of dentists’ prescribing to the problem of antibiotic resistance was likely to be far less than medical colleagues.

Dentists who reported that dental prescribing was likely to have little to no impact on the prevalence of antimicrobial resistance generally justified this with the smaller number of antibiotics prescribed by dentists in comparison with medical professionals, and the shorter courses and narrower range of antibiotics typically used within dentistry. Several practitioners specifically cited overprescribing by GPs as the most significant cause of antibiotic resistance, whilst other explanations offered for antibiotic resistance included antibiotic use in agriculture, prescribing by hospital doctors and the availability of antibiotics in developing countries.

“The dental team, compared to our medical cousins, we actually prescribe very very little, compared to them... we can’t bear the brunt, as it is, of antibiotic resistance developing in the world.”

GDP8, male, predominantly NHS, qualified >30 years

“I know some people who’ve got a [medical] problem and their GP will end up giving them seven days of something and then another seven days and then another seven days. I think that’s probably going to cause more problems than a four day course from the dentist”.

GDP6, female, predominantly NHS, qualified ≤10 years

Clinicians who acknowledged that dental prescribing could contribute to resistance still encountered difficulties balancing clinical pressures and public health considerations.

“...there is the wider public health issue that we should be using things appropriately. Because the one time you might need it, it might not work. And, whilst it might help you out on that Monday morning when you've got three people in at nine o'clock, then in a few years time, when nothing works, you've contributed to that.”

GDP5, male, predominantly NHS, qualified ≤10 years

Overall the practitioners interviewed felt a low level of responsibility for problems associated with antimicrobial resistance and experienced little urgency with regards to limiting the use of antimicrobials within dentistry in order to reduce the emergence of antibiotic resistant strains. Concerns about the use of antimicrobials were more focused on the effective treatment of patients with acute dental conditions and individual patient-outcomes, rather than wider public health considerations.

7.3.2 Beliefs and attitudes about antibiotics, and factors that influenced knowledge about antibiotics

Practitioners viewed the management of patients with acute dental conditions, often unscheduled, on-the-day attendances, as part and parcel of their work as a primary dental care professional. Practitioners recognised that antibiotics were a useful, and sometimes essential, part of the therapeutic armamentarium when managing patients with acute conditions. Dentists felt confident prescribing antibiotics and had a narrow, well-practised repertoire of frequently used antimicrobial agents. Almost all, if not all, antibiotics were prescribed empirically, although one GDP expressed a desire for greater availability of culture and sensitivity testing in the General Dental Service (GDS).

The majority of practitioners reported that they would be most likely to prescribe an antibiotic in instances where operative treatment was not practicable, or in cases of acute infection. Most practitioners reported that if they felt it was feasible they would attempt an operative intervention as their first line measure for an acute condition.

“My simple rule is, if I’ve got the time and I think the patient’s suitable I prefer to do something operative and, you know, to relieve pain, etcetera. And if we’re talking about pulp pain, you know it’s usually an extirpation, an extraction or, you know, an open and drain, whatever. And those are the lines I would try and go down. If I’m going to go down the antibiotics route it might be if there’s some facial swelling already present and the root canal looks an awkward one to do, if I’ve got a very nervous patient and particularly if it’s not my patient I might be less inclined to, you know, attempt an awkward operative procedure and have it all go wrong on me then step in there and try and calm the symptoms down and deal with it in a more controlled manner.”

GDP23, male, predominantly private, qualified >30 years

Many clinicians cited undergraduate or early career teaching (particularly during Vocational Training) as a major influence on their prescribing behaviour. However, practitioners reflected that whilst a large amount of their prescribing knowledge was derived from undergraduate experience, this had largely been obtained whilst prescribing antimicrobials in situations that would not be routinely encountered within general practice. Other key sources of guidance regarding antibiotic use were practice colleagues, particularly practice principals or educational supervisors.

“I think there should be a little bit more in terms of teaching on how you can prescribe in general practice. I think most of the prescriptions that we’d seen in dental school, or certainly when I was there, were done in Oral Surgery, which is a specialist department. So the problems that they see are quite different from the problems that you see in general practice. It’s a secondary care unit, so usually, you do see acute pain on the [EMERGENCY CLINIC] but if you’re on a [ORAL SURGERY CLINIC] usually the patient will not be in the acute phase. And also, in the hospital environment, they can prescribe a lot more things than you can, or I can, in the general practice environment.”

GDP10, male, predominantly NHS, qualified ≤10 years

Formal sources of knowledge about antibiotics were primarily clinical guidelines and postgraduate continuing professional development (CPD) courses, with only a minority of practitioners reporting seeking updates from peer-reviewed literature.

“I did a course, might be as many as several years ago now, from Mike Martin from Liverpool who was very against, you know, abusing antibiotics and his course was very useful. His was a one day course and he ran through all the scenarios and antibiotics and dosages and reasons etcetera. And I pretty much follow the protocol I picked up from that. That would be several years ago but from what I’ve picked up reading journals, I’ve not seen a big change in, you know, he was one of these, ‘Don’t give five hundred milligrams etcetera of amoxicillin and etcetera’ and stuff like that because an awful lot tended, well tend, to double up doses.”

GDP23, male, predominantly private, qualified >30 years

Some practitioners raised concerns about conflicting messages that arose from antimicrobial prescribing courses and their subsequent reinterpretation by colleagues. This clearly resulted in confusion for practitioners and uncertainty about which recommendation they should implement into practice, as a result many chose to stay with their tried and tested behaviours, presumably out of fear of getting it wrong.

“We had a chat about this not long ago. One of the girls had been on a course and she was told something, not to do this or prescribe this, and someone else was told something else completely different on a different course. So that completely confused me. One of the dentist’s wives, who’s a dentist, she was told to give three gramme sachets of amoxicillin, which I’ve never been told, and then this other girl said, ‘No you don’t do that, it doesn’t work.’ So there’s quite a lot of conflicting messages, so I just stick to what I’m used to.”

GDP32, female, predominantly private, qualified 11-20 years

7.3.3 Clinical guidelines

Whilst the majority of practitioners had a degree of awareness of currently available clinical guidelines (in particular the Scottish Dental Clinical Effectiveness Programme publication:

Prescribing in Dentistry (2011)), there was a variable level of familiarity with the specific content of these documents.

“I have a copy of the Clinical-I-don’t-really-blah-de-blah. It’s there if I want to look at it.”

GDP5, male, predominantly NHS, qualified ≤10 years

However, even good familiarity with guidelines did not guarantee that the practitioner used antibiotics as per the recommendations. Whilst the majority of clinicians did not specifically disagree with the introduction of guidelines *per se*, several practitioners disagreed with the specific content of the guidelines. This was particularly prominent amongst more established practitioners who relied on their own clinical knowledge and experience to guide their antibiotic prescribing practice and occasionally considered their patients to be outside the boundaries of evidence-based guidelines.

“GDP - One thing I found very useful, which I think we don’t have in the NHS in Wales or England is the Scottish people have produced this little booklet on prescriptions... and I think it’s superb.

INT – Do you use that quite a lot?

GDP – Yeah, I’ve had that and I’ve used it. Certain things are not in it, like I think clindamycin isn’t in it, yet I find clindamycin a very good antibiotic.”

GDP59, male, predominantly NHS, qualified 21-30 years

“I do give antibiotics for dry socket which I know is not everyone’s cup of tea, but I do...”

GDP15, female, predominantly NHS, qualified 10-20 years

The majority of the scientific evidence and clinical guidelines relating to the effectiveness of antimicrobial for dental conditions make their recommendations based on clinical diagnosis of the patient. Yet several of the GDPs interviewed expressed a lack of fluency with the use of such diagnoses.

“... apical periodontitis or irreversible pulpitis or chronic abscess or acute abscess. All these diagnoses that I knew back to front, maybe years ago, I've sort of got to know as toothache that needs antibiotics and toothache that doesn't need antibiotics... as much as, an accurate diagnosis is important, if it doesn't change the solution or the outcome, you tend to forget about it!”

GDP4, female, predominantly NHS, qualified ≤10 years

7.3.4 Changes in prescribing

Many practitioners confidently discussed changes they had made in their prescribing practices, often as a direct or indirect result of guidelines. However, the majority of changes were transformational in nature, exchanging one type of antibiotic to another, or a general drive to ‘prescribe less’. Despite questioning, no clinicians described clinical conditions they no longer prescribed antibiotics for.

“Well, yes, I mean as a student we were told penicillin V was what we normally used and didn't use a lot of metronidazole then, just for, you know, periodontal problems really. And erythromycin was used a lot more. And now I'd say the main two antibiotics I would use would be amoxicillin and metronidazole, and very rarely any of the others, unless they've got patient allergies or a really nasty infection that's not responding.”

GDP23, male, predominantly private, qualified >30 years

“But, as far as types of antibiotics, I probably prescribe amoxicillin far more now, it probably would have been Pen V when I first, first came. I probably prescribe more metronidazole now, than one used to. I don't, probably I, I probably used to prescribe more erythromycin than I do today. I very very very rarely prescribe tetracyclines. I think amoxicillin and metronidazole are the two main mainstays.”

GDP8, male, predominantly NHS, qualified >30 years

When clinicians described making alterations (usually type, dose, duration or frequency of antibiotic courses) to their prescribing behaviours, personal ownership of this decision seemed

high, although practitioners acknowledged that having practice-wide change would help them maintain this change.

“I decided to do it off my own back [change prescribing practice] rather than because everyone else is doing it but yeah, I suppose if you’re all saying, ‘This is how we’re going to do it as a practice’, then yes, but my own personal thing I just sort of decided to do it myself.”

GDP26, female, predominantly NHS, qualified 21-30 years

When discussing changes in their prescribing behaviours, practitioners also talked simultaneously about improvements in the prescribing practices of the wider dental profession, often using phrases such as ‘us’ and ‘we’ and wanted to convey the social responsibility of the profession. However, when discussing this wider group of practitioners it was unclear whether practitioners did intend to extend this sentiment to include all dental practitioners or whether they were talking about their own professional network within dentistry and practitioners they identified similarities with.

“I would say under current clinical guidelines we really are trying to avoid giving antibiotics. There has been a big change, I mean in the timespan that we’ve worked in general practice there’s been a huge change in that.”

GDP3, female, predominantly NHS, qualified 21-30 years

7.3.4.1 1000 Lives Plus Antimicrobial Prescribing Audit

At the time of interview eleven out of the nineteen practitioners interviewed had recently or were currently taking part in the 1000 Lives Plus Antimicrobial Prescribing Audit (Wales Deanery 2012). Several practitioners cited that this audit had increased their familiarity with guidelines and had resulted in changes in practice.

“INT – Would you say that since you’ve graduated dental school that your antibiotic prescribing has changed at all, or is it very much based on what you were taught at dental school?”

GDP – Pretty much what I was taught at dental school to be honest, it hasn’t varied an awful lot. Although I have to admit, in the Thousand Lives Audit... it was quite clear on that paperwork that amoxicillin was the, the first line, or the preferred antibiotic for dental abscesses. And I have to say my, up until that point, I would have usually been prescribing metronidazole rather than amoxicillin. I’m not sure why, it’s just, what I was used to...But having seen that paperwork I’ve sort of gone back the other way and patients who aren’t allergic to penicillin, I have, I have been prescribing amoxicillin rather than metronidazole again. But other than that, I haven’t changed much to be honest.”

GDP4, female, predominantly NHS, qualified ≤10 years

However, again this change in prescribing behaviour is more subtle and requires less alteration in clinical practice than providing more operative treatment and conversely fewer antibiotics. Furthermore, it is unclear whether interventions such as the 1000 Lives Audit result in long-term reductions in antimicrobial prescribing. In the quote below, the practitioner describes trying to perform more operative treatment for patients with an acute condition in situations where he felt short of clinical time. The Audit, whilst heightening his awareness that prescribing for this reason was not in line with current guidelines, had not provided him with the specific resources to be able to overcome this barrier to providing operative treatment, and as such, he is unsure as to whether he will be able to maintain this change long-term.

“I was disappointed with the number of times that myself and my colleagues had ticked the 'lack of time' box, for prescribing. So that did cause me to reflect on that, and it has, at least in the short term, changed, you know, if I'm thinking, 'I'm short of time here, what shall I do', it does click, 'Well I said to myself when I filled in that thing I would go ahead and do the treatment anyway.' You know, so at the moment, it has altered what I'm doing, but whether that will last in the long run, I don't know. Not that I, I don't think, I say I ticked it a lot, I don't think I ticked it a lot, I think I ticked it a few times and I'd rather I hadn't ticked it at all, you know. You know, so that's the major reflection.”

GDP22, male, predominantly NHS, qualified 11-20 years

7.4 The influence of others

7.4.1 Colleagues and the wider profession - professional norms

When describing their prescribing patterns compared with those of the wider dental profession, all practitioners confidently reported that they felt their prescribing level was either average or below average.

“I like to think I'm, I'm fairly down the middle in terms of my prescription pattern. I don't think I'm over-prescribing... there are times when I would [prescribe] but I like to think that a lot of people do that as well. But at the same time I don't think that I just throw antibiotics around for fun so I think that I'm fairly down the middle, certainly compared to my other colleagues in my practice, we all have a fairly similar policy all the way round, so I'm fairly comfortable in there.”

GDP10, male, predominantly NHS, qualified ≤10 years

“I think there are some practitioners like that [over use antibiotics] but the majority are generally quite good and are the same as me I'd say.”

GDP24, male, predominantly NHS, qualified ≤10 years

To these practitioners their conscientious prescribing behaviours were clearly a source of professional pride. Whilst almost all clinicians acknowledged that antibiotics were prescribed too often within the dental field, most of the practitioners interviewed felt little urgency to alter their prescribing practices as they already felt they were 'ahead of the curve'. When asked about which practitioners were responsible for the overuse of antibiotics, clinicians tended to identify groups of dentists who possessed different characteristics to themselves; young practitioners highlighted older practitioners and several GDPs suggested that dentists working in the Emergency Dental Service prescribed more than those working in general practice.

"I would imagine, and not meaning for it to sound derogatory at all, but I would expect maybe the middle to older generation maybe prescribing more. Whereas maybe the younger generation are more aware of, of the fact that if it's an emergency that requires antibiotics then it needs treatment as well, or instead of, and are more aware of over prescribing and the dangers and disadvantages of over prescribing whereas the older generation who, when antibiotics might have been the answer to everything because it was a wonderful thing to have, it was fashionable and thought to be the best thing to do, I don't know, that's just what I would expect if, if I'd come across stats about it."

GDP4, female, predominantly NHS, qualified ≤10 years

"I think in, with the emergency services, on the weekends, they do tend to be quite prescription-happy... almost invariably when I see a patient on a Monday saying that they've been to the emergency dentist they will have had some sort of antibiotics, regardless of, almost regardless of what it is... They are basically, I think, in a way they, they're trying to, sort of, fob the patient off, trying to do as little as possible but I can understand that especially if they've been really busy on the weekend and they've got sort of like, patients lining up all the way outside the door, I can understand that."

GDP10, male, predominantly NHS, qualified ≤10 years

There was also an implication that members of the dental profession would under-report their prescribing behaviours in an attempt to 'save face' when discussing their habits with other dentists. This indicates that antimicrobial prescribing is a professionally sensitive issue and practitioners will seek to comply with professional norms to avoid being seen as an irresponsible or negligent.

"...when you go to post graduate meeting what many say, speaking to them you'd never think they prescribe any but when you have nurses who come and work with us we actually realise they prescribe quite a few! So, it's how truthful people really are. I think most of us know that we shouldn't prescribe them anymore than we have to, it's in practice what they actually do."

GDP23, male, predominantly private, qualified >30 years

However, assessment of professional norms carried a large caveat – many of the practitioners, whilst apparently confident their prescribing wasn't high, confessed that they didn't really know what was happening outside the walls of their practice, or even sometimes their surgery.

"It's difficult to know because, dentists because we work, as you know, we work in our own little room, it's difficult, we never see other dentists working."

GDP4, female, predominantly NHS, qualified ≤10 years

The prevalence of professional isolation highlighted an unmet feedback need within the profession. However, when asked whether they would value feedback on their prescribing the majority of dentists felt that although it would be useful, they felt that prescribing rates could only be fully interpreted within the context of the individual practice. A number replied defensively, suggesting that such feedback may impose on their professional autonomy and or may incorrectly highlight them as high prescribers.

"INT - Do you think it would be useful for dentists to know how much, how many antibiotics they prescribe in relation to their peers in the area maybe, or in Wales as a whole?"

GDP - I suppose it probably would but it depends comparing the practices how busy they are, and where they are, what areas they're situated in. It might be, might be an eye opener if you were suddenly told that you, you're prescribing twice as many antibiotics, but then you know you hear figures and numbers that GPs are prescribing and, you know I'm led to believe, I may be wrong, but I'm led to believe that GPs tend to prescribe a lot more antibiotics than dentists do."

GDP8, male, predominantly NHS, qualified >30 years

When clinicians identified other dentists within their own practice who they perceived were prescribing antibiotics inappropriately this could potentially be a source of personal disgruntlement. However, whilst several dentists were derogatory about colleagues who they felt used antibiotics inappropriately, there was a clear shared view of non-interference when it comes to GDPs intervening in the antibiotic prescribing behaviour of their colleagues.

“Sadly [NAME] is bit of a reach-for-the-prescription-thing because, and I don’t think I can change anything about that really. I tried to encourage him to take part in some of these schemes because of audits coming up and he was just not very interested. You know he’s actually younger than me and I was thinking, ‘Crikey’. You know? But I don’t know... he’ll very often give a patient of mine who comes in with toothache a course of antibiotics and quite often I would say I probably think it’s rather inappropriate but you know I can’t, as the principal of the practice if he wasn’t there then there’d be an even worse situation so I can’t really, I haven’t really been brave enough to tackle him directly about it, no...”

GDP39, female, predominantly NHS, qualified 11-20 years

7.4.2 Patients - anxiety, dental attendance and expectations of care

Clinicians' accounts revealed a number clinical signs and symptoms of infection such as trismus, diffuse facial swelling or dysphagia that, if present, may make them more likely to prescribe an antibiotic. In contrast, other practitioners reported making a more general assessment of a patient’s condition and a judgement of how likely a patient would be able to ‘cope’ with undergoing operative treatment.

“I think I’d be governed by if they had limited opening, so that would be a big thing. And whether people would cope with, if they are uncomfortable we try our best to get an x-ray so I know where we’re going and I can discuss it with them. People come in, they can quite often be a little bit agitated, a little bit anxious, if they’ve got a facial swelling. They want to know what’s going on, so if I can get an x-ray then we’ll take it from there. It depends how uncomfortable they are.”

GDP3, female, predominantly NHS, qualified 21-30 years

Practitioners often associated a patient’s level of dental anxiety with their ability to accept a surgical intervention such as exodontia or endodontic treatment, and described how anxious patients may be more likely to request time to mentally prepare themselves before undergoing operative treatment. This clearly left GDPs with a dilemma: unable to perform first line operative treatment but at the same time wanting to provide symptomatic relief for their patient. Several practitioners described that, faced with this situation they may be highly likely to prescribe an

antibiotic, despite an awareness that it was not the optimal treatment option. Other practitioners expressed an anxiety that if they incorrectly assessed a patient's ability to cope with treatment this could result in a catastrophic breakdown of the consultation. Therefore, practitioners were cautious about recommending operative treatment to patients known to be dentally-anxious and were more likely to prescribe antibiotics so that operative treatment could be delayed until a more 'controlled' appointment.

"...you just get the odd patient where you just know if it doesn't work first time they are going to be hysterical on the floor and probably I shouldn't give them antibiotics but I suppose I sometimes do."

GDP15, female, predominantly NHS, qualified 10-20 years

Furthermore, dentists described how patients with dental anxiety may be less likely to engage with regular dental examinations and often only attended in when they had pain. As a result, there was often little pre-existing patient-practitioner relationship. GDPs explained that this lack of rapport, compounded by the fact that anxious patients may be more reluctant to accept recommendations about operative treatment, led to potentially challenging consultations.

"It's more stressful because you don't know their history, you don't know, you know because within a short space of time you've got to develop a relationship with the patient, you know if they are the sort of person who is tending to understand what dental care is about, tending to understand you know the trust and sort of and the rapport necessary it's no problem, but if it's somebody who's very, had bad experiences in the past which quite often they say they may have had or they are phobics or something like that. They are already in pain it's a very stressful time for them it's very difficult to get rapport in that sort of situation."

GDP59, male, predominantly NHS, qualified 21-30 years

Clinicians described that the majority of patients attending an appointment, either scheduled or unscheduled, brought with them expectations of the treatment they would receive. Practitioners reported that irregular attenders were often more vocal about their expectation of the management they would like to receive, but that expectations varied between patients, some wanting operative treatment, others antibiotics.

“Quite often you find if someone tends to be phobic and someone tends to be poor attenders and they come in as an emergency you get two scenarios, either they want everything done at that fifteen minute appointment or the second scenario is they say, ‘Look, I want some antibiotics. I do not want to have any, I do not want any injections, I do not want any fillings, I do not, I just want some antibiotics.’”

GDP59, male, predominantly NHS, qualified 21-30 years

Dentists also remarked that irregular attenders were usually less interested in undergoing restorative treatment, such as endodontic therapy, to ‘save’ a failing tooth and were less likely to accept recommendations regarding treatment plans.

“GDP - Most come in and say, ‘Rip it out’, that is a general comment you get coming through the door. Some of them you know you can persuade them to have a root canal treatment but if they’re really in severe pain they just want out of pain. They don’t want to know about a lot of it, and the more regular attenders it’s just something that’s blown up they will listen but I would say the ones who are poor attenders it’s just getting that tooth out, normally.

INT - So you notice the difference between the people who kind of come regularly for their check-ups and things and people who don’t?

GDP - Oh definitely, yeah, definitely. I mean the ones who are regular are much more keen to save it and much more ready to contemplate a root canal, might even have already had a root canal. Whereas the ones who are you know don’t come regularly it’s just a case of, ‘This is another tooth to take out please and just get on with it because I can’t cope.’ Yeah.”

GDP58, female, predominantly NHS, qualified, ≤10 years

Practitioners generally accepted that patient expectations were a part of clinical life and the majority felt that it was up to the dental profession to attempt to modify patient attitudes to care. However many felt frustrated by the often dogmatic attitudes held by their patients. This exasperation generally arose when practitioners felt that a patient wasn’t acting in their own best interests, or that when a patient’s preconceived expectations of treatment unduly affected the balance of control within the consultation.

“GDP - I would say they have a mind-set and the majority of people in this area still think it’s an extraction or nothing.

INT – And how does that make you feel?

GDP – Downhearted, I would certainly take the time to discuss with them if I think a tooth is saveable. I like to show them an x-ray and talk it through with them, most people are quite insistent it’s just out.”

GDP3, female, predominantly NHS, qualified 21-30 years

“It doesn't bother me in terms of 'I know best' or anything like that, that doesn't bother me. If they want to come in with their own opinions about what they want doing. But it can make you feel a little anxious if you feel that you're going to be pushed towards a treatment that perhaps you're not prepared to do, you don't have the time to do, you, or you're not clinically capable of doing, if it's a particularly difficult extraction or something like that. So I suppose there's an anxiety as soon as they come in and say 'I want the tooth out' and you haven't even seen it, you're thinking, 'Am I going to be able to get it out? Are they going to get annoyed if I don't do it?'. So that sort of that sort of anxiety comes into it, yeah.”

GDP22, male, predominantly NHS, qualified 11-20 years

However some dentists, particularly those who were well established in their practice, encountered fewer problems relating to discordant patient expectation. They described how, over the years, their patients had become accustomed to the kind of treatment they may be likely to recommend during an acute episode. More established practitioners also perceived that their patients were more likely to take recommendations during treatment planning. These patient-practitioner relationships were represented as more paternalistic than those between less established dentist and their patients, where clinicians were more likely to describe elements of shared decision making within consultations and portray themselves as an advisor, guiding patients towards a treatment plan.

“I’ve been there for the fifteen years now so they come in and they just let me, I can get away with telling them anything you know in many ways. But other people’s patients, yeah they very often will come in and say, you know, “I have toothache I need a prescription”, you do get a degree of that.... I mean my patients rarely do it, people rarely come in and ask for a specific thing now because I think they know what my response would be but occasionally other people’s do”

GDP33, male, predominantly private, qualified 11-20 years

This development of the patient-practitioner relationship often occurs over several years and in some cases, even decades. It can be a delicate process requiring perseverance on the part of both practitioner and patient, especially if a predecessor had a different attitude to managing acute conditions.

“It varies and I think that’s something that’s changed the five years I’ve been in the practice. When I started [laughs], they were obviously expecting to just pop in for a quick minute so I can write them a script, suggesting to be that’s probably how, how they had probably been dealt with in the past. And when, when the receptionist used to tell them, ‘No she hasn’t got anything today’, they’d be quite, sort of, adamant, ‘Well it’ll only take a minute, because she’ll only need to write me a prescription.’ But I think over the five years that I’ve been there I’ve either lost those patients because they don’t like the fact that I treat them differently to the predecessor, or they’ve learnt my way and now they’re appreciating that actually that’s not really the way it happens, the way it works, if they’ve got an emergency, it needs to be treated. So I think over a period of time they’ve, they’ve generally speaking, got, they’ve become, or they’ve got to a point where they understand that treatment is probably necessary and, if I can do it then I will, but if I can’t I’ll book them back in pretty soon to do it.

GDP4, female, predominantly NHS, qualified ≤10 years

Many practitioners described how they, on occasion, experienced explicit requests for antibiotics from patients. However, a large proportion of practitioners described how, with appropriate explanation, patients who may have entered the consultation expecting an antibiotic were often satisfied not receiving one as long they were able to provide an acceptable explanation of why antibiotics may not be the optimal treatment and alternative treatment to

provide symptomatic relief was undertaken. However, there were a minority of instances where refusal of an antibiotic led to a breakdown in the consultation.

“Most people are accepting of it because they trust your judgement and your professionalism and if it’s put over properly and the facts are explained I think the majority of people never have a great problem with it at all. I’ve never had anybody leave the surgery unhappy about the fact that I haven’t given them a prescription at all... as long as it’s explained to them properly and we can alleviate their pain by other clinical means then they’re more than happy.”

GDP37, male, predominantly private, qualified >30 years

“I’ve also had a case whereby a girl she was over sixteen but she was coming in with her mother. I’d taken her tooth out but the next time they came in the mother had apparently spoken to a neighbour and the neighbour had said, ‘Oh she should have had antibiotics’, and the mother was absolutely furious with me that I’d taken her tooth out but didn’t give antibiotics and they refused to come anymore.”

GDP3, female, predominantly NHS, qualified 21-30 years

When asked why patients may expect an antibiotic during a consultation for toothache, the majority of practitioners highlighted that previous antibiotic prescriptions for an acute condition probably played a role and heightened expectations of receiving an antibiotic during future episodes of pain.

“They often seem quite content to go away with some antibiotics and I think we have sort of created that for ourselves really as dentists because of expediency we’ve given them antibiotics, perhaps knowing it wasn’t absolutely the right thing to do.”

GDP23, male, predominantly private, qualified >30 years

Dentists’ perceptions of their patients’ attitudes towards antibiotic resistance broadly fitted into one of two typologies: those possessing low level anxiety about antibiotic resistance and those with increasing (although not necessarily high) anxiety. Low anxiety patients were typically characterised as being more likely to belong a socially disadvantaged group and were perceived to have limited awareness of aetiology and consequences of antibiotics. Clinicians reported that patients with lower concern were less likely to consider antibiotic resistance a personal threat

and were more likely to prioritise potential immediate benefits of antibiotics over long term considerations of resistance. Clinicians perceived that patients within this group may be more likely to request or expect an antibiotic during a consultation for an acute condition. In contrast, patients with increasing anxiety about resistance were perceived to be from less deprived social groups and more reluctant to take antibiotics due to potential consequences, such as gastrointestinal upset.

“I think there’s been a lot of, I’ve seen a lot more in the press about GPs not dishing out antibiotics anything like they used to and obviously all the bacteria, the distance. I think it has dawned on a lot of people and again this is going to sound awful but I think a lot of the sort of lower classes seem to want antibiotics more than maybe the middle and upper ones. I don’t know why that is but they’re the ones who say, ‘Oh I just need a prescription, off I go’, sort of thing. We don’t see it quite so much as we used to now we’re private”

GDP32, female, predominantly private, qualified 11-20 years

“In fact a lot of patients now prefer not to have antibiotics... Some of them appreciate some of them have side effects, things like thrush, etcetera”

GDP23, male, predominantly private, qualified >30 years

7.5 In control?

7.5.1 An issue of time

During the course of the interviews practitioners discussed a number of issues that could influence their management of adult patients with acute dental conditions. However the factor discussed most consistently, and the one that clinicians reported had the most significant influence their antibiotic prescribing behaviour, was the availability of clinical time. Patients described how the amount of time they had to manage a patient often dictated, to a greater or lesser extent, the treatment plan they proposed, particularly with reference to unscheduled emergency care. Many dentists described how, in an ideal world, the majority of patients with an acute condition would receive an operative intervention during a consultation for pain, but

that such treatment was time consuming and could adversely impact their ability to complete scheduled care for subsequent patients.

“It really depends whether that patient presented at a time when I had a fair bit of time on my hands. Now if I was under pressure, I will be honest and tell you that I will write them a prescription for some antibiotics, if I’ve got six people sitting waiting for treatment, you know... I always think you know, would you, if you were the patient, would you be wanting that particular type of treatment? That’s the question you have to ask yourself and in an ideal world we’d all be able to answer that correctly but you know I don’t think there’s any dentist living that hasn’t just reached for the prescription pad at some point because of time constraints.”

GDP26, female, predominantly NHS, qualified 21-30 years

In these situations, antibiotics were viewed as an alternative to providing operative care, rather than an adjunct to surgical management. Whilst there was awareness amongst practitioners that antibiotics were not the optimal treatment for most acute dental conditions, by and large the dentists interviewed believed that patients would experience symptomatic relief from antibiotics when provided for odontogenic infections.

“INT - If you gave them antibiotics in that situation do you think that would probably be good at settling the pain down, it would kind of buy them some time? Or do you think its more just to give them something to keep them happy?”

GDP - No, no, I think it generally seems to get rid of the pain. If they genuinely have an infection there, you know, not immediately but within a couple of days you tend to find that they're out of pain in my experience, after taking antibiotics. So its not just about placating the patient, it does seem to have an effect.”

GDP22, male, predominantly NHS, qualified 11-20 years

When making decisions about the management of acute cases, practitioners described how they balanced the severity of a patient’s condition, potential improvement operative treatment may provide, possible consequences not providing operative treatment and the impact of providing operative treatment on the remainder of their clinical day.

“...especially if its the middle of the day and you're busy already and you're running behind you, you try to do what you would do normally, if the pulp needs extirpating you try to do it, then and there, but I do find myself sometimes making excuses for myself, to try to get away from operational treatment, especially if its going to be a long, drawn out process if I'm running behind. But I try not to... For example, a patient comes in with a tooth which is unrestorable. He's showing some signs of systemic involvement with maybe a little bit of lymphadenopathy, and maybe a bit of swelling. Normally I would say, 'Well let's go and then, just extract it anyway', but if I'm really pushed for time then I'll say, 'Well, there's a lot of swelling there, it probably won't numb up as well, we'll just give them some antibiotics and come back in a couple days time when we'll do the extraction'.”

GDP10, male, predominantly NHS, qualified ≤10 years

“... sometimes they will come in and they've got a huge facial swelling and all you can do is drain it or incise it and give them an antibiotic prescription, or if they come in and they've got a pulpitis and you've got to get the pulp out and you've got to get them numb to get the pulp out, and it can be difficult to do that, you can be forty-five minutes. Just before Christmas actually I had a guy who came in with a huge swelling under a huge bridge and I had to. It took me; it took me an hour to find the pulp chamber under the bridge. But there are occasions when we get a genuine emergency like that. I mean his eye had closed it was a real big swelling and my receptionist will just tell patients who are booked in, 'I'm sorry there's an emergency and we have to deal with it.'”

GDP26, female, predominantly NHS, qualified 21-30 years

In situations where practitioners elected to undertake operative treatment that exceeded the time they may have available, this would often result in them running late for subsequent appointments. Practitioners expressed an array of attitudes towards this, some avoiding it all costs, others being more willing to run behind, accepting that unscheduled care was part of the nature of their business. The culture of the general practice the dentist was working in appeared to play an important role in dictating their attitudes toward running late. The following two examples demonstrate two different practice philosophies.

“...there can be pressure from other members of the team. I think receptionists can drive, can put pressure on you so if you're running behind, you know, patients are complaining at the desk. I think nurses can also put, you know, they have an impact as well if they're disgruntled about the fact that that you're running late they're not going to be happy if you then get into complex treatment... I'm not saying its all down to other members of staff at all, its primarily down to the dentist and their own opinion on it, whether they're, willing to run late, whether they're, you know, able to carry out the treatment in the allotted time but I think those other factors will have an impact too on sort of like, the culture of the practice really, and the attitudes within the practice.”

GDP22, male, predominantly NHS, qualified 11-20 years

“People are told they have got to sit and wait and people are happy to do so...my nurses are always very happy to work into lunchtime because it means they get paid more and they feel they eat less. And also we invariably have a spare surgery so you can sort of, do a bit of juggling... For whatever reason we have a spare number of staff as well. It's quite, it's actually quite efficient if they are in a room greeting the patient. If the patient has taken their coat off, had a bit of a chat that I kind of appear. And although I do, we do have quite a lot of a chatting time which is why I do run late, it's actually quite an efficient way of doing things in a busy NHS practice...I find it quite exhilarating.”

GDP15, female, predominantly NHS, qualified 10-20 years

Overall, GPs who expressed a more relaxed attitude towards running late tended to have more flexible appointment schedules or protected time to treat on-the-day emergencies, so only infrequently encountered intense clinical time pressures. Several of these practitioners also described how increasing clinical experience and professional stability had led them to feel more empowered about occasionally running late.

“INT - Going back to that gentleman you mentioned who had the abscess associated with the bridge. How did that, how did seeing him and treating him impact on the rest of your day?”

GDP - It put me an hour behind all day

INT - How did that make you feel?

GDP - If you'd asked me the question twenty years ago I'd have said I would have been in a right flap about it, but having been in practice for over twenty-five years I just accept it. And I've learnt to deal with it really I suppose. It's not a good feeling when you've got a waiting room stacking up. It doesn't make you, it does make you tense and it also cuts short treatment that you might have wanted to do on the next patient because you think oh well I'd like to do A, B, C but I'll have to do something else instead. So it does impact on your day but I try, I genuinely try not to let it bother me because if you go down that road you've lost everything then you know? You've just got to keep it together haven't you?”

GDP26, female, predominantly NHS, qualified 21-30 years

However other practitioners, particularly those providing predominantly NHS care, described working conditions where they habitually felt that they had insufficient time to provide operative treatment to unscheduled emergency patients. Many of these practitioners routinely employed a two-stage treatment plan where antibiotics were provided at the initial consultation and the patient rebooked for definitive, operative treatment within the next few weeks. Overall these practitioners tended to be younger and were more likely to be employed as associate dentists than practice owners.

“My pain appointments are double-booked at half eight or two o'clock. If I have got time to do treatment I will do, but if someone needs a molar opened and dressed which is going to take me, you know, fifteen, twenty minutes, and I've got three people in the waiting room you know what I'll do, because I only actually book, you know, a week in advance, I'll give them some antibiotics to settle down the pain or, you know, put a temporary filling in, or whatever it is I need to do to stabilise it for the time being and then, you know, rebook them in a week or in a couple of days. Or quite often I'll take their names for a cancellation list and I can normally get them in within a day or two then.”

GDP6, female, predominantly NHS, qualified ≤10 years

Split treatment plans were considered effective by these practitioners at controlling symptoms and perceived as offering greater predictability, both for the success of operative treatment and for the day to day organisation of their appointment schedule. A particular scenario cited on several occasions was the presentation of a patient with facial swelling with practitioners describing how local anaesthetic solution may not be effective in such patients. Anxious about both the unpredictability and time multiple local anaesthetic injections may take, many elected, rather than to try and fail, to provide antibiotics at the initial visit and wait for the resolution of any swelling when they perceived that the likelihood of failure was much lower.

“...I try not to inject into the infected area because I think that you know, the problem is a lot of times it works but when it doesn't work it goes horribly wrong...quite often they have waited that long to come in, you know they are a bit pyrexia, they're not feeling well...But probably we try, at least I myself try not to just give them an antibiotic and send them off, I try to get them back in within about three or four days, maximum a week and then start the extirpation or the extraction...generally you find that if they have come in and I would say within about 4 days you are more or less guaranteed a response.”

GDP59, male, predominantly NHS, qualified 21-30 years

“If I’m going to go down the antibiotics route it might be if there’s some facial swelling already present and the root canal looks an awkward one to do, if I’ve got a very nervous patient and particularly if it’s not my patient I might be less inclined to, you know, attempt an awkward operative procedure and have it all go wrong on me then step in there and try and calm the symptoms down and deal with it in a more controlled manner.”

GDP23, male, predominantly private, qualified >30 years

7.5.1.1 Time and money - the business of dentistry

Whilst discussing the clinical time pressures the majority of practitioners articulated, either implicitly or explicitly, the association between time and financial productivity in general dental practice. Many of the dentists interviewed, particularly those who were practice owners, identified themselves as both clinicians and business-people simultaneously. Whilst for the most part these identities co-existed harmoniously, there were instances where practitioners acknowledged the difficulties balancing opposing responsibilities. This was particularly revealed when talking about protected time for unscheduled cases. Whilst most practitioners identified that protected time would allow dentists more time to undertake operative treatment for patients with acute conditions, there was recognition that, should this time remain unfilled, there would be a financial implication for both the practitioner and practice, and as a result some clinicians would be hesitant about the introduction of such a system. Even GDPs who would welcome the introduction of a system could identify colleagues who would be reluctant to make the change.

“They [colleagues] don’t take such a broad view of things, they see each individual five, ten, fifteen minute slot as an ability to earn X, Y and Z and therefore you know, what happens is they were seeing it as perhaps as a dead half an hour where they weren’t going to earn anything. Whereas if you look at it as a round robin and you see it at the end of the day it’s sort of, it’s the same as all treatments on the NHS, there’s some that you make money on, there’s some that you lose money on, it’s you just have to accept that, its swings and roundabouts so yeah.”

GDP33, male, predominantly private, qualified 11-20 years

Practices that had moved to such a system for emergency appointments were more likely to be those providing predominantly private dentistry, where practitioners reported there was less pressure to fill all available clinical time due to consistent remuneration or higher returns per item of treatment.

“INT - We’ve talked right at the beginning about your appointment schedule and how this allows you to set aside designated time for treating people with dental pain. Do you think maybe if other practices moved towards that system it would help prescribers do more operative treatment and maybe prescribe fewer antibiotics?”

GDP - Yes definitely, but that would be a very hard thing to convince dentists to allow a period of time that might not be filled. I mean I’ve always adhered to it but I’m cushioned slightly as much as our service is subsidised by [NAME COMPANY] to a degree, only to a degree it’s not a massive subsidy but it does give me that little bit of flexibility to spend a bit more time with patients but general practice is obviously not like that.”

GDP37, male, predominantly private, qualified >30 years

“GDP - I think in the past if I’m being completely honest, if you did have someone you would give antibiotics more than I do now because it was a quick and easy and then they’re off and then they come back later to have whatever it is they need. But nowadays you tend to, we don’t give antibiotics, we do tend to spend more time having a good look at the tooth or do an extraction or whatever.

INT - And would you say that’s because now you’re on the Denplan and the private system your appointments are slightly longer?”

GDP - Yeah, yeah.”

GDP32, female, predominantly private, qualified 11-20 years

In comparison, several dentists predominantly providing NHS subsidised care explained that it would be hard to implement protected emergency slots in their practice mainly due to the pressures they already experienced trying to provide scheduled care. There was a view amongst a number of NHS practitioners that the current contract resulted in a ‘treadmill’ of treatment, which prioritised volume over quality of care. These GDPs were constantly aware of the need to

maximise clinical time and of the repercussions should they fail to fulfil their contractual obligation of Units of Dental Activity (UDAs). Several dentists providing predominantly NHS care were disillusioned with the working conditions they felt the current NHS contract implemented and felt generally disempowered to make changes within their practice.

“I think that maybe they’ve [antibiotics] been used just a little bit too widely. I think also that maybe within dentistry specifically we work a little bit within the NHS on a conveyor belt, seeing as many people as we could maybe, seeing people quickly rather than maybe trying to do some operative treatment that would relieve the situation that somebody’s presented with”

GDP3, female, predominantly NHS, qualified 21-30 years

“I’m going to go back to the old chestnut now of the NHS contract that we have. It’s clearly not working, dentists are under huge pressure, and particularly associates which I am not, but you know, I know of associates who are working for the corporates who are demanding you know fifty UDAs a day well you know a young dentist can’t produce that and do quality, decent work and that’s what it comes down to really... I can’t do much more than thirty UDAs a day if I’m doing it properly so when I hear of people doing fifty, and in excess of fifty, I know they are cutting corners because there is no way that you could do it.”

GDP26, female, predominantly NHS, qualified 21-30 years.

However, there were a minority of practitioners who reported that their NHS practice had taken other steps to improve their emergency care provision. Generally this had occurred following a critical build-up of pressure, and therefore changes resulted were made not only because of the desire to provide more effective care for patients but also due to a sense of distress related to the conflict within the practice. In the following example the practice had moved from a system where patients with acute (or even non-acute conditions) were double booked over scheduled care to a sit-and-wait arrangement.

“When they were being squeezed in there was more pressure of thinking, ‘Oh I’ve got another three waiting, I’ll just write a prescription and get them out of the door,’ but I think everyone’s, you know, certainly within the Audit and everything that we’ve been doing, it’s registering that we shouldn’t really be giving out but people are yeah much more conscientious now I think... We discussed it at a practice meeting how to sort of get through the emergencies because it was becoming quite a, relationships were breaking down with reception and with the dentists really and it wasn’t fair on either party. No one was to blame but it wasn’t really how it should be run, so we had to chat it through and decide what we were going to do... And it has cut down on the ones who are, ‘Oh I’ve chipped a tooth, I need some treatment now.’ They do tend to be dental emergencies.”

GDP58, female, predominantly NHS, qualified, ≤10 years

7.5.2 Uncertainty, outcome expectancy and self-efficacy

When managing patients with acute conditions, practitioners acknowledged that there frequently existed both diagnostic and prognostic uncertainties related to care, and that these had an influence on the management a patient may receive. In cases of diagnostic uncertainty, antibiotics were also seen as a minimally invasive intervention if the origin of pain could not be located.

“if they're flying to Spain tomorrow morning and I can't, you know, they clearly need something done but without seeing, without being able to localise the problem and see what exactly needs to be done I'd rather give them antibiotics where it might not possibly be needed than open a canal or take a tooth out if, sometimes, not often, it's the better of the two devils.”

GDP4, female, predominantly NHS, qualified ≤10 years

Incidence of diagnostic uncertainty appeared to have an inverse correlation with length of practicing career, with practitioners refining and becoming more confident in their diagnostic abilities with increasing time in practice.

"I think I'm more, I'm more sort of confident in my diagnosis. I am more confident in my decision making. I think when you first qualify you need everything to indicate that there is a tooth that needs a nerve taking out of it so you want to see the area on the X-ray and you want to see the deep filling or you want the history of having done the deep filling. You want everything, all the boxes ticked whereas and I think if they are not you're naturally a little bit more cautious and therefore you might be inclined to well let's just try this for a few days even if it just gives you time to think a little bit more or gives the condition a little bit more time to develop so it becomes a little bit more clear cut and you know so I think as you got greater experience I think you more confidently make a diagnosis."

GDP33, male, predominantly private, qualified 11-20 years

Furthermore, whilst participants generally felt that undergraduate training in the management of acute conditions had provided information on the scientific aetiology and pathogenesis of odontogenic infections and associated conditions, some considered that it left newly qualified practitioners insufficiently equipped to make effective clinical decisions with regards to managing patients with acute dental conditions. This may reflect that the balance of undergraduate education is more weighted to providing scheduled, routine care than managing emergency cases.

However, unlike diagnostic uncertainties, prognostic uncertainties did not seem to decrease with increasing clinical experience. Whilst many practitioners accepted that a degree of prognostic uncertainty was inevitable, it created unease, particularly if a patient would be unable to access further treatment should a problem arise. In this situation many dentists viewed antibiotics as providing a precautionary defence against future pain and was such viewed as providing a comprehensive 'belt and braces' approach to care.

"..say you've done the root canal and you've started it and you think, I don't want this patient going to hospital with a problem as well, but then I would think, 'I might just belt and brace this one' and give them antibiotics too if they're unwell anyway but that's the only time yeah."

GDP58, female, predominantly NHS, qualified, ≤10 years

Practitioners also described instances where, due to the past history of a tooth and uncertainties regarding its prognosis, they would consider providing antibiotics to a patient, typically who was about go to on holiday, even in the absence of current symptoms. Prescribing in this situation was possibly more about appeasing the anxieties of both parties and maintenance of the practitioner-patient relationship than the possible clinical benefit that may arise from the administration of systemic therapy.

“I won't lie, there have been times when patients have been going, going on holiday, and they've actually come in saying that they're a bit concerned about a tooth, but it's not causing problems at the moment and I have, I have again I know it's not something one should do but I have given them a prescription to take away.”

GDP8, male, predominantly NHS, qualified >30 years

However, if a practitioner was able to reassure both themselves and their patient that effective emergency care would be accessible in this situation they reported feeling less inclined to prescribe an antimicrobial.

“INT - And if the patient came in and you felt they did expect antibiotics, ‘Well I’m going on holiday and I don’t want this to flare up’, would you feel more likely to prescribe them do you think?”

GDP - Yes I think I would. Yes I would. Well actually, again ironically perhaps with [NAMED COMPANY] taking over our practice if they were on holiday in this country I would feel less so because there is a little bit of an ability to go to another practice of [NAMED COMPANY] and they are around the country. But certainly if they were going abroad I wouldn't really have much hesitation. If I had just provided a patient with an extraction or extirpated a tooth and were going on holiday the next morning or something I probably would give them some antibiotics just to put in their toilet bag just in case basis rather than them have to try and find a dentist while they are away.”

GDP33, male, predominantly private, qualified 11-20 years

Whilst all practitioners identified clinical scenarios where operative treatment would most effectively relieve the symptoms of a patient suffering from an acute dental condition, a minority of practitioners described how they lacked confidence to complete such procedures, in particular incision and drainage of an intraoral swelling, surgical extractions or complex

endodontic treatment. This lack of self-efficacy meant they were less likely to initiate these treatments and, as a result these practitioners may be more likely to prescribe antibiotics in such scenarios.

“...sometimes it is a little bit, the whole idea of shoving a scalpel in and things, you know, that’s a bit terrifying for a lot of people”

GDP58, female, predominantly NHS, qualified, ≤10 years

In contrast, practitioners perceived a higher self-efficacy were more likely to initiate this kind of treatment and, as a result, reported prescribing fewer antibiotics.

“I would say is that I’m more confident with treatment now so I’m much more likely to get stuck into an extraction now than I was when I first started, when I first graduated I might have been much more cautious about which extractions I would take on in an emergency appointment and which ones I wouldn’t, and also about endodontics as well. Whereas now I’m much more confident about those things. So that will have altered the prescribing profile I’d imagine I’d be prescribing less because I’m more comfortable doing the treatment than I was at that point”

GDP22, male, predominantly NHS, qualified 11-20 years

7.6 Summary of findings

GDPs considered antibiotics a useful tool in the management of acute conditions. They described how, in an ideal world, fewer antibiotics would be prescribed and more operative treatment undertaken during the management of acute conditions, but acknowledged there were many factors that influenced the management of patients presenting with an odontogenic infection or associated condition. Some knowledge barriers existed in relation to the integration of clinical guidelines into practice and many of the practitioners did not regularly access postgraduate resources about prescribing. Patient willingness and ability to accept operative treatment was cited by many as an important influence on prescribing behaviours, as were issues of diagnostic and prognostic uncertainty. A minority of practitioners also described limited self-efficacy and lack of outcome expectancy in relation to undertaking operative treatment during acute conditions.

The primary influence on antibiotic usage was the availability of clinical time. Practitioners highlighted the difficulties balancing the provision of effective symptomatic relief for patients with acute conditions against the pressures of providing scheduled care for other patients. Many practitioners felt resigned that this was the nature of dental care and only a majority described changes that had been made within their practice to address concerns related to availability of clinical time.

Many GPs did not feel urgency to change their prescribing pattern and most practitioners thought their prescribing was as good, if not better, than the rest of their profession. They perceived that their prescribing contributed minimally, if at all to problems of increasing antimicrobial resistance. Any changes they described in their prescribing patterns were subtle and were usually the substitution of one type of antibiotic for another.

The autonomy of decision-making with relation to antibiotic prescribing meant GPs were unlikely to question the practice of colleagues, even if they considered their use of antibiotics inappropriate. Similarly, many were reluctant to receive feedback about their own prescribing behaviours.

Discussion of the main results of this chapter and the implications for practice and future research are presented in Chapter 9.

8. The Presentation and Management of Dental Conditions in General Medical Practice: a Qualitative Study - Results

8.1 Introduction

Analysis of the CPRD consultation data has allowed the quantification of dental consultations in general medical practice in the UK (Chapters 4 and 5). However, in order to gain a deeper understanding of the impact of dental consultations with general medical practice, a qualitative investigation was undertaken with a sample of general medical practitioners (GMPs) working in Wales. The methods of this study are described in Chapter 7.

The following chapter explores the three principal themes arising from the data: experience of and attitudes towards dental consultations in general medical practice (Section 8.3); the use of antibiotics in the management of dental problems and factors that influence the use of antibiotics in dental conditions (Section 8.4), and professional relationships between primary care doctors and dentists (Section 8.5).

8.2 Sample

One hundred and seventy practitioners were sent brief written information about the study and invited to participate. In total 42 practitioners expressed an interest in learning more about the study and 18 returned their consent form. Of the 17 GMPs interviewed (one consenting practitioner did not return further communication), 9 were male and the median number of years since graduation was 21. All but two qualified from medical schools within the UK. Five Welsh Local Health Boards (LHBs) were represented in the sample and practitioners came from a mix of urban (13/17) and rural locations (4/17) as determined by the 2011 Rural-Urban Classification for Small Area Geographies (Office for National Statistics 2013a). Fourteen practitioners worked in practices in areas which had Wales Index of Multiple Deprivation 2011 (WIMD '11), the official measure of relative deprivation for small areas in Wales (Statistics for Wales 2011), ranks indicating they served the 50% most deprived areas, whilst three were from practices which had WIMD '11 scores suggesting they served the 50% least deprived areas. Interviews lasted on average 23.6 minutes (SD 8.0 minutes).

Practitioner ID	Gender	Number of years since qualification	Practice location	Local deprivation
GMP2	Female	≤10 years	Urban - city and town	50% most deprived ranks
GMP6	Female	>30 years	Rural town and fringe in a sparse setting	50% least deprived ranks
GMP7	Male	≤10 years	Urban - city and town	50% most deprived ranks
GMP8	Male	11-20 years	Rural town and fringe in a sparse setting	50% least deprived ranks
GMP11	Male	21-30 years	Urban - city and town	50% most deprived ranks
GMP14	Male	>30 years	Urban - city and town	50% most deprived ranks
GMP15	Male	11-20 years	Urban - city and town	50% least deprived ranks
GMP18	Male	11-20 years	Urban - city and town	50% most deprived ranks
GMP21	Male	≤10 years	Urban - city and town	50% most deprived ranks
GMP27	Female	21-30 years	Urban - city and town	50% most deprived ranks
GMP30	Female	21-30 years	Urban - city and town	50% most deprived ranks

Practitioner ID	Gender	Number of years since qualification	Practice location	Local deprivation
GMP32	Female	11-20 years	Urban - city and town	50% most deprived ranks
GMP33	Female	21-30 years	Urban - city and town	50% most deprived ranks
GMP37	Female	11-20 years	Urban - city and town	50% most deprived ranks
GMP38	Female	21-30 years	Urban - city and town	50% most deprived ranks
GMP39	Male	21-30 years	Rural town and fringe in a sparse setting	50% least deprived ranks
GMP40	Male	21-30 years	Rural town and fringe in a sparse setting	50% most deprived ranks

Table 8.1 – GMP characteristics

Number of years since qualification – since primary medical degree

Practice location – determined by 2011 Rural-Urban Classification for Small Area Geographies, based on practice postcode

Local deprived – determined Wales Index of Multiple Deprivation 2011 (WIMD '11) ranks, based on practice postcode

Explanation of participant identifiers

Participant ID, gender, number of years since primary qualification, practice location

e.g. GMP14, male, qualified >30 years, urban practice

8.3 Experience of and attitudes towards dental consultations in general medical practice

8.3.1 Frequency of dental consultations

Dental consultations were not unusual occurrences in day-to-day general medical practice, with reported frequency per clinician varying from approximately once a week, to once every few months. Whilst some practitioners reported that the rate of dental consultations had remained relatively stable over the previous few years, there were GMPs who described how the number of patients attending with dental problems had increased or decreased during their time at the practice. Increases in dental consultation frequency were most often attributed to the reduction or disruption of local NHS dental services, for example a local dentist going private. In comparison, reductions in the number of patients attending with tooth-related problems were credited to improved access to dental services, more rigorous triaging systems or the education of patients regarding where to access appropriate dental care.

“It may be that they're not getting through the triage system to us. It may be that they're being given better advice on contacting the practice by telephone and they're being told, 'Look if this is a dental problem you need to see a dentist not a GMP and you know, you can access a dentist through NHS direct.' ... It's one of these things that we see, I think less frequently than we did a couple of years ago, whether that's, whether our behaviour has influenced that by refusing to, well not refusing to treat them but by being fairly blunt about the fact that they've come to the wrong professional, or, I don't know but it's less, it certainly feels less of a problem anyway.”

GMP15, male, qualified 11-20 years, urban practice

Several practitioners described how the rate of dental consultations varied between the practices they had worked at. These differences were usually attributed to differential healthcare seeking behaviours of the local populations, and these appeared to be strongly associated with patients' socioeconomic status, with patients from more deprived areas considered more likely to present with a dental problem.

“We actually saw more [dental patients] I would say. And I think it's more because of, I don't know whether it's kind of, demographics of the area, but it was quite a deprived area that we were working in and patients just because of, you know, deprivation, in terms of poor access to transport and things like that, they wouldn't necessarily either have a car or, you know, even have money to pay for a bus, so they would come to see the GMP because of everything and anything, you know?”

GMP21, male, qualified ≤10 years, urban practice

8.3.2 Why patients see their GMP with dental problems

When asked whether patients with dental problems attended exclusively due to tooth-related complaint or whether it was more commonly raised along with a collection of other concerns, GMPs replied almost unanimously that dental consultations were usually the sole motivation for attending. Dental consultations were usually booked-in at short notice or presented during open surgery.

“Usually if it's a dental problem, it's usually a one stop problem really. It's very rare I think that someone will raise a dental problem in amongst a shopping list of medical problems. If they've got toothache, they've got toothache, and they're in with that!”

GMP15, male, qualified 11-20 years, urban practice

Patients attending for dental consultations were typically characterised as likely to be of working-age and socioeconomically deprived. One practitioner described a high prevalence of mental health problems within the population of patients consulting for tooth-related problems. Such co-morbidities may contribute not only to poor self-care, but also impact on an individual's ability to access mainstream dental services.

“They're not so much the younger ones or children, and not so much the older ones. They're mostly, well, twenties to sixties. Bit of wide middle-age range but it's that age range, possibly skewed a bit to the lower income end. Also skewed in that a significant proportion of them will have other problems particularly mental health issues and therefore they've not looked after their teeth for many years.”

GMP40, male, qualified 21-30 years, rural practice

Practitioners described a number of reasons why patients may consult a GMP when experiencing dental problem and these factors were often interrelated. Of these, difficulties accessing dental services and the comparative ease of access in primary medical care were the most commonly cited explanations. Several GMPs described how local dental services had suffered financial or workforce shortages, which led to difficulties providing adequate levels of access to emergency dental care for their patient population.

“...there’s a huge problem with recruitment for dentistry. I would say about five years ago now, things were desperate then. Nobody could get registered.”

GMP6, female, qualified >30 years, rural practice

Practitioners also explained how a historical lack of access had resulted in persistent belief amongst patients that they would not be able to access care, years after the local situation had improved. This, they described, discouraged patients from trying to register with dental services as there was an assumption they would be unsuccessful. Practitioners also recognised that patients who did not prioritise dental care may be poorly motivated to register with a dentist prior to an acute episode. Both groups of patients may therefore encounter difficulties identifying where they could get emergency care when they had dental pain.

“I think probably a lot of the population that we have are not very proactive when it comes to looking after their health so maybe because we’re not particularly a middle class area, people wouldn’t think about going and having routine checks. They’d wait until there was a problem.”

GMP32, female, qualified 11-20 years, urban practice

“I think perhaps just the lack of awareness of the other options that are out there. I mean some patients will try NHS Direct who might point them in the right direction but I think none of them are really aware of the Dental Hospital or you know other sources of emergency dental care.”

GMP7, male, qualified ≤10 years, urban practice

Even if a patient is registered with a dentist, GMPs described how limited appointment availability or length of travelling distance may discourage or prevent a patient from seeking emergency care from their dentist, often resulting in a general practice consultation instead.

“The patients often say they can't get in to see the dentist for, you know, a week, a fortnight, a month or whatever... Or they say that their dentist is, is, twenty miles away or ten miles away and they can't, they haven't got access to him because they haven't got transport that day. Whereas the patients with us they tend to be registered in our locality, so even if they haven't got transport they can still walk to the surgery.”

GMP14, male, qualified >30 years, urban practice

In comparison, GMPs described how their surgeries provided same-day appointment arrangements and that patients were often very familiar with how to access these. In some cases GMPs perceived that access was so easy at their practice it had resulted in a lower threshold at which patients would seek care.

“I suppose what happened when we had the walk in access I think we almost created a monster of expectation because people could just trot in and see their GMP and actually that wasn't really helping them to learn what was reasonable health seeking behaviour.”

GMP33, female, qualified 21-30 years, urban practice

“I think a lot of the time these patients don't know how to access the help that they need and we're very identifiable and very easily accessible.”

GMP7, male, qualified ≤10 years, urban practice

Practitioners described other instances where a patient may specifically elect to seek treatment for a dental problem from their GMP rather than a dentist. These were typically instances where a patient was dissatisfied with previous dental treatment or suffered from a dental phobia. In this latter situation, GMPs explained that patients may favour consulting general practice for a dental problem because they knew that there was no possibility of having to undergo operative treatment.

“We do have some patients who say they're too scared to go to the dentist and we do spend quite a lot of time and say if you do tell the dentist that you are a nervous patient they can do quite a lot to put you at your ease. Some of them think it is, if people haven't had recent experiences then they're going on what their mum said fifty years ago. And I think that puts them off a bit.”

GMP32, female, qualified 11-20 years, urban practice

Whether a patient might seek emergency care from a doctor rather than a dentist due to financial reasons drew conflicting opinions amongst the doctors interviewed. Whilst some felt

that having to pay to see a dentist would be unlikely to influence a patient's choice of practitioner, many others felt that the costs associated with dental treatment were considered prohibitive by some patients. One GMP went further and discussed a sense of entitlement he perceived amongst his local community. He explained that whilst most were able to pay for treatment, many were motivated to seek care from free providers in preference to services that were associated with a fee.

“Particularly in our area where to be honest wages are not high. People have to be careful how they spend their money and if they think they can get something free from the GMP, particularly when prescriptions are free in Wales and then they have to go and see a dentist and pay for a prescription. I don't really know what else.”

GMP39, male, qualified 21-30 years, rural practice

“We have the same thing with opticians; people come to us with visual problems and they pure and simply should have gone to see the optician. But if they go and see the optician, usually they've got to pay, granted not always, but usually they have. So they're like, 'Let's go where it's free'. Yeah? It's human nature basically, or it's human nature in South Wales [laughs]... I say this type of thing to people working elsewhere and they're absolutely gobsmacked that the patients are doing it, they say, 'Well, no, our patients never do that'... I think it's inbred within the working class community of South Wales basically... Nobody knows the reason why, it's so deep rooted, it's just permanently in the Welsh person's psyche. And the other thing I'm wondering, was it because of Nye Bevan, when he set up the health service? He based the model of the health service on the, the systems they had in the mining valleys where the miners used to pay a contribution every week and mine owners would then employ a doctor on their behalf. So the implication was, 'I'm paying every week to employ you, and therefore you are my doctor now and you do what I want you to', you know? It's been, it may have been, passed down from generation to generation.”

GMP14, male, qualified >30 years, urban practice

There was also recognition amongst most GMPs that some patients attended their medical practice with the sole aim of obtaining antibiotics for a dental condition. GMPs thought motivated by prior experience of receiving antibiotics from a dental practitioner for a similar condition. Practitioners believed that when combined with easier access available at GMP practices, the fact that they would receive broadly equivalent therapy from either service may motivate patients to attend their GMP for antibiotics to stabilise their condition. There were also

anecdotal reports of patients being directed by over-stretched dental services to seek antibiotics from their GMP.

“Most of the time they have like a preconceived, you know, perception of what's going on. So, most of the time they'll say, 'I think I've got an abscess doc, can you give me some antibiotics, it worked last time?' And some of them will be quite, kind of, informed, in the sense they'll say, 'I've had this problem before, I've been to my dentist and they normally say, 'Have some antibiotics, and once it's settle down we'll consider, you know, intervention, whether it be, like root-, ' I don't know what they do, root canal or drainage or whatever. So they'll say they can't get an appointment anyway, they know the dentist is going to say, 'Have antibiotics', so, you know, by the time they see the dentist next they've had the antibiotics and they're at stage two anyway, do you know what I mean?”

GMP21, male, qualified ≤10 years, urban practice

“I haven't had it recently but certainly up until as recently as two years ago we would get patients turn up having been apparently sent by a dentist, they're telling our receptionist that they have to come and see the GMP. What was actually happening is that there's a dental practice in [NAME PLACE] where the receptionist at the dental practice was seeing the patients and telling them to get antibiotics off the GMP and not to bother the dentist again until they'd got better.”

GMP40, male, qualified 21-30 years, rural practice

The final reason described by clinicians as to why patients with dental problems may seek care from a medical practitioner was related to referred or poorly differentiated pain. This was recognised as complexity of diagnosing pain of the head and neck and patients attending for this reason were, overall, viewed more sympathetically than those with a cut-and-dried dental problem.

“We see patients that might have, or they think they have, sinusitis but it's actually a dental abscess. So that would be one case. We see quite a lot of patients with unexplained earache that they would present to us but it's actually toothache but they think it's referred pain, they think it's an earache.”

GMP38, female, qualified 21-30 years, urban practice

8.3.3 Attitudes towards dental problems in general practice

Attitudes towards the dental consultations varied amongst the GMPs interviewed. Whilst there was a consensus that general practice was not the optimal environment for dental problems to be managed in, a minority of GMPs considered that the management of dental problems was usually only a marginal inconvenience in their day to day practice. These practitioners described how consultations for dental problems were typically swift and relatively straight forward, and could even provide an element of relief following more complex patients. These practitioners seemed reconciled to the reality of dental problems in general practice and preferred to 'grin and bear it' rather than take any action to reduce the frequency of dental consultations.

"It is usually a brief consultation which, for me, is quite pleasant for me to have a short, brief consultation rather than somebody walking in with a list of about ten different things. Yeah? Not that I welcome it but I don't find it a burden."

GMP14, male, qualified >30 years, urban practice

However, more moderate practitioners expressed that when under pressure, they began to feel somewhat exasperated with dental consultations. This was compounded by little to no financial reimbursement for dental consultations and the fact that these appointments often resulted in prescriptions and therefore, medicines cost.

"You know the occasional patient, I don't think any of us really mind, they're not long consultations, they're not complex consultations, or challenging consultations, you just get on and do it because it's an emergency consultation. But certainly if you get a week where, you know you get days where there are three or four dental patients in and you think, 'That's an hour', when we've got waiting lists and it's a frustration. And then you kind of think, 'This is not something we're going to be directly reimbursed for, either'.

GMP2, female, qualified ≤10 years, urban practice

Some GMPs were more overtly opposed to seeing patients with dental concerns. They described how they considered dental consultations an abuse of the system and diverted resources away from patients presenting with more GMP-appropriate complaints.

“Absolutely a huge time waster... I don’t want to give you the impression we’re suffering, but I think since the new contract we do thirty percent more work than we safely should do so all it takes is a couple of toothaches on your screen who want a phone call and you’re really biting your tongue.”

GMP11, male, qualified 21-30 years, urban practice

“[sighs], I think that sigh says it all... my standard line to them is that they've gone to the wrong professional, it'd be no different than someone coming to see me and saying that they wanted me to cut their toenails or to perform some physiotherapy on them. You know you feel a little aggrieved, shall we say, that someone's using up valuable consultation time to see, to see the wrong professional ... it's a bit of a heart sink presentation.”

GMP15, male, qualified 11-20 years, urban practice

Feelings of animosity towards dental consultations primarily arose due to two reasons. Firstly, practitioners felt they were ill-equipped to treat such problems and consequentially had concerns regarding the possible repercussions of attempting to treat dental problems, both for the patient and medico-legally. Secondly, GMPs felt that their service and accessibility was being taken advantage of.

“I have to say rather than seeing it as a burden it would be more that I feel out of my depth.”

GMP32, female, qualified 11-20 years, urban practice

Attitudes towards the presentation and management of dental problems could vary dramatically within a single practice. More moderate practitioners described colleagues who refused to see dental problems as stubborn or obstinate, although always in good humour. In comparison, practitioners who were strongly opposed to the treatment of dental problems in general practice expressed varying degrees of consternation towards colleagues who willingly treated patients with a dental problem. They described how it led to an increased likelihood of consultation during subsequent episodes of dental pain. In the following example a practitioner explains how differences in opinion regarding the management of dental problems contributed to a breakdown of partner relations within his practice.

“I’m aware that two of the partners we did have appeared to be quite happy to see the [dental] patients and just give them some antibiotics for a week... the other two of us were not terribly happy that was a good thing for the GPs to be doing, because we felt it wasn’t actually giving the patients the best treatment... We ordered the guidelines from your Dean and copied them round to the other two and subsequent to that we’ve actually expelled one of the partners for that and a number of other things, and the other one will be going at the end of this June... I think they found that pleasing the patient may have been more important than teaching them optimally.”

GMP40, male, qualified 21-30 years, rural practice

However, despite negativity towards the overall issue of dental problems within their practice, in general, GMPs expressed empathy towards patients suffering from dental problems. They appreciated the debilitating impact that dental pain could have on an individual, and appreciated the complexities of accessing emergency dental care. These sentiments illustrated that much of the antagonism GMPs expressed in relation to dental consultations were associated with the flawed system that resulted in inadequate access to emergency dental care, rather than directed to the individual patients. The exception to this was patients perceived to be attending to avoid costs associated with dental treatment, particularly privately-treated patients who were judged to have the resources to afford such care.

“The ones that probably annoy us most are the ones that are coming in because they have to, they’ve got a private dentist and they have to pay for their antibiotics, and they come into us saying, ‘Well I don’t want to pay’ and you think, ‘Well, this is, I suppose, a cost to our service’, so they’re the ones that annoy, if you like.”

GMP2, female, qualified ≤10 years, urban practice

8.4 Are antibiotics the answer?

8.4.1 Assessment and diagnosis of dental problems

When the GMPs did see patients with dental problems the majority reported undertaking a brief extra- and intraoral examination. Whilst practitioners reported they were willing and indeed familiar with oral examination, specifically assessing for dental problems was often hindered by limited knowledge of dental pathologies and practical problems such as inadequate lighting. When questioned about specific signs they would look for when investigating a potential dental

problem, the majority of practitioners focused on hallmark signs of inflammation and infection – swelling, lymphadenopathy and pyrexia. Some GMPs also replied that they would look for evidence of poor dental health such as plaque or dental caries and a minority reported that they would try to tap the teeth to try and identify the source of pain.

When asked to discuss the conditions that could cause toothache the majority of practitioners discussed dental abscesses, considering dental pain and infection somewhat synonymously. Only two practitioners discussed inflammatory conditions of a dying dental nerve that could result in toothache. This knowledge gap may be one of the reasons why antibiotics are used so frequently in the management of dental problems in general practice.

8.4.2 Sources of dental knowledge

The majority of GMPs were keen to emphasise that they had received little or no education at either under- or postgraduate level regarding the diagnosis and management of dental conditions. For most GMPs any dental knowledge had been gained more informally from interaction with friends who were dentists, from working alongside dentists in A&E during their early career, or from being a patient themselves.

“A good friend of mine was a maxillofacial trainee who, obviously had done dentistry first and then came through medicine with us and I remember doing casualty with him and he was a font of knowledge and put me straight on a number of occasions working in A&E with him. So yes, there has been lots of that and I'm still friendly with a lot of my dental colleagues from college, so there's some informal education. But nothing that formal it's fair to say.”

GMP15, male, qualified 11-20 years, urban practice

However, a disadvantage associated with this ‘informal’ method of knowledge transfer was the confusion that arose when GMPs received mixed messages regarding the management of dental problems, in particular the use of antibiotics.

“I’ve always found it a bit of a dilemma because my own dentist, I’ve had two since I’ve been in [NAME PLACE], one of whom said, ‘I wish GPs wouldn’t give antibiotics because often the patient won’t consult until several days later. It’s actually much harder for me to unravel what’s gone on before it’, and the other one who said he thought GPs were very mean if they didn’t treat someone who’s in pain and needed antibiotics to tide them over.”

GMP32, female, qualified 11-20 years, urban practice

In the absence of any other sources of information many GMPs seemed influenced by the anecdotal reports of patients or attempted to apply wider medical knowledge to dental problems, with varying levels of accuracy. Others sought information on the internet from sites such as doctors.net.uk, an online professional forum for UK doctors.

“So, most of the time they’ll say, ‘I think I’ve got an abscess doc, can you give me some antibiotics, it worked last time?’ And some of them will be quite kind of, informed, in the sense they’ll say, ‘I’ve had this problem before, I’ve been to my dentist and they normally say, ‘Have some antibiotics, and once it’s settle down we’ll consider, you know, intervention, whether it be, like root-,’ I don’t know what they do, root canal or drainage or whatever.”

GMP21, male, qualified ≤10 years, urban practice

“Probably co-amoxiclav because it has, it’s good for dental problems... When I worked in A&E and then bites were always supposed to be treated with co-amoxiclav because of bacteria that were in the mouth most of them are sensitive to co-amoxiclav.”

GMP38, female, 21-30 years since qualification, urban practice

Regarding whether dental patients should be managed at all in general practice at all, only a few GMPs recalled receiving guidance from official organisations such as Dental Schools, British Medical Association, General Medical Council, or their LHB. When recommendations were issued they varied depending on geographical location, with some GMPs actively remunerated and encouraged to see dental patients, yet others discouraged from attempting to manage patients with toothache.

8.4.3 Professional identity and attitudes towards education about dental problems

In many ways doctors and dentists working in primary care share similarities: they are highly educated individuals engaged maintaining and improving the health of patients, they both have long training periods, often in close proximity to each other and following graduation hold similar statuses within the community. Despite these similarities, almost all the GMPs interviewed sought to separate the identities of the two professions. Nearly all, at some point during the interview emphasised that they were a doctor *not* a dentist, highlighting the perceived differentiation of the two professions and their varying scopes of practice. Dentists were by and large considered a distinct professional group within healthcare, rather than a medical subspecialty, and several GMPs implicitly described how dentists had benefited from this independence, both financially and in terms of work-life balance.

This distinction of professional identity was one reason why some practitioners felt so strongly about the presentation of patients with dental problems in their practice. It was also epitomised by practitioners' reactions to the possibility of receiving education on management of patients with dental conditions. Despite having identified both a knowledge gap in relation to the management of dental problems and reasons why patients would consult a GMP with tooth-related problems, the majority of practitioners were opposed, some vehemently, to formal training or the introduction of guidelines regarding the management of dental problems in general practice. Rather than viewing these as an additional skill which would help them manage dental consultations more efficiently, they felt that this 'crossed the line' and would compel them to attempt work outside their jurisdiction as general medical practitioners.

"I don't want to start managing people. You know, where does it stop? Do we become dentists? It seems like a strange door to open, a Pandora's Box. I would imagine because people you know would likely get the idea they could come to us for their more minor dental problems and it I don't want, the trouble is we would not get resourced for it. And also there are limits to the training. One afternoon here and there isn't going to make me qualified. I wouldn't mind a sort of a half an hour session at one of our learning sessions from a dentist just sort of saying don't give antibiotics with reasons. I think that would be really appropriate but to start saying do give antibiotics in these other situations is a bit of a minefield because people would then think they should have antibiotics if, sorry I'm not making myself clear, what I'm saying is that there are two sides of it."

GMP39, male, qualified 21-30 years, rural practice

In comparison, attitudes were somewhat different towards the management of non-dental, orofacial pathologies such as temporomandibular joint dysfunction and oral ulceration. Within these conditions GMPs recognised an overlap between medical and dental specialties and considered these more appropriate for general practice, despite sometimes admitting to having limited knowledge of the management of these conditions.

"I think you know you've got to draw the line. I mean there's a small area of dental and medical overlap which might be TMJ dysfunction, rheumatoid disease or you know arthritis or temporal masseter muscle pain, you know, but we don't ever won't to get involved in doing routine dental work or offering an opinion."

GMP11, male, qualified 21-30 years, urban practice

8.4.4 Use of antibiotics

The use of antibiotics in the management of dental problems varied dramatically within the group of GMPs. Some practitioners reported that they would prescribe an antibiotic to most, if not all patients with dental problems, whilst others were much more reluctant to prescribe an antibiotic and would consider prescribing analgesics instead. Practitioners who identified themselves as working within 'low prescribing' practices as a whole were more likely to report rarely or never prescribing antibiotics during dental consultations.

"I think generally if it's a dental problem we usually end up prescribing antibiotics."

GMP2, female, qualified ≤10 years, urban practice

"I'd say the vast majority don't receive anything other than analgesia off me really."

GMP15, male, qualified 11-20 years, urban practice

There were some practitioners who looked for specific signs and symptoms before they were willing to prescribe an antibiotic, such as pain on percussion of a tooth. In comparison, other GMP described how their prescribing decisions were dictated more by history of symptoms and their general impression of the patient.

“Unless they’ve got the classic abscess under the tooth symptom – tapping over the tooth causes pain, clenching the teeth causes pain because if it’s not an infection then they don’t need antibiotics. It’s not going to kill the pain, it’s going to relieve things but it’s going to clear it a little bit more quickly but again it’s not going to kill the bacteria.”

GMP18, male, qualified 11-20 years, urban practice

There were conflicting opinions amongst the practitioners as to whether antibiotics were the optimal treatment for acute dental conditions. Although all thought that antibiotics were effective in the management of dental conditions to a greater or less extent, a small number of practitioners thought that, as dental abscesses were infections, antibiotics were the recommended first line therapy. Others discussed that whilst antibiotics may provide symptomatic relief for a dental abscess, definitive operative treatment was also required. A number of practitioners went on to describe how operative dental treatment may be indeed best undertaken following the resolution of an infection using antibiotics.

“I have had people say that they’re going to see their dentist next week because that was the earliest appointment they could get, and they know from previously that the dentist isn’t keen to take out an obviously infected tooth so they would like something to clear up the infection before they get there.... And I can sort of see the logic in not operating, the same way that a surgeon isn’t going to operate on a gall bladder for instance they would treat with antibiotics, get the infection under control and bring them back for an elective cholecystectomy later but so yeah presumably it works on that basis.”

GMP18, male, qualified 11-20 years, urban practice

Amongst some practitioners the rate of antibiotic prescribing for dental problems seemed inversely associated with the availability of local dental service. Several GMPs described how reduction of emergency dental services during weekends or holiday periods would increase their likelihood of prescribing an antibiotic. Similarly, one practitioner described how their rate of antibiotic prescription for dental problems had decreased since the improvements in emergency dental care as they were now able to direct patients to a source of more appropriate care and they felt less obliged to try and manage the condition themselves.

“It is awkward if they’re consulting you at four o’clock, five o’clock on a Friday afternoon and they haven’t got any dentist up until the following Monday or Tuesday or whatever. So you’ve got to say, ‘Hang on, am I doing this patient a disservice by not giving him something.’ That’s the awkward thing then.”

GMP14, male, qualified >30 years, urban practice

“[Talking about how frequently they prescribe antibiotics] Very infrequently now we’ve got the NHS Direct facility to reroute them, so it would be less than ten percent of the time. You end up being the patient’s advocate and doctors don’t like to see people suffering.”

GMP11, male, qualified 21-30 years, urban practice

It also became apparent that GMPs were prescribing antibiotics not only to treat dental infections but in some instances to prevent the onset of a serious infection, particularly in immunocompromised individuals. Several practitioners had personal experience or had heard anecdotal reports of patients being admitted to hospital or even dying from dental infections and therefore opted to prescribe antibiotics to mitigate the risk of the patient developing a serious infection.

8.4.5 Requests for antibiotics

Generally GMPs described that expectations for antibiotics were high amongst patients consulting with a dental condition. Practitioners reported that many patients who expected to receive an antibiotic often vocalised this expectation early in the appointment, some even when checking in at the reception desk.

“Ninety percent of the patients that I have seen are more or less convinced that it’s a dental abscess and they need antibiotics. And they are aware of it and they come asking for it. Even when they book their appointment with the receptionist they will say that they think they have a dental abscess and they’d like to book an appointment with us. Ninety percent of the time people think or they know that they have a dental abscess and they come for antibiotics.”

GMP8, male, qualified 11-20 years, rural practice

A minority of practitioners reported that they would be more likely to prescribe an antibiotic to dental patients who asked for one. These practitioners were likely to have a moderate attitude towards dental consultations in general practice and prescribed antibiotics in these situations to appease the patient and avoid conflict. One practitioner even went further and described how, when patient expectations were clearly articulated, it reduced the length of the appointment and resulted in both patient and practitioner satisfaction.

“Well there’s certainly patient pressure there to prescribe. Very often, to be quite honest with you, it’s easier just to prescribe than spend time arguing.”

GMP6, female, qualified >30 years, rural practice

“Generally speaking, to be quite honest with you, it’s quite refreshing to be honest, because it’s generally quite a simple consultation and you know, it’s nice and quick and, you know, patient expectation is, is always made quite clear and patients leave quite satisfied. So from that point of view it’s quite a good consult.”

GMP21, male, qualified ≤10 years, urban practice

However, such a positive response to antibiotic requests was not echoed by the majority of GMPs. Many practitioners, particularly those who did not routinely prescribe antimicrobials for dental problems, were prepared to decline requests for antibiotics, even if it led to patient dissatisfaction. Several GMPs described how denying patient requests for antibiotics, not just for dental problems, was a common feature of their practice and discussed the sense of entitlement to antibiotics amongst some patients.

“INT – How do patients react when you tell them that you’re not going to give them antibiotics?”

GMP – Well some of them are upset and will go and ask the receptionist if they can see the other doctor instead. Some of them will put up a little bit of fight, go and then they accept that they’ve got to go and see the dentist. And some of them will fight a bit and say, ‘Well give me some painkillers,’ and say, ‘We’ll go and find the dentist’”

GMP40, male, qualified 21-30 years, rural practice

“For some reason, I don’t know what it is with antibiotics, people feel that they can and indeed should question it when we say to people they don’t need an antibiotic. I’ve never had anyone who I’ve told doesn’t need for instance, to have insulin to turn around and say, ‘Well can’t I have some anyway?’ Whereas with antibiotics, I’m sure, I don’t know whether your dental colleagues back this up, they will often say, ‘Well I’d like an antibiotic, can’t I have one anyway?’ ‘Well you don’t need one.’ ‘But I’d still like one.’ And as I say it seems to be one of the things that people feel that they need almost to question.

GMP18, male, qualified 11-20 years, urban practice

8.4.6 Prioritisation

GMPs described how they balanced trying to provide symptomatic relief for patients with dental problems against trying to motivate patients to access more appropriate sources of care for tooth-related pain. GMPs who reported that they were more likely to prescribe an antibiotic generally did so because they prioritised a patient’s immediate needs and to minimise the likelihood of clinical deterioration.

“I’m perhaps a bit soft and, at the end of the day if your suspicions are that, you know, there is a dental abscess or there is an infection there I don’t believe in saying, ‘Oh well, you know, you’re going to see a dentist tomorrow, wait ‘til then’. My feeling is, you know, most of the time when you’re seeing it, it is genuine and, you know, I don’t think, you know, I’m quite convinced that there is an infection there so I’ll crack on and give antibiotics”

GMP21, male, qualified ≤10 years, urban practice

‘Well certainly I don’t personally send people away without treatment. You know they’ve got an acute need and the vast majority have either got very nasty abscesses or, quite a lot of pain so they usually get a prescription from us again but again, they’re advised again, given printed information on dental access, emergency dentists and how to get a dentist themselves in the long term then how to register for an NHS dentist.’

GMP2, female, qualified ≤10 years, urban practice

However, there was recognition within this group of practitioners that this reinforced expectations of receiving antibiotics from a GMP during subsequent episodes of dental pain. Similarly, those practitioners who reported rarely prescribing antibiotics for dental conditions did so to motivate patients to seek more appropriate care which they believed would lead to quicker resolution of pain.

“Maybe we’re not getting through to patients because we’re doing one thing and then saying the other aren’t we? We’re saying, ‘Oh you should see your dentist,’ but we’re actually seeing them. Whereas if we actually said no and they had to access emergency dental care then they’d learn that there’s no point coming to the doctor, they really have to see the dentist. I think perhaps actions speak louder than words really.”

GMP27, female, qualified 21-30 years, urban practice

“I try very hard not to [prescribe antibiotics] because then I feel it will close the loop and they will then have the expectation that they don’t actually need dental care.”

GMP33, female, qualified 21-30 years, urban practice

8.5 Interprofessional communication

8.5.1 Relationships and interaction with local dentists

Approximately half the GMPs interviewed reported little to no contact with dental professionals, apart from social interaction with friends who happened to be dentists or discussions with their own dentist. Several of the GMPs from rural practices actually reported better relationships with local veterinary surgeons than dentists because of joint British Medical Association and British Veterinary Association educational meetings in the area. However, a minority of the GMPs interviewed reported regular interaction with local dentists. These practitioners were more likely to share premises with a dental surgery and generally described a mutually beneficial working relationship.

“I have no idea who they are... I don’t speak to them. I don’t meet them. In fact the only place I meet dentists, oh that’s not dentists, that’s vets. Sorry going completely off-track there. There you go, no I don’t meet dentists at all.”

GMP39, male, 21-30 years, rural practice

“There is a dental surgery actually within the building apart from on Friday afternoons so we would advise them [patients with a dental problem] to see the dentist instead and the receptionists have the dental helpline number in case our dentist is not here or unavailable or if they’ve been trying to see the dentist and won’t see them... Occasionally the dentist from the room next door will pop along and say, ‘Is it ok if I do this or will it upset the Warfarin level?’ Things like that. So we work quite well with our dentist. He’s very friendly.”

GMP40, male, qualified 21-30 years, rural practice

GMPs who were in contact with local dentists tended to report that the majority of the interactions were dentist-initiated, usually in relation to the suitability of patients with complex medical histories or multiple co-morbidities for various procedures or therapeutics. Generally these enquiries were well received by GMPs and considered in the best interests of patient. However, some GMPs felt a minority of local dentists abused their good-will and would direct patients to general practices to obtain analgesics or on occasion, antibiotics.

“When I joined the practice we had a dentist onsite. Employed by [local health board]. And, as it happens, he was about two years older than me in college, so I knew him by sight. Once he sort of realised I'd joined the practice he was down a couple of times a week coming to ask me about, 'Is it safe to give so and so some treatment for this?' or 'Is it safe, this patient has a heart problem, should I treat them with this, should I treat them with that?' and so in all fairness to him, he would often come and ask advice about, about patients.”

GMP14, male, qualified >30 years, urban practice

“We did have one local practice who weren’t happy sort of prescribing analgesics and so and which did cause a bit of extra work for us.”

GMP32, female, qualified 11-20 years, urban practice

Many of the GMPs recognise potential value in improving relationships with dental practitioners. They described how it could reduce the burden of dental consultations in general practice, improve patient outcomes and increase efficiency within the health service. One practitioner described how improvements in care pathways for optical health that had been made by the introduction of the Primary Eyecare Assessment and Referral Service (PEARS) in their local area and inferred that this could be a model for GMP-GDP interactions.

"These patients just turning up and saying, 'Oh I've got, erm, you know, I can't get into to see the dentist, I can't get in for another fortnight', if you know Mr Jones [the dentist] down the road, you could say, 'Well hang on, I know Mr Jones and he is quite prepared to see anybody', and so you could always pick up the phone and get through to Mr Jones' receptionist and say 'Look, I've got a patient here who says he can't get in. Can you see him today or tomorrow?'"

GMP14, male, qualified >30 years, urban practice

"Sometimes the other group that we other professionals that we would have much more liaison with, just thinking that this would be a good model, is actually opticians. Because we have the PEARS... I can phone them up and say, 'I've got a patient they've turned up with a red eye and they've got a problem. Could you see them and assess them?' And they will give me an appointment for them, like the next day or maybe later on that day and they will go in. They don't have to be their own optician or anything but they will do a very kind of thorough assessment and take on the problem and refer them somewhere else and send information back to me about it."

GMP37, female, qualified 11-20 years, urban practice

Some GMPs expressed regret at the current standard of communication between medical and dental professionals. They described how written correspondence was highly unusual, despite being the standard means of communication within both professions. As a result a lot of information transfer between the two professions happened via patients, which practitioners recognised was subject to misinterpretation.

"Maybe dentists feel that GPs don't communicate very well with them, but how would I know? Sometimes people have actually even said, 'And my dentist said this and I have to come and see you', and it's like, 'What?' You know, if that's really the truth why don't they write a letter? Write a note saying, 'I've seen this person, I've done this, I've checked this, can't find anything wrong. Do you think it could be this?', and sort of send them over. If that's really what's happened rather than just asking the patient to kind of transmit a message like that really... I mean even the pharmacist, you know... they'll sometimes do people's blood pressure, do whatever and then say, write something saying, 'Could you, I've found this could you see them?' Or whatever."

GMP37, female, qualified 11-20 years, urban practice

8.5.2 Referral pathways

Unless they had first-hand experience of accessing dental services in the local area as a patient, GMPs' knowledge of the various dental services available to their patients was limited. Practitioners were unsure which dental practices were accepting patients, and whether care was provided under NHS or privately arrangements. Several practitioners were unsure about the costs associated with NHS care and who may qualify for free treatment. When practices did provide patients with information about local dental services some practitioners recognised this may not be up-to-date.

"I didn't know they had to pay, I didn't know that in certain circumstances they had to pay a contribution if its classes as an emergency, I thought it was free."

GMP21, male, qualified ≤10 years, urban practice

"I know one of my partners, one of my more vociferous partners, has got a notice on her wall saying, 'No dental patients are treated, if you have dental problems please phone this number.' And she actually gives a sheet of paper with the number, the emergency phone number for everybody to contact. The fact that the number then changed and is totally useless, not part of the issue!"

GMP14, male, qualified >30 years, urban practice

When seeing patients with dental problems all GMPs said that they would advise the patient to see a dentist. However, in comparison with other healthcare services such as physiotherapy where a direct referral would often be made, GMPs seemed reluctant to make formal referrals to primary care dental services. Accessing dentistry was considered by many to be a patient's responsibility, not a general practitioner's. One GMP commented that making referrals to dental services would increase their workload, and another that it would be a burden on general practitioners. Even a practitioner who considered herself a gatekeeper to healthcare services and clearly took pride in helping her patients access appropriate care admitted that she had never made a referral to general dental services. She preferred instead to direct patients online, despite acknowledging the difficulties that they may encounter in relation to this.

"I would probably ask the patient to go and see the dentist rather than picking up the phone for that one... I wouldn't do it on the patient's behalf."

GMP6, female, qualified >30 years, rural practice

“I think some of them, some of them would probably find it [referral] a burden, you know, because it's just taking up their time.”

GMP14, male, qualified >30 years, urban practice

“Sometimes if I've found out that the issue is that they can't get registered with a dentist and have access to a dentist I show them where the information is online about how to find a dentist and the phone the number for the LHB... I mean that website's not that intuitive and if you've got a low level of literacy that's not really going to help you figure out.”

GMP37, female, qualified 11-20 years, urban practice

However, in comparison, a number of GMPs described how they may, in rare circumstances, consider making referrals to secondary care dental services, mainly hospital-based Oral and Maxillofacial Surgery (OMFS) departments. This was generally only considered necessary for disabled and vulnerable patients considered unable to access primary dental care. These referrals were made infrequently and not without complications, some GMPs describing how local OMFS services were no longer accepting referrals from practitioners outside dentistry.

“I think there is an issue about accessing secondary care, oral surgery as well, we're not able to do that so it's made it even more inappropriate for GMPs to see dental problems I think.”

GMP15, male, qualified 11-20 years, urban practice

This reticence to make referral to dental services is a further illustration of the perceived separation of the two professions. Whilst most GMPs acknowledged that many patients would be unlikely to see a dentist because of their advice, making direct referrals to primary care dental services were considered outside the remit of a general practitioners' work.

8.6 Chapter summary

GMPs report variation in the frequency of dental consultations in general practice. The reasons why patients may consult their GMP with a dental problem were multifactorial but difficulty accessing emergency dental care, and comparative easy access to GMP services was the principal explanation provided by practitioners. Attitudes towards consultation for dental problems varied between GMPs, although all agreed that patients would receive more optimal management from a dentist rather than a medical practitioner.

GMPs' knowledge of the diagnosis and management of dental conditions was limited and not always congruent with current dental guidelines. Many considered antibiotics an appropriate treatment for an acute dental condition. Whilst patient expectations for antibiotics were perceived to be high, antibiotic usage for dental conditions varied between practitioners. GMPs who reported that their usual practice was to prescribe antibiotics were more likely to prioritise patients' symptomatic relief, whereas GMPs who reported rarely prescribing antibiotics for dental problems did so to encourage patients to consult a dental professional.

Practitioners considered that the management of dental problems should not be part of the GMP scope of practice. Communication between doctors and local dentists were often limited and there was reluctance amongst GMPs to make direct referrals to primary care dental service. This was mainly due to concerns about workload, limited knowledge of locally available services and a healthcare culture which leads to separation of the professions.

Discussion of the main results of this chapter and the implications for practice and future research are presented in Chapter 9.

9. Discussion

9.1 Introduction

This chapter presents a discussion of the main findings of the thesis (Section 9.2) and considers the potential limitations of the results in the context of the methods used (Section 9.3). The findings are then interpreted in the context of other published work (Section 9.4) and the implications for policy and practice and further work are discussed (Section 9.5). Finally, the thesis conclusions are outlined in Section 9.6.

9.2 Main findings

The literature review completed in Chapter 1 highlighted evidence gaps with respect to the use of antibiotics in the management of dental problems in primary care. Despite the fact that dentists prescribe almost 1 in 10 of all antibiotics dispensed in primary care in the UK, relatively little was known about factors that influence the prescribing behaviours of general dental practitioners (GDPs). Similarly, little was known about antibiotic usage for dental problems in primary medical care. Therefore further investigation of these gaps in the evidence base were indicated.

Within the cross-sectional study (Chapters 2 and 3) 57.4% of adult patients who presented to their GDP with an acute dental problem received an antibiotic as part of their management and 4.4% were prescribed an analgesic. Approximately 70% of patients prescribed antibiotics had no adjunctive operative treatment performed at the same visit to relieve or remove the source of infection or inflammation. Over a quarter of antibiotics (27%) were provided for the management of inflammatory conditions such as pulpitis or apical periodontitis. Only 19.0% of antibiotics were provided in clinical situations recommended by Scottish Dental Clinical Effectiveness Programme (SDCEP) and Faculty of General Dental Practice (UK) (FGDP(UK)) guidelines.

The likelihood of a patient receiving an antibiotic during a consultation for an acute dental problem was influenced by the patients' gender and whether swelling, lymphadenopathy (abnormality in the size or character of lymph nodes) or trismus (restricted mouth opening) were present. Appointment features such as whether patients were unwilling or unable to accept

operative treatment, failure of previous operative treatment, if adequate local anaesthesia could be obtained, and if a GDP reported having insufficient time to perform operative treatment were also predictors of antibiotic use. The likelihood of a patient being prescribed an antibiotic in a situation incongruent with clinical guidelines was influenced by the duration of symptoms (the effect of which differed by gender), and whether localised swelling or fever was present. Appointment features such as a patient being unwilling or unable to accept operative treatment, failure of previous operative treatment, failure of local anaesthesia, if a GDP reported having insufficient time to perform operative treatment and if the patient requested an antibiotic, all influenced the likelihood of a patient being prescribed an antibiotic in a situation where one was not indicated.

Qualitative interviews with GDPs corroborated that shortage of clinical time was one of the principal modifiers of antibiotic prescribing behaviour. Patient willingness and ability to accept operative treatment was also identified as an important influence on prescribing behaviour, as were issues of diagnostic and prognostic uncertainty. Practitioners highlighted difficulties balancing clinical pressures and wider public health concerns regarding antimicrobial resistance, and many practitioners did not feel urgency to alter their prescribing patterns.

Within the cohort study of dental consultations in UK general medical practice (Chapters 4 and 5), the rate of dental consultations in 2004-2011 varied between 6.49 and 7.40 dental consultations per 1000 patient-years. Female patients were more likely to consult with a dental problem than male patients, and the highest rates of consultations were amongst individuals aged between 21 and 30 years. An antibiotic was prescribed in 56.2% of occasions and an analgesic in 20.1%. The likelihood of an antibiotic being prescribed was influenced by patient age, gender, number of previous consultations for dental problems, the day of the week and month of the year of consultation, and the country in which the consultation occurred. There were statistically significant associations between prescription for systemic antibiotics or analgesics during a consultation, and reattendance for a tooth-related problem within two-years. Patient age and gender were also predictors of reconsultation.

Attitudes towards consultations for dental problems varied between GMPs. Practitioners' knowledge of the diagnosis and management of dental conditions was limited and not always congruent with current dental guidelines. Whilst patient expectations for antibiotics were perceived to be high, antibiotic use in dental conditions varied between practitioners. GMPs who reported that their usual practice was to prescribe antibiotics were more likely to prioritise

patients' symptomatic relief, whereas GMPs who reported rarely prescribing antibiotics for dental problems did so to encourage patients to consult a dental professional.

9.3 Study strengths, limitations and sources of bias

9.3.1 Observational study of the management of acute dental conditions in general dental practice (Chapters 2 and 3)

9.3.1.1 External validity of GDP sample

In an attempt to ensure that practitioners were as representative of UK GDPs as possible both NHS and private practitioners were eligible for inclusion, and GDPs were selected from publicly held registers of all working practitioners. However, in order to expedite recruitment, only the first 45 practitioners who responded to a single invitation letter were enrolled into the study. Therefore the included practitioners may have been more familiar with participating in research, or have an interest in postgraduate education or antimicrobial prescribing. Indeed a higher proportion of the GDPs who participated in the current study had a postgraduate qualification than in previous studies of GDPs in South Wales (Seager et al. 2006). Since evidence from the wider healthcare literature suggests that medical professionals with postgraduate qualifications prescribe fewer antibiotics than those without (Bharathiraja et al. 2005), the proportion of patients prescribed an antibiotic within this study may represent an underestimation of the true extent of antibiotic use in general dental practice. Furthermore, at the time of data collection, over half of practitioners had been, or were currently involved in completing the 1000 Lives Plus Antimicrobial Prescribing Audit (Wales Deanery 2012). As involvement in clinical audit is known to improve prescribing behaviours (Chate et al. 2006), the results of the current study may be a further underestimation of antibiotic use for dental problems. As a result, selection bias, the error introduced when the study population does not represent the target population (Ellenberg 1994), could have occurred.

In addition, whilst the GDP-sample had a similar gender-distribution to that of the total workforce, enrolled practitioners were on average younger, and more likely to have qualified within the UK than the Welsh GDP population (National Leadership and Innovation Agency for Healthcare 2012). The age difference between the sample and the total population could have arisen due to differences in workloads or attitudes towards research, with more experienced clinicians typically being more likely to be practice principals and therefore subject to large

volumes of administrative correspondence. Furthermore, the offer of reimbursement could have been perceived as more attractive by younger practitioners. Reasons why the sample contained fewer non-UK graduates are less clear, although differences of this type may be more common in a relatively small sample.

Within the study, three practitioners did not return any data collection booklets. All three GDPs were male, but had no other similar features and at least one dropout was known to be due to relocation of the practitioner out of the study area. However, the withdrawal of remaining two GDPs may have been due to pressures of workload or concerns they had about reporting prescribing that deviated from guideline recommendations, and therefore the impact this has on the external validity of the results cannot be excluded.

Recruitment of GDPs began as soon as R&D approval was received from the Local Health Board (LHB). Response to the invitation to participate exceeded expectation and as a result, the LHBs in which recruitment began first, Cwm Taf Health Board (HB) and Cardiff and Vale University Health Board (UHB), are over-represented within the sample. Similarly, other health boards where recruitment began later such as Aneurin Bevan Health Board and ABM UHB, are unrepresented (National Leadership and Innovation Agency for Healthcare 2012). Both of the Cwm Taf HB and Cardiff and Vale UHB have higher ratios of GDPs per 10,000 head of population than the Welsh average (National Leadership and Innovation Agency for Healthcare 2012). Furthermore, whilst caries experience in Cwm Taf HB is similar to the Welsh average, caries experience in Cardiff and Vale UHB is significantly lower than Welsh averages (Morgan 2012a, 2012b). This indicates that the population of patients served by the GDPs enrolled within this study may have had slightly better oral health and better access to dental care than the Welsh average, and this has consequences on the generalisability of results.

This study was undertaken in Wales, and therefore results can only tentatively be extrapolated to other areas where differences in dental need, organisation of dental services and remuneration arrangements for GDPs exist. Due to similarities in the contracting arrangements for NHS services, the prescribing patterns in this study may be more representative of antibiotic usage in England than Scotland and Northern Ireland, where a 'fee-per-item' contract still operates. Furthermore, the results of this study may not be generalisable to other providers of primary dental care such as the Community, Public or Salaried Dental Service, as the organisation and patient populations of these clinics are likely to substantially differ to those of the General Dental Service (GDS). However, whilst their relative magnitudes may vary, the

clinical pressures and patient-related factors experienced by practitioners are likely to be similar through the United Kingdom.

Data collection for this study was undertaken between October 2012 and February 2013, and throughout the intervening Christmas period. Whilst seasonal variations of antibiotic use for acute dental conditions has not previously been described, a number of the GDPs interviewed as part of this thesis indicated that planned closures of dental practices would increase the likelihood that they may prescribe an antibiotic in the management of a tooth with an uncertain prognosis. GDPs also discussed how patients may be more likely to request an antibiotic prior to periods where they may be less able to access their usual dental services (such as Christmas or holidays), which again may influence likelihood of prescribing. The magnitude of the effect that seasonal variation may have had on prescribing behaviour within this study is unclear, but warrants attention within future studies.

9.3.1.2 External validity of patient sample

The study sought to describe the management of adult patients with acute dental problems. Whilst the patient inclusion criteria (Section 2.5.1.2) included the most common acute conditions (Dailey and Martin 2001), other pathologies such as necrotising ulcerative gingivitis and alveolar osteitis were not included. However, these represent less than 10% of all attendances for acute dental problems (Dailey and Martin 2001). Patients with a chronic apical abscess were also included for the study but this is a chronic, not an acute, condition. As a result, the sample of patients may not be fully representative of an adult population consulting a GDP with an acute dental condition. This issue may have been identified if the case report form (CRF) had been piloted prior to the initiation of data collection.

Antimicrobial prescribing behaviour is potentially a professionally-sensitive topic and therefore studies which wish to record such information, particularly prescribing that is incongruent with clinical guidelines, may be subject to underreporting bias. To minimise this risk GDPs were asked to complete CRFs for consecutive patients meeting the inclusion criteria.

9.3.1.3 Data collection

A strength of this study is that data were collected prospectively and it was therefore possible to collect detailed information about clinical and non-clinical factors that may not be routinely recorded. The prospective design resulted in much higher levels of clinical diagnoses recorded than occurred in a retrospective studies on the same topic (Tulip and Palmer 2008), thus reducing bias that can arise from systematically missing data, and allowing a more comprehensive description of antibiotic prescribing per clinical condition.

Dentists participating within this study may have been influenced by the 'Hawthorne effect', in which individuals under observation alter their behaviour as a consequence of being studied (Delgado-Rodríguez and Llorca 2004). Within this study, all participants were aware that their management of patients with acute conditions was being observed, and the majority probably had an idea that antibiotic prescribing was one of the primary outcomes of the study. This was no doubt highlighted by the fact that the study title made direct reference to this and this appeared on a large number of the study materials. This awareness may have led to higher levels of conformity with clinical guidelines and therefore the reported proportions of antibiotic use may in fact represent an underestimation of true prescribing levels. However, within the qualitative interviews GDPs were typically candid about instances where they were aware their prescribing behaviours deviated from best practice recommendations and therefore it is reasonable to expect they recorded data in the observational study within similar veracity.

9.3.1.4 Misclassification bias

Misclassification bias arises when the sensitivity and/or specificity of the procedure to measure variables is imprecise (Copeland et al. 1977). Within this study there were a number of potential sources of non-differential misclassification bias.

Firstly, the measure of deprivation for practice location, the Wales Index of Multiple Deprivation 2011 was assigned based on the practice, not patient, postcode. This is a relatively crude measure of patient deprivation, as practice location is not necessarily representative of the population of patients who attend it, as many patients may travel to access care (Harris 2003). This may be particularly exacerbated in cases of practices providing primarily specialist or private treatment, where the patient base may have a greater geographical distribution or lower levels of deprivation. In future studies consideration should be given to the relative advantages of

collecting patients' postcodes in order to determine socioeconomic status, or if the need to obtain individual patient consent will adversely impact on recruitment and the generalisability of the sample.

Within '*Section 2 – Signs and symptoms*' of the CRF, practitioners were asked to record the presence or absence of certain symptoms (Appendix IX). Since no diagnostic definitions or measurement tools (in the case of temperature) were provided to practitioners, these were subjective measures which may vary between GPs. During the design of the study consideration was given to providing practitioners with a thermometer to record patient temperature, however it was judged that GPs were unlikely to routinely use one during their everyday practice and the provision of one may alter their patient management.

As reported in Chapter 7, the factors influencing the management of patients with acute conditions are complex and often highly situation-specific. Therefore the use of a discrete number of responses in '*Section 6 – Non-clinical factors influencing treatment*' meant that GPs may have been forced to select the reason that most closely fitted the clinical situation the closest, even if it was not strictly true. This was discussed by one of the GPs interviewed, who felt that the choice of influencing factors was too narrow. This misclassification of appointment features could have been mitigated by providing a free-text response box in which practitioners could have recorded the specific factors that modified their management of a patient.

Furthermore, GPs were asked only to record appointment features which had influenced their management of the patient. However, consideration should have also been given to asking GPs to record appointment features that *were* present but that did *not* influence management. For example, insufficient clinical time was reported to have influenced management in 73 out of the 568 consultations reported. In 67 of these cases an antibiotic was prescribed, and therefore an association between this particular appointment feature which influenced treatment and antibiotic prescribing was established (Section 3.5.4, Table 3.11). However, this does not describe instances where a practitioner experienced a shortage of clinical time but this did not influence management. Therefore, whilst qualitative results support associations between several appointment features and antibiotic use, the strength of the association suggested by the current study cannot be extrapolated to all instances where one of these appointment features arises.

9.3.1.5 Sample size, statistical power and risk of error

Within the study, steps were taken in order to minimise the rate of CRF completion errors, and to encourage practitioners to return all of their data collection booklets. Inclusion criteria were stated on both the front page of the CRF booklet and repeated on every CRF thereafter. Practitioners also received a reimbursement cheque after every completed booklet in order to maintain their enthusiasm in the study. Despite this, completion errors were higher than initially predicted and not all enrolled practitioners completed all 15 CRFs. This meant that the required sample size of completed CRFs was not met. Furthermore, there were much higher levels of clustering (ICC=0.50) of antibiotic use at practitioner-level within the sample than initially predicted, and as a result confidence intervals are considerably wider (+/- 30%) than initially specified. In order to have obtained the +/- 5% margin initially proposed, in a population with an ICC of 0.50 and cluster size of 15, the number of completed CRFs would have had to be 3,080 which would have required the recruitment of at least 206 GPs.

This was only the second published study which modelled predictors of antibiotic use in general dental practice. Furthermore, to our knowledge, it was the first to quantify the effects of appointment features such as shortage of clinical time, on the likelihood of a patient receiving an antibiotic (Section 3.5.6). However, the modest sample size resulted in large confidence intervals surrounding the odds ratios within the multilevel models. In addition, the study was not powered to detect such associations, and for this reason Type II errors, incorrect failure to reject a false null hypothesis, may have occurred. In order to be confident in future studies that no similar errors will occur, the sample size should be specifically calculated with the modelling of such predictors in mind.

In order to determine which predictors would be entered into the multilevel models, multiple univariate analyses were conducted. Multiple testing increases the likelihood of Type I errors (in which the null hypothesis is incorrectly rejected) and therefore the p-values and associations described within this preliminary analysis need to be interpreted within the context of model building.

9.3.1.6 Missing data

Whilst the vast majority of CRFs were completed correctly, one question with a high proportion of missing answers was 'Section 5 – Antibiotic prescription – As far as you know has the patient

taken systemic antibiotics (for any reason) within the last 4 weeks?' This question was designed to investigate whether there would be a difference in the antibiotic agent selected in instances of recent antibiotic use. Out of the 326 instances where an antibiotic was prescribed, this question was left blank on 96 occasions (29.5%). It was subsequently excluded from the analysis as it was considered poorly designed; without knowing the other antibiotic the patient had taken it was not possible to state whether this led to a higher probability of a second or third line agent being selected for the management of the dental condition.

Missing information may also have introduced bias into multivariate analysis; if participants with complete information did not represent the target population (Ellenberg 1994) however, the ten patients with missing information do not appear systematically different from the rest of the sample.

9.3.1.7 Confounding

Within the cross-sectional study no data were collected about patients' medical history, other than whether an antibiotic was prescribed prophylactically for infective endocarditis. Since it is known that the presence of co-morbidities can influence antibiotic prescribing behaviours of healthcare providers (Francke et al. 2008, Teixeira Rodrigues et al. 2013), the decision to prescribe antibiotics to some patients may have been modified by the presence of medical history findings. Furthermore, some antibiotic prescribing guidelines advise that antibiotics may be indicated in the management of odontogenic infections in 'a patient who needs to be treated in a hospital environment due to co-morbidities'. Therefore some antibiotic prescriptions within this study could have been incorrectly judged incongruent with clinical guidelines because of failure to collect these data (Palmer et al. 2012).

9.3.2 Retrospective longitudinal cohort study of dental consultations in UK general medical practice (Chapters 4 and 5)

9.3.2.1 Sample selection

To date, this is the largest study of dental consultations in general medical practice in the UK. The geographical distribution and size of general practices represented in Clinical Practice Research Datalink (CPRD) is largely representative of the UK population, despite some

underrepresentation in younger age groups (Campbell et al. 2013). The current study used an inclusive sample of dental consultations between 2001 and 2011 and therefore the findings are representative of the CPRD dataset within this period.

The majority of CPRD-contributing practices are in England (n=437), with Scotland, Wales and Northern Ireland each having fewer than 70 practices providing data. However, compared with the Office of National Statistics Annual Mid-year Population Estimates, 2001 to 2011, the CPRD population has a slightly higher proportion of individuals from Scotland, Wales and Northern Ireland, and a smaller proportion of individuals residing in England (Office for National Statistics 2013b). Therefore, whilst the dataset may be broadly representative of the UK population in terms of age and gender, if there are significant differences between antibiotic and analgesic use between countries, as the models from Section 5.4 suggest there may be, this means that some of the results may lack external validity.

The data used for the hypothesis-testing within the analyses (Section 5.5) represents a subsample of the CPRD dataset. Censoring the dataset was required to ensure all individuals had equal likelihood of achieving the outcome event. However, characteristics of the subsample used in hypothesis testing were similar to the complete CPRD dataset (Table 9.1), which enhances the internal validity of this analysis.

	Total CPRD dataset (n=321,260)	Subsample for hypothesis testing (n=242,684)
Age in years (SD)	40.17 (21.65)	39.85 (21.70)
Male gender (%)	44.60%	44.70%
Country (%)		
England	81.3	81.1
Scotland	7.1	7.2
Wales	9.2	9.2
Northern Ireland	2.4	2.5
Therapeutic modality (%)		
Neither antibiotic nor analgesic	34.0	33.0
Antibiotic only	45.9	46.9
Analgesic only	9.8	9.4
Antibiotic and analgesic	10.3	10.8

Table 9.1 – Comparison of the characteristics of the CPRD dataset and censored subsample used for hypothesis testing.

9.3.2.2 Quality of data within CPRD

The major benefit of using CPRD for answering research questions regarding consultation for dental problems in general practice was the large sample of dental consultations size it was possible to obtain, thus increasing the external validity of results. Furthermore, using routinely collected consultation records also minimises issues associated with the Hawthorne effect and recall bias.

However, it is important to consider that the data held within CPRD are primarily collected for clinical rather than for research use, and therefore there are certain limitations to its use. Inevitably there are missing and erroneous data, coding imperfections, and variations in coding between practices. Applying the CPRD's data quality metrics helped in the removal of records in which there were obvious data quality problems, some inaccuracies may have remained.

A fundamental assumption of the dataset is that the diagnoses and other data held are accurate and that the most appropriate Read Codes are used (Khan et al. 2010). This study aimed to identify only patients who consult due to a dental problem, whilst excluding individuals who might be consulting due to oral problems such as altered taste or dry mouth. A wide range of Read Codes were used (Appendix XIV), conferring high sensitivity but relatively low specificity. The decision to include such a wide range of Read Codes was made in the light of previous work which identified serious deficiencies in diagnostic awareness with regard to dental conditions amongst qualified physicians (McCann et al. 2005). Whilst a sample of 20 records was studied to ensure they related to dental consultations, within a sample of >320,000 it should be acknowledged that some misclassification might have occurred.

Furthermore, the manner in which consultations are coded for in CPRD mean that it is difficult to separate different elements of an individual consultation. For example, a patient may consult for a dental problem and at the same time may request a repeat prescription of analgesic medication for an unrelated condition. This effectively results in a dental consultation in which an analgesic was prescribed. Therefore the presence of such uncertainties mean that interpretation of findings of the current study should be considered within this limitation.

9.3.2.3 Misclassification

This was the first study to model predictors of antibiotic and analgesic use with regard to dental consultations in general medical practice. Whilst steps were taken to ensure the data used was

of an acceptable standard (Section 4.3.2), the two hypothesis generating multilevel models both included day of the week as a predictor variable (Section 5.4). Whilst weekday events are usually well coded within CPRD, there is anecdotal evidence from CPRD users that entries with weekend event dates are often based on communication received from out-of-hours providers, which may not be as comprehensive or complete as original consultation records. As a result the weekend events recorded in CPRD may not be representative of all weekend consultations for dental problems in out-of-hours surgeries. Therefore relationships which involve weekend prescribing of antibiotics and analgesics should be interpreted cautiously.

These models included a predictor variable representing the number of previous episodes of dental problems for which a patient had consulted their GMP. However, this variable is subject to a non-differential misclassification bias as the initial consultation does not necessarily coincide with the first consultation with a GMP for a dental problem. For example, a patient could have consulted pre-2001 or at a non-CPRD registered practice. This lack of information about the start of the process can be viewed as a missing data problem and within a multilevel model can result in biased estimates of the coefficients and of the residual variance. A dynamic model, in which previous responses can exert a causal influence on subsequent responses, may have provided a more accurate representation of how episodes affect the outcome of current consultations (Steele 2014).

9.3.2.4 Confounding

The type of treatment received, in the index episode was identified as a predictor of reattendance within two years (Section 5.5). However, in these situations, confounding by indication can occur if a drug treatment serves as a marker for a clinical characteristic that triggers the use of the treatment and, at the same time, increases the risk of the outcome under study (Psaty et al. 1999). For example, a patient may be more likely to receive an antibiotic because a GMP observes they have a large number of carious teeth which may, in turn, mean they are more likely to have a further dental problem within two years than someone with less severe disease.

Furthermore, the presence of co-morbidities such as diabetes, immunosuppression, pregnancy or opiate dependence amongst the study population could have influenced their likelihood of receiving an antibiotic, analgesic or of reconsultation. Entry of these predictors in to the multilevel models may have revealed their status as confounders and allowed for more accurate

determination of prescribing or reconsultation behaviour. This is an avenue for further work within this area.

9.3.2.5 Data analysis

As discussed in Section 9.3.1.5, multiple hypothesis testing such as that conducted within the model building process analysis (Sections 5.4 and 5.5) increases the possibility of Type I errors. Caution was therefore exercised when interpreting statistical tests with borderline significant p-values. Furthermore, large datasets provide so much statistical power that even small differences may be significant at 5%. Therefore, it is critical to evaluate the clinical implications of statistically significant differences when similarly large datasets. For example, the odds of a female patient receiving an analgesic were 1.06 (95% CI 1.04 – 1.08) (Section 5.4.2). Whilst statistically significant, the overall probability of a patient receiving an analgesic was low and therefore such a small difference in odds is unlikely to be clinically meaningful.

9.3.3 Qualitative methods (Chapters 6, 7 and 8)

Reflecting on the strengths and limitations of qualitative methods, it has been suggested that the following criteria should be considered by qualitative researchers in pursuit of a trustworthy study: credibility; transferability; dependability and confirmability (Guba 1981).

9.3.3.1 Credibility

Credibility is the extent to which the findings of the qualitative investigation are congruent with reality (Merriam 1998). The adoption of well-established research methods, the use of probing questions to elicit detailed data, frequent debriefing sessions during monthly project group meetings, the researchers' reflexive commentary (Section 6.8), and the thick description of the phenomenon under scrutiny are all recognised techniques for ensuring credibility employed within this thesis (Shenton 2004).

Interviewing clinicians about prescribing and antibiotic resistance was potentially professionally sensitive. Practitioners may be aware that their prescribing behaviour deviates from an 'ideal' that exists within clinical guidelines and therefore their responses may be biased to attempt to

provide 'correct', rather than honest responses. To attempt to minimise this effect, all clinicians were reassured at the start of the interview that they were not going to be judged on their prescribing decisions and that no consequences would result from anything revealed during the study. In fact, practitioners were typically candid about their usual practice and the pressures they experienced.

Other approaches which promote confidence that qualitative research has accurately recorded the phenomena under scrutiny are triangulation, the use of different data collection strategies, and validation checks by the interviewed participants (Shenton 2004). Whilst quantitative data collected as part of the observational study of GDPs triangulated with GDP interviews to a certain extent, focus groups with groups of GDPs and GMPs may have corroborated the findings of interviews with individual practitioners.

9.3.3.2 Transferability

The practitioners interviewed as part of these studies were drawn from a wide range of geographical areas, served local communities of varying socioeconomic status, had different lengths of practicing career and, in the case of GDPs, were a mix of private and NHS, providers and performers. However, whilst an attempt was made to interview practitioners from a broad purposive sample, the aim was to identify important themes not to generate statements generalisable to other practitioners. Furthermore, it is likely that clinicians who agreed to take part in these studies may have had a special interest in antibiotic prescribing or postgraduate education and therefore it is possible that important data obtainable only from those who did not wish to participate was missed.

9.3.3.3 Dependability

Dependability in qualitative research is a similar concept to reliability in quantitative research; if the work were repeated in the same context, with the same methods and same participants, would similar results be obtained (Shenton 2004)? However, since clinical decision-making is a dynamic process, we cannot assume the factors that influence prescribing behaviours have not shifted since the interviews were conducted. Therefore the results presented within this thesis represent a snapshot of the '*ethnographic present*' in which they were captured (Florio-Ruane 1991).

In order to ensure the dependability of the coding framework, 20% of the transcripts were double coded by a second researcher (FW) to ensure code definitions were accurate and sufficiently descriptive. Furthermore, saturation point for both studies was only confirmed following examination of the narrative by a second researcher (FW), which adds to the dependability that this point had indeed been reached.

9.3.3.4 Confirmability

The concept of confirmability is concerned with ensuring, as far as possible, that the work's findings are the result of the experiences and ideas of the informants, rather than the characteristics and preferences of the researcher (Shenton 2004). One of the key criterion for confirmability is the extent to which the researcher admits his or her own predispositions, and therefore a reflexive commentary was included with this thesis (Section 6.8).

9.4 Interpretation of findings and comparison with other published work - the use of antibiotics in the management of acute dental conditions in primary dental care (Chapters 2, 3, 6 and 7)

9.4.1 The proportion of patients consulting a GDP with an acute dental condition who receive a prescription for systemic antibiotics and variability between practitioners.

In the current study, 57.4% of the adult patients who consulted a GDP with an acute dental problem were prescribed an antibiotic as part of their management. The proportion of patients who received antibiotics in previous studies varied between 28% and 58% (Anderson et al. 2000, Dailey and Martin 2001, Seager et al. 2006, Tulip and Palmer 2008). The proportion from the current study is at the higher end of this range, and is notably higher than the most analogous study, a trial investigating academic detailing on antibiotic prescribing in general dental practice in South Wales (Seager et al., 2006). In that trial, 32% of patients in the the non-intervention trial arm received antibiotics. Why the rate of antibiotic use are higher in the current study than have been previously described within the general dental service is somewhat unclear. However, it may have arisen due to differences in the patient populations included in the studies. The inclusion criteria for the current study was condition specific, which may have resulted in a

greater disease severity than those included in the trial, which appeared to include all adults with acute dental pain. More likely however, is that these differences arose because of the high degree of clustering of antibiotic use within the GDP sample. The results suggest that some GDPs are prescribing to only a small proportion of patients, whilst others are prescribing to a much higher proportion of patients with similar problems. The inclusion of just a few GDPs with high antibiotic usage may have increased the proportion of patients receiving antibiotics over that reported in other studies.

9.4.2 Antibiotic use by clinical diagnosis

The most common indications for antibiotic therapy were pericoronitis, followed by acute apical abscess, chronic apical abscess, irreversible pulpitis, and symptomatic apical periodontitis (Section 3.5.2.4). This is broadly similar to that reported in previous observational studies and clinical audits, although direct comparison is problematic as many of the other studies do not employ the AAE Consensus Conference Recommended Diagnostic Terminology and group multiple conditions together (Dailey and Martin 2001, Palmer et al. 2001a, Chate et al. 2006, Tulip and Palmer 2008, Kudiyirickal and Hollinshead 2011). This indicates that a relatively large proportion of antibiotics are being used to treat conditions which are primarily inflammatory in origin such as irreversible pulpitis and symptomatic apical periodontitis.

Overall, the proportions of patients with specific clinical diagnoses prescribed an antibiotic were similar to that reported in other studies (Palmer and Martin 1998, Dailey and Martin 2001, Palmer et al. 2001a, Tulip and Palmer 2008). Prescribing rates for periodontal abscess were slightly lower than previously reported, although this is likely due to differences in diagnostic terminology used, and there were wide confidence intervals associated with this estimate due to the relative infrequency of this diagnosis. Again this raises concerns regarding the relative frequency with which antibiotics are being prescribed for inflammatory conditions such as irreversible pulpitis (38.2% of occasions) and symptomatic apical periodontitis (45.1% of occasions).

9.4.3 Type, dose, duration and frequency of antibiotics

In the current study, amoxicillin was the most frequently prescribed antibiotic, accounting for approximately three-fifths of all antibiotics (Section 3.5.2.1). This was followed by metronidazole

which made up a third of all prescriptions. Small amounts of erythromycin, co-amoxiclav and clindamycin were also prescribed. These proportions are similar to those reported in official health reports from England and Wales (Holyfield and Karki 2009, Health and Social Care Information Centre 2014), and in clinical audit (Chate et al. 2006).

None of the interviewed dentists routinely employed culture and sensitivity testing of odontogenic infections and therefore prescribed empirically (Section 7.1.2). Amoxicillin was most frequently prescribed for pulpal and apical pathologies such as acute apical abscess, symptomatic apical periodontitis, chronic apical abscess and irreversible pulpitis. Conversely, metronidazole was most commonly prescribed in the management of periodontal pathologies such as pericoronitis and acute periodontal conditions. This distribution is similar to that reported in a previous study of antibiotic use by GPs in England (Palmer et al. 2000a). Within the GP interviews it became apparent that this pattern of use of antibiotics most likely reflects undergraduate teaching and postgraduate education, as only a minority of practitioners discussed the efficacy of these agents based on the predominant microflora associated with acute conditions.

9.4.4 Delayed prescribing

In the current study approximately 90% antibiotics were provided for immediate use, with the remaining prescriptions provided for use if patients felt their condition deteriorated, or if local measures failed to relieve symptoms. To our knowledge delayed or contingency prescribing has not previously been described within primary dental care in the UK. However, in an observational study of Belgian GPs a third of antibiotics were prescribed in this way (Mainjot et al. 2009). This raises concerns that patients or family members may keep the antibiotics to self-medicate during another episode of ill health, increasing risks of antimicrobial resistance, antibiotic-related side-effects or interactions with existing medication.

9.4.5 Differences between antibiotics prescribed for NHS and private patients

A previous trial of academic detailing for antibiotic prescribing conducted in general dental practice in South Wales reported that there were no significant differences between NHS and private patients regarding the likelihood of receiving an antibiotic (Seager et al. 2006). However, other than this trial there has been little investigation of differences between antibiotics

received by NHS and private patients. Whilst the current study also reported no significant differences in the proportion of NHS and private patients who receive an antibiotic, results of post hoc analyses indicate differences in the use of delayed prescribing techniques and duration of antibiotic courses prescribed between NHS and private patients (Section 3.2.2.6). However, as this testing was performed post hoc, it is important that these results are interpreted cautiously (Elliott 1996), as this type of analysis often involves multiple hypotheses testing which increases the likelihood of Type I errors (Delgado-Rodríguez and Llorca 2004).

Private patients were more likely to receive delayed prescriptions than NHS patients, and this may be related to the characteristics of the private patient population. Private patients may be more likely elect to undergo complex treatment to save a tooth; procedures which may increase the likelihood of prognostic uncertainties. Furthermore, as private treatments are often associated with higher costs, practitioners treating patients privately may be more anxious about potential consequences should symptoms fail to resolve, and therefore may prescribe an antibiotic 'just in case'. Alternatively, qualitative interviews indicate that practitioners believed that less socioeconomically deprived patients may be less willing to take an antibiotic immediately due to concerns about antimicrobial resistance (Section 7.2.2), and therefore private patients may prefer to receive a delayed prescription than commence one immediately.

Private patients also received longer courses of antibiotics than NHS patients. This may be a consequence of dispensing arrangements in general dental practice. NHS prescriptions are typically dispensed at community pharmacies which will supply the duration of course specified on the prescription. In contrast, dental practices treating a large proportion of patients on a private basis will buy in boxes of antibiotic courses from dental suppliers and will dispense private prescriptions in-house. As these boxes usually contain 21 tablets (7-day course) it is more convenient for practitioners to prescribe a full 7-day course than have to open and cut apart the blister packs of antibiotics on every occasion an antibiotic is prescribed.

9.4.6 Comparison with clinical guidelines

Whilst rates of antibiotic prescribing are higher in the current study than in previous observational studies within the emergency dental service (EDS), so too were rates of operative intervention (60.2% vs. 55.0% and 45.0%) (Dailey and Martin 2001, Tulip and Palmer 2008). This suggests that either the practitioners in the current study were more likely to attempt an operative treatment when prescribing an antibiotic than in previous studies, or that when

attempting an operative treatment, GPs in the current study are more likely to also prescribe an antibiotic.

However, whilst rates of operative intervention were higher than in previous studies, less than 30% of patients who received an antibiotic had concurrent dental treatment to relieve or remove the source of infection and inflammation during the same visit (Dailey and Martin 2001). This indicates that antibiotics are being used as an alternative, not an adjunct, to operative measures such as exodontia or endodontic treatment. This is corroborated by qualitative interviews in which some practitioners described prescribing antibiotics at an initial visit for an acute condition before scheduling definitive treatment for a later date. This two-stage treatment plan was most frequently used by practitioners who regularly had little time in which to complete unscheduled care. Further work is therefore indicated to explore the association between scheduling of acute cases and use of antibiotics without concurrent operative intervention.

Less than 20% of antibiotics were prescribed in compliance with SDCEP and FGDP(UK) guidelines (Section 3.5.3.2). That is, where there is evidence of spreading infection or systemic involvement, operative measures are also attempted, or where definitive treatment has to be delayed or has been ineffective. This is a lower proportion than reported in previous studies, although differences are likely to have arisen due to differences in the clinical guidelines used, and how authors judged prescriptions against the recommendations within them (Chate et al. 2006, Seager et al. 2006). This current study therefore contributes to the growing awareness that antibiotics are being commonly used in the management of acute dental conditions in general dental practice in the UK often in limited compliance with clinical guidelines.

Judging prescriptions within this study against both the indications for antibiotic use and the type, dose, frequency or duration of antibiotic used would have probably lead to even lower rates of compliance with guidelines. In line with previous reports (Muthukrishnan et al. 1996, Palmer et al. 2000a, 2000b, Chate et al. 2006), there was substantial variation in the dose, frequency and duration of antibiotic courses prescribed by GPs in this study. The proportions of amoxicillin and erythromycin prescriptions deviating from guidelines was similar to that reported by a large observational study conducted in England (Palmer et al. 2000b). There were fewer errors in metronidazole prescriptions reported in the current work and this may be partly due to the wide heterogeneity of dosing and recommended duration of course that exists between the three main clinical guidelines (SDCEP, FGDP(UK) and British National Formulary (BNF)). The presence of variation between guidelines may cause confusion amongst

practitioners and could reduce the credibility of guidelines. Whilst greater communication between guideline developers may result in less variation between publications, adequately powered, well-constructed randomised controlled trials regarding the effects of antibiotics in acute conditions are also required.

9.4.7 Factors that influence the antibiotic prescribing behaviours of GPs for acute dental problems

The GPs interviewed as part of the current study reported that, when feasible, they would attempt an operative intervention as a first line measure for an adult with an acute condition, and would only prescribe antibiotics in the presence of severe infection (Section 7.1.2). Yet in the observational study, an operative intervention was attempted in less than two thirds of consultations and the majority of the patients prescribed an antibiotic had no signs of spreading infection or systemic involvement. This indicates that there are factors that influence the management of patients with acute dental conditions and these affect the prescribing behaviours of GPs.

9.4.7.1 Clinician characteristics

The healthcare literature describes studies where gender, length of practicing career and the characteristics of undergraduate education have been associated with differences in antibiotic use (Lopez-Vazquez et al. 2012). However, there are equal numbers of studies in which no associations between these variables were found (Lopez-Vazquez et al. 2012). In the current observational study, no clinician characteristics such as gender, place of primary dental qualification, postgraduate qualification status, involvement in the 1000 Lives Plus Antibiotic Prescribing Audit, or the local level of deprivation of the dental practice, were identified as significant predictors of antibiotic use (Section 3.5.6). A similar finding was reported by investigators in a trial of academic detailing on antimicrobial prescribing conducted amongst GPs in South Wales (Seager et al. 2006). However, neither the trial by Seager and colleagues (2006), nor the current study were powered to detect differences at this level. The results therefore indicate that either no association exists, or that associations exist but the studies were underpowered to detect them (Type II errors).

Whilst the quantitative study did not identify an association between length of career and pattern of antibiotic use, qualitative interviews indicated that there were differences in attitudes towards clinical guidelines between more recently qualified and more established practitioners. Longer-qualified practitioners were more likely to rely on their clinical experience when managing patients with acute conditions and were more likely to describe using doses or types of antibiotic not in clinical guidelines, or prescribing antibiotics for conditions which guidelines recommended against.

Qualitative interviews indicated that there were also differences in the dynamics of patient-practitioner interactions between younger and more established practitioners. Older practitioners often had a stable patient base and often described having treated many of their patients for years, if not decades. These GPs typically encountered fewer conflicts relating to unmet patient expectation than younger dentists or practitioners with greater numbers of new patients. This may have been a result of the strength of rapport older clinicians had with their patients, this association having been previously described within the medical literature (Mustafa et al. 2014). The strength of the influence that patient rapport can have on prescribing behaviours of dentists may warrant further investigation as it may be significant in services where there is no existing relationship between the practitioner and patient, such as in out-of-hours clinics.

9.4.7.2 Knowledge

The majority of clinicians interviewed within the current study were aware of the existence of clinical guidelines regarding antimicrobial use in dentistry and most were aware that an operative intervention should be attempted when managing patients with acute conditions. However, a number of practitioners felt that, contrary to guidelines, antibiotics were effective in some conditions such as localised apical abscesses, uncomplicated pericoronitis and alveolar osteitis (Section 7.3.3). Whilst the lack of high quality trials mean that there is uncertainty regarding the effects of antibiotics in these conditions, GPs' beliefs usually arose from their clinical experience rather than awareness of the scientific literature. Similarly, some practitioners believed operative interventions were not indicated in individuals with signs of acute infection, again contrary to guidelines (Scottish Dental Clinical Effectiveness Programme 2011, Palmer et al. 2012). These beliefs may contribute to the low rates of compliance with clinical guidelines encountered in the cross-sectional study.

However, lack of familiarity or disagreement with guidelines may not be the only knowledge barrier preventing the application of recommendations regarding antibiotic use. To a greater or lesser extent, most of the guidelines currently available are diagnosis-specific. However, several of the GPs interviewed described rarely recording diagnoses, and being relatively unfamiliar with their definitions (Section 7.3.3). As a result, practitioners may struggle to translate the recommendations of clinical guidelines into practice. This finding is corroborated by a cross-sectional study conducted in England and Scotland (Palmer et al. 2001c) in which the majority of GPs could identify clinical signs indicating the need to prescribe antibiotics but struggled when asked which clinical diagnoses indicated the need for antibiotics. Furthermore, this phenomenon has also been described in medicine; in that whilst therapeutic decisions are normally ascribed to a diagnostic label, in reality practitioners make therapeutic decisions in terms of symptoms, signs and influencing factors (Coenen et al. 2000). This identifiable gap in GPs' knowledge represents an educational opportunity by which guideline adherence could be improved. It also provides a possible explanation as to why clinical diagnoses have been poorly recorded in previous retrospective studies (Tulip and Palmer 2008).

Among the GPs interviewed there were also variable levels of understanding regarding the mode of action of antibiotics and antimicrobial resistance. Exploration of the literature suggests that this has not previously been described amongst UK GPs. Many clinicians cited undergraduate or early career as major influences on their day-to-day use of antibiotics. Correspondingly, it is likely that much of the knowledge GPs have regarding the action of antibiotics and antimicrobial resistance was obtained in the same way. This indicates that there may be difficulties related to either undergraduate dental education or more likely, retention of knowledge, following qualification amongst dental practitioners. This knowledge gap may not only impact on practitioners' choice of type, dose or duration of courses when prescribing antibiotics, it may also influence attitudes towards antibiotic stewardship within dentistry.

9.4.7.3 Attitudes

This thesis revealed that GPs' antibiotic prescribing decisions were a balancing act between immediate duty to their patient and wider concerns regarding the appropriate use of antimicrobials (Chapter 7). This is a similar finding to that reported in qualitative studies exploring antimicrobial prescribing in general medical practice, both in the UK and internationally (Hart et al. 2006, Simpson et al. 2007).

Whilst there was an appreciation amongst practitioners that prevalence of resistance was increasing, many GPs had reservations regarding the impact dental prescribing may have on this phenomenon. Some felt there was a lack of evidence implicating dental prescribing in the emergence of resistant strains, and overall dental practitioners generally felt a low level of responsibility for problems associated with antimicrobial resistance. Similar to studies conducted within primary medical care, resistance was seen as a community issue whereas practitioners' priority was the wellbeing of their individual patients (Butler et al. 1998). Possibly as a result, GPs experienced little urgency with regards to limiting the use of antimicrobials within dentistry, as they felt that changes in prescribing behaviours' of dentists would be unlikely to reduce the prevalence of antimicrobial resistance. Several practitioners felt that it should be up to other healthcare professionals such as GPs to reduce their prescribing before action within dentistry was required. This lack of urgency amongst practitioners may be one of the reasons why antibiotic use in general dental practice differs from clinical guidelines.

Furthermore, all clinicians interviewed perceived that they were 'average' or 'lower than average' prescribers of antibiotics (Section 7.2.1). This was consistently reported amongst the GPs interviewed despite an admission by several that they had little evidence on which to base this assumption. This phenomenon has been previously described within studies of antimicrobial use in primary medical care (Butler et al. 1998). Whilst it is possible that practitioners willing to engage in such research may be those who have a special interest in antimicrobial prescribing (Section 9.3.1.2), the fact that GPs had little way of benchmarking their prescribing, means that this perception may be a result of illusory superiority bias commonly referred to as the 'better than average' effect. This phenomenon means individuals evaluate their performance more positively than that of others (Brown 2012). The effect of this within the context of the current study is that practitioners who perceive themselves to be 'better than average' are likely to feel less urgency to improve their prescribing.

When managing patients with acute conditions, practitioners acknowledged that diagnostic and prognostic uncertainties could increase their likelihood of prescribing an antibiotic. Studies of English GPs have indicated that 2.9% of antibiotics are provided due to diagnostic uncertainty and a further 3.8% were prescribed due to prognostic uncertainties (Chate et al. 2006). Furthermore, diagnostic uncertainty, and its association with the incongruent prescribing of antibiotics, is well described within the wider medical literature (Lopez-Vazquez et al. 2012, Teixeira Rodrigues et al. 2013). In situations where uncertainty existed, GPs preferred to prescribe an antibiotic when one was not necessary than the potential consequences of not prescribing. The fear of possible complications arising from withholding antibiotics and the

effect this has on prescribing has previously been described within the wider medical literature as the 'chagrin factor' (Feinstein 1985).

In addition, a minority of practitioners described instances where they would prescribe an antibiotic because they lacked the skills or confidence to complete complex operative procedures. Since it is likely that practitioners gain only limited experience in undertaking treatments such as surgical extractions as an undergraduate, they are reliant on postgraduate development to become competent in these procedures. As operative skills training is not part of core continued professional development (CPD), some practitioners may never acquire these skills, or those that do may have insufficient opportunity to feel proficient. Improving the skills of these practitioners may increase their self-efficacy and reduce their reliance on antibiotics when managing complex cases.

9.4.7.4 Healthcare system-related factors

Within the observational study, having insufficient time to perform operative treatment increased the odds of a patient receiving an antibiotic which was not indicated by clinical guidelines by 4.53 (95% CI 1.45 – 14.15) (Section 3.5.6). Likewise, time pressures were consistently reported as one of the most influential factors in the management of acute dental conditions in the qualitative study (Section 7.5). These findings are supported by studies which describe the association between clinical time and workload pressures and prescribing, on both GPs (Chate et al. 2006, Palmer et al. 2000a) and physicians (Cabana et al. 1999).

Within the sample of dentists interviewed a number viewed the prescription of antibiotics as an alternative to providing operative care in cases where there was insufficient time to undertake surgical management. Several practitioners, usually those providing NHS care, described how they habitually had felt that they had insufficient time to provide operative treatment for patients with acute conditions. A few referred to the 'treadmill' of NHS dentistry and how this negatively impacted on their ability to provide unscheduled care. The 'treadmill' refers to the pattern of working as dentists are remunerated according to the quantity of dental activity they deliver rather than for prevention or for the quality of services they provide (Dental and Eye Care Services 2010).

Whilst within the interviews the 'treadmill' was portrayed as something imposed upon the dentists, dictating the way they undertake care, in reality it may be a professional ethos which has led to this way of working. Since the introduction of NHS dentistry in the late 1940s it has

been possible for practitioners to maximise their profitability by completing large volumes of treatment. In order to do this they need a well-structured appointment book which minimises waste (i.e. empty space). Whilst this maximises the amount of scheduled care they are able to complete and their financial productivity, it may mean there is often insufficient time to complete operative treatment for unscheduled patients.

The increasing widespread use of the 'treadmill' metaphor since the 1960s suggests that this has become a habitual way of working amongst NHS dentists (Pitts 2003, Chestnutt et al. 2009, Steele 2009). Dentistry is a relatively close-knit profession, where the behaviour of influential clinician-peers appears to have substantial influence on the practices of individual practitioners (Stone et al. 2014). Therefore, if young professionals model their practice on clinician-peers, often practice principals who are simultaneously juggling patient care with business responsibilities, the 'treadmill' pattern of working becomes ingrained through the 'hidden curriculum' of NHS general dental practice (Hafferty 1998).

In contrast, predominantly private practitioners discussed how they experienced less pressure to minimise the amount of unfilled time (Section 7.3.1.1). They described how the financial returns from providing private treatment 'cushioned' periods they left free for emergencies. This often gave them sufficient time to attempt operative treatment when patients presented with pain. However, there were no significant differences in the proportion of NHS and private patients who received antibiotics, indicating there may be other factors that influence the prescribing behaviours of private practitioners (Section 9.4.5).

9.4.7.5 Patient-related factors

Previous studies within the healthcare literature have indicated that patient demographic characteristics may be associated with different patterns of antimicrobial use (Lopez-Vazquez et al. 2012). However within the cross-sectional study, patient age was not identified as significant predictor of antibiotic use (Section 3.5.6). This is contrary to the results of a trial conducted in general dental practice in South Wales, which reported that younger patients amongst an adult-only population were significantly more likely to receive an antibiotic during a consultation with a GDP for an acute dental condition than older patients (Seager et al. 2006). Whilst these conflicting results could have occurred because of differences that existed between the practitioners and patient populations in the two studies, alternatively it could be due to the lack of power within the current study to detect this association.

Whilst duration of symptoms was not significantly associated with the likelihood of a patient receiving an antibiotic, greater symptom duration was associated with reduced likelihood of a guideline incongruent antibiotic prescription (Section 3.5.6). This may be due to an association between later presentation and greater symptom severity; patients who present later may be more likely to have signs of spreading infection, signs which guidelines recommend antibiotics are prescribed for. A statistically significant difference regarding the influence of symptom duration on guideline incongruent prescribing exists between genders, with the reduction in inappropriate prescribing with increasing symptom duration being greater in males than females. This may be attributable to differences in health-seeking behaviours between genders, in which males may typically delay seeking help until symptoms worsen (Galdas et al. 2005). Future studies could consider recording patient-reported symptom intensity at presentation in order to confirm whether this is the case.

Female gender was a significant predictor of antibiotic prescribing within the total prescribing model. This is inconsistent with the results of a prior study which failed to find association between gender and prescribing (Seager et al. 2006). Whilst there are isolated reports of female gender being associated with higher prescribing rates within certain demographic groups (Liu and Christensen 2002), the correlation within this study may be a result of the confounding between gender and symptom duration. Whilst in the guideline incongruent model this is controlled for by the addition of an interaction term, when a similar interaction term was added to the total prescribing model (Section 3.5.6), convergence could not be achieved. This is most probably a result of the insufficient number of cases with the dataset to support the number of variable and interactions within the model. A larger sample is therefore indicated in order to further explore the influences of patient gender and symptom duration on antibiotic prescribing.

The multilevel models arising from the observational study included patient signs and symptoms as possible predictors of prescribing behaviour. Signs and symptoms predictive of antibiotic prescribing were localised or diffuse swelling, lymphadenopathy, and trismus. All cases of dysphagia resulted in a prescription for an antibiotic, and therefore whilst this variable was not included in the model, it appears to be an important predictor of antibiotic use. This suggests that overall, the presence of indicators of infection such as swelling, trismus, or dysphagia may increase the likelihood of a GDP prescribing an antibiotic. However cellulitis, purulent discharge or draining sinus, fever, and mucosal ulceration all failed to reach statistical significance in the final model. This may be due to the relative scarcity of these features within the dataset or lack of power to detect associations. However, the qualitative data are broadly supportive of the assertion that GDPs may be more likely to prescribe an antibiotic when a patient presents with

overt signs of infection (Section 7.4.2). This is corroborated by findings of an observation study of English GDPs in which more than 80% of respondents replied that they would prescribe antibiotics in cases presenting with diffuse swelling, trismus, or dysphagia (Palmer et al. 2000a).

The current study also indicates that patient willingness and ability to accept operative treatment may also influence antibiotic use for acute conditions (Sections 3.5.6. and 7.4.2). Within the qualitative investigation GDPs described instances where dentally-phobic patients refused recommended operative treatment, or wished to delay such treatment until a later date. The most common result was that an antibiotic was provided during that initial appointment with a verbal understanding that the patient needed to return for definitive treatment. This is supported by results from the multilevel models which identify a patient's rejection of operative treatment options as a predictor of both total antibiotic prescribing and guideline incongruent prescribing and patient's inability to accept operative treatment as a predictor of guideline incongruent antibiotic use.

Furthermore, dental practitioners described experiencing greater apprehension when performing operative treatment on anxious patients (Section 7.4.2). So whilst some practitioners reported trying to encourage dentally-phobic patients to undergo operative treatment, prescribing antibiotics and delaying treatment until a scheduled time was often viewed as more predictable by clinicians. However, it remains unclear the extent to which patients are aware that antibiotics are not routinely recommended in the management of dental problems. This is an avenue for further investigation as this may contribute to acceptance of operative treatment and less expectation for antibiotics on the part of patients.

Patient requests for antibiotics were found to be a significant predictor of both overall and incongruent antibiotic use within the observational study. This may be a result of practitioners' desire to satisfy the patient requests (Butler et al. 1998), or maintain patient-practitioner rapport. Perceived patient expectation of an antibiotics has previously been demonstrated to influence antibiotic prescribing both in primary care dentistry (Palmer et al. 2000a) and medicine (Cockburn and Pit 1997, Macfarlane et al. 1997, Coenen et al. 2000, Akkerman et al. 2005, Coenen et al. 2006).

Studies suggest that perceived patient expectation of antibiotics may be associated with an even greater likelihood of prescribing than direct requests (Coenen et al. 2013). So whilst results of the qualitative study indicate that clinicians perceived expectation for antibiotics amongst some patients attending for acute dental conditions (Section 3.5.6), it is currently unclear the degree to which perceived patient expectation affects dentists' prescribing decisions. Whilst the

majority of GPs interviewed as part of the current study stated that patient expectation would be unlikely to influence their prescribing practices, research from primary care medicine suggests this may not be the case (Cockburn and Pit 1997, Macfarlane et al. 1997, Coenen et al. 2000, Akkerman et al. 2005, Coenen et al. 2006). Since previous studies have suggested that patient expectation for antibiotics during episodes of acute dental conditions may be as high as 40% (Steed and Gibson 1997), further research is indicated to explore the degree to which patient expectations and clinicians' perceptions of patient expectation influence antibiotic prescribing for dental conditions.

Whilst not explored in detail within this study, there may also be financial reasons why patients express certain treatment preferences when they attend with acute conditions. In the 2009 Adult Dental Health Survey, a quarter of adults said that the type of dental treatment they had opted to have in the past had been affected by the cost of treatment and almost one fifth had delayed dental treatment for financial reasons (Nuttal et al. 2011). Refusal of operative treatment on the grounds of inability to pay may plausibly increase the likelihood of an antibiotic being prescribed. Future studies should therefore consider investigating whether patients' willingness and ability to pay for some dental treatments impacts on the management they receive for acute conditions.

9.5 Interpretation of findings and comparison with other published work - the use of antibiotics in the management of dental conditions in primary medical care (Chapters 4, 5, 6 and 8)

9.5.1 Rates of dental consultation in general medical practice

The observed rate of dental consultations within the CPRD cohort study ranged between 6.49 to 7.40 consultations per 1000 patient-years (Section 5.2.2). Therefore, during the study period a practice with 6,000 patients would have expected to have had between 39 and 44 dental consultations per year. This is a similar rate of consultations to that reported by the only other comparable study of dental consultations in general medical practice. In that study there were 6.90 consultations per 1000 patient-years for tooth-related problems within the General Practice Morbidity Database for Wales (Anderson et al. 1999). In comparison, there are 86 consultations per 1000 patient-years for upper respiratory tract infections, 13 consultations per 1000 patient-years for acute otitis media and 5 consultations per 1000 patient-years for

laryngitis in similar studies of general medical practice (Ashworth et al. 2005, Currie et al. 2014). Therefore, dental problems may represent a similar burden on general medical practice as some of the other common infections of the head and neck.

Analysis of the CPRD database showed that rates of dental consultations varied considerably between practices (Section 5.2.1). This is consistent with a previous study (Anderson et al. 1999), and correlates with findings of the qualitative interviews with general medical practitioners. Inter-practice differences are likely to result from variations in accessibility to dental services, dental needs and health seeking behaviours of the local patient population, as well as individual practice policies and attitudes towards managing dental problems. The wide differences in dental consultation rates between practices mean that the burden of dental consultations on individual medical practices and local commissioning services is also likely to be highly variable. An economic analysis to determine the costs of dental consultation in primary care medical practice may therefore be a logical further step.

In the population studied, rates of dental consultation were highest amongst patients aged 21-30 years, followed by those aged 31-40 and 41-50 years. This was also perceived to be typical of patients consulting with dental problems amongst the GMPs interviewed (Section 8.3.2). Higher rates of dental consultation amongst patients of working age may be the result of difficulties accessing dental services at convenient times within this population. The reasons why patients may consult a GMP for dental problems are explored further in 9.5.2.

Rates of dental consultation were consistently higher among female patients than male patients. This is consistent with the study conducted by Anderson et al. (1999), and reports within the wider healthcare literature (Hippisley-Cox and Vinogradova 2009). However, whilst female patients were responsible for over 55% of all consultations in all age groups over the age of 11, within the age group 10 or younger male patients accounted for nearly 53% of consultations. Again, this is supported by sources which suggest higher consultation rates amongst male patients under the age of 5 years old for other conditions within primary care (Hippisley-Cox and Vinogradova 2009).

During the seven year period for which denominator data were available, rates of consultation for dental problems changed relatively little, in comparison to consultation rates for other common infections which declined more dramatically during a similar period (Currie et al. 2014). Reductions in consultation rates for other common infections in general practice have been attributed to reduced rates of antibiotic prescribing for these conditions (Ashworth et al. 2005). As antibiotic prescribing rates for dental problems do not appear to have decreased in the same

way (Figure 5.6), this may explain why rates of dental consultations have remained relatively constant. However, an observational study cannot prove a causal relationship and therefore further investigation is required.

Differences in consultation rates for dental problems were observed between England, Wales, Scotland and Northern Ireland, with higher rates of consultation in England and Wales than in Scotland and Northern Ireland (Figure 5.5). Rates of dental consultation in England and Wales begin to decrease around the time the new NHS Dental Contract was introduced, whilst rates of dental consultations in Scotland and Northern Ireland continued to increase. However it is not possible to state with certainty that these changes were a result the introduction of the new contract, as causation cannot confidently be determined from observational studies. Furthermore, absence of longer term information about rates of dental consultation and the presence of confounding variables such as changes in GMP practice policy, changes in the availability of local dental services occurring independently of the contract change, and the entry and exit of general medical practices to CPRD, all add to the uncertainty in this situation. Furthermore, the variability of consultation rates in Scotland and Northern Ireland (where the previous contracting arrangements were maintained) highlights that there may be other factors more influential in determining consultation rates for dental problems in general medical practice. A possibility for further work within this area would be to conduct a change point analysis which are designed expressly to detect subtle changes in incidence and characterise changing trends in time series (Kass-Hout et al. 2012).

9.5.2 Reasons why patients consult for dental problems in general medical practice

Previous research has indicated that choice of primary care practitioner during episodes of dental problems may be influenced by: access to healthcare services; dental anxiety; costs associated with treatment; the attributes of the dental practice; presentation of dentoalveolar pain and patients' preferences regarding healthcare practitioners (Freeman 1999, Mansour and Cox 2006, Bell et al. 2008, Nuttal et al. 2011). All of these factors were discussed to a greater or lesser extent by the GMPs interviewed (Section 8.3.2).

Difficulties accessing NHS dental care was the most commonly cited explanation why patients may consult a GMP with a dental problem. In recent years access to NHS dental services has occasionally been a contentious issue, with some reports suggesting that it is difficult to obtain an appointment with an NHS dentist (Hope 2008). However, whilst only 58% of adults report

attempting to make an NHS dental appointment in the previous three years, 93% of those who had tried were successful in obtaining an appointment (Nuttal et al. 2011). This suggests that patients may not attempt to access NHS dental services because they perceive that they will be unsuccessful and instead attend their general medical practice, as opposed to having tried and been unsuccessful.

In addition, GMPs perceived that the duration of time a patient may have to wait between initial contact with a practice and the appointment for an acute condition was typically longer in general dental practice than in general medical practice. They perceived that this delay may make patients, particularly those in pain, more likely to consult their general medical practice, where they may be able to obtain a same-day appointment. Furthermore, GMPs felt that patients typically had more experience of accessing medical services and were more likely to know how to make an appointment, when “open-surgery” was and so forth. It is likely therefore that perceived ease of access does influence patient choice of practitioner when suffering from a dental problem. This is supported by a cross-sectional study in which 79.5% of Scottish patients indicated that, when it came to booking appointments, their GMP was more accessible than their GDP (Bell et al. 2008).

There was also an opinion among the GMPs interviewed that some patients may consult a medical practitioner believing that they need antibiotics for their dental condition. This may be corroborated by the scientific literature which suggests that a high proportion of patients expect an antibiotic when they have an episode of dental pain (Steed and Gibson 1997, Seager et al. 2006). GMPs believed that expectations for antibiotics were often motivated by prior experience of receiving antibiotics from a dental practitioner for a similar condition. This is supported by evidence that the outcomes of previous consultations influence patient expectations during future episodes of care (Bowling et al. 2012), and studies that have identified a statistically significant relationship between previous antibiotic treatment and greater expectation for antibiotics (Shlomo et al. 2003).

GMPs also indicated that dissatisfaction with the outcome of previous dental consultations may influence a patient to seek care from their general medical practitioner instead. Whilst it is unclear how frequently this influences patients to consult a GMP for a dental problem, previous research has suggested that as many as 20% of dental appointments are reported as less than satisfactory by consulting patients (Nuttal et al. 2011).

GMPs had conflicting opinions as to whether a patient might seek emergency care from a doctor rather than a dentist due to financial reasons. However, a study reported that that 67.3% of

patients who reported that they would see a doctor when experiencing problems of the mouth or jaw regarded having to pay to see a dental practitioner but not having to pay to see a medical practitioner as influencing who they would consult (Bell et al. 2008). This difference may be due to patients' unwillingness to disclose to their GMP that they either cannot afford, or do not want to pay for dental treatment. In addition, the extent to which financial motivations impact on the health seeking behaviours of patients are likely to vary across differential levels of socioeconomic deprivation, possibly explaining differences in perceptions of this phenomenon among the GMPs interviewed.

GMPs indicated that patients may choose to consult a doctor when experiencing dental problems due to anxieties relating to dental treatment (Section 8.3.2). Two of the most common operative interventions for dental pain are root canal treatment or dental extraction, yet research has indicated that patients consistently rate these two procedures amongst the most anxiety-inducing of all dental stimuli (Oosterink et al. 2008). It is therefore possible that fear of operative procedures prevents some patients seeking care from a dentist. In contrast GMPs may be perceived as a 'non-surgical' alternative. Increased prevalence of extreme dental anxiety amongst women and lower socioeconomic groups may begin to account for higher rates of dental consultations in females, and observations of GMPs that patients consulting for dental problems were typically socioeconomically deprived (Nuttal et al. 2011).

Finally, GMPs identified that in some instances a patient may present with symptoms indicating a non-classical presentation of toothache, or due to uncertainties as to whom was the most appropriate profession to consult regarding orofacial conditions. This latter point is supported by research which suggests that whilst only 2.7% of patients would consult a doctor in preference to a dentist if they had toothache, over a third of patients prefer to consult a doctor if they had more non-specific symptoms of dental disease such as a lump on the gum, or trismus (Bell et al. 2008). Therefore, if patients do not associate these symptoms with a dental aetiology, they may logically select their GMP as the most appropriate professional to consult (Mansour and Cox 2006).

9.5.3 Attitudes of medical practitioners towards managing patients with dental problems in general medical practice

Attitudes of GMPs towards managing patients with dental problems varied not only between practitioners, but according to the specific situation in which the consultation occurred (Section

8.3.3). Practitioners' feelings were related to the perceived burden of dental conditions, general pressures of their workload, perceptions about why the patient had been motivated to seek care, confidence when managing patients with dental conditions, and concepts of best practice regarding dental problems. Whilst this is the first study to comprehensively investigate the attitudes of GMPs towards the management of dental problems, these findings are broadly supported by anecdotal evidence (Bint 2008, Matthews-King 2013).

The implication of this intra- and inter-practitioner variation is that, depending on the circumstances surrounding a consultation and the GMP seen, patients may receive different messages about the appropriateness of seeking care for dental problems in general medical practice which may affect their future consultation pattern. This variation can also result in conflicts within a practice (Section 8.3.3).

9.5.4 Use of antibiotics in the management of dental problems in general medical practice

In the cohort study (Section 5.3.1) 56.2% of consultations resulted in a prescription for antibiotics. This is less than previously reported in a 1996 study of oral problems in general medical practice in which 67.6% of patients received an antibiotic (Anderson et al. 2000). This may be due to a decrease in the proportion of dental consultations in general medical practice resulting in an antibiotic. However, the current study suggests that rates of antibiotic use for dental problems have remained relative stable in recent years, and the 10% difference observed may reflect differences in inclusion criteria between studies.

Penicillins were the most commonly prescribed antibiotic, followed by metronidazole and tinidazole, then macrolides (Section 5.3.1). Whilst these three types of antibiotics were the most common types prescribed in a previous study, relative proportions of penicillin were smaller and metronidazole and tinidazole proportions larger than previously reported (Anderson et al. 2000). This corresponds with current findings demonstrating that metronidazole use has increased for dental problems in the general medical practice during the study period. It also correlates with the increase in metronidazole usage in general dental practice (Health and Social Care Information Centre 2008, 2014). Whilst these trends may be due to increasing concerns about penicillin-resistant organisms amongst primary care practitioners, it is difficult to be certain as to the exact cause of this change.

9.5.5 Factors that influence the use of antibiotics for dental problems in general medical practice

9.5.5.1 Knowledge

Most of the GMPs interviewed had a relatively limited understanding of the aetiology and diagnosis of dental problems. Consequently, many made inferences from their knowledge of other common infections. As a result, most practitioners considered that dental pain was nearly always the result of an infection and neglected to consider inflammatory causes of pain. Furthermore, many were not aware that operative treatment was often required to resolve odontogenic infections. This may explain beliefs regarding the positive effects of antibiotics in the management of acute dental conditions held by many physicians. This is supported by others studies which have described limited diagnostic awareness regarding non-dental orofacial conditions and dental emergencies amongst physicians (McCann et al. 2005, Trivedy et al. 2012, Bissett et al. 2013).

In the absence of formal teaching on dental pathologies, GMPs' knowledge was principally derived from dental friends or colleagues, or from being a patient themselves. A similar finding was reported by an observational study of GMPs in India, where the most common sources of practitioners' oral health knowledge were the media, friends and relatives, and their own dentist (Nagarakanti et al. 2013).

9.5.5.2 Attitudes

There was a consensus amongst GMPs that general practice was not the optimal environment to manage patients with a dental problem. Yet, attitudes towards attempting to manage dental conditions differed within the sample. These attitudes appeared to be influenced by the extent to which the practitioners balanced the immediate needs of the patients against their desire to motivate patients to seek more appropriate care for their dental problem. This was a dynamic process influenced by a patients' presentation, the availability of local dental services and the practitioner's own attitude towards managing dental problems. Practitioners who had strong feelings that they should attempt to relieve a patients' symptoms were more likely to prescribe antibiotics, as were those who had concerns about the possible negative consequences of withholding these agents. Conversely, practitioners who prioritised educating patients about appropriate health seeking behaviour, GMPs who felt strongly that they should not be managing

dental problems, and practitioners who had strong feelings towards antimicrobial use reported that they were less likely to prescribe antibiotics. Instead these practitioners described prescribing analgesics, or more commonly, providing no active treatment. Both prescribing and non-prescribing practitioners were able to justify that their treatment decision as being in the best interests of their patients, either in the short or longer term. This is supported by previous studies which have described prescribing decisions of GMPs as balancing acts between addressing patients' immediate needs and responsibilities towards antimicrobial stewardship (Wood et al. 2007).

9.5.5.3 Health-care environment

The relative availability of dental services was identified as a factor that could influence a GMP's decision to prescribe antibiotics for a patient with dental problems. Several of the practitioners interviewed described how the reduction of dental services at weekends would increase their likelihood of prescribing an antibiotic on a Friday. This is corroborated by the multilevel model which indicates that antibiotics were statistically more likely to be prescribed on a Friday than a day in the middle of the week (Section 5.4.1.). As well as concerns about when the patient may be able to access dental care, increased Friday prescribing may be a result of greater anxieties about the patients developing a severe infection over the weekend.

Furthermore, a recent study has described how primary care practitioners experience 'decision fatigue', the erosion of self-control after making repeated decisions, towards the end of the working day (Muraven and Baumeister 2000, Linder et al. 2014). This is thought to be responsible for higher rates of inappropriate prescribing in afternoon sessions than in the morning (Linder et al. 2014). Hypothetically, it is also possible that practitioners experience a similar phenomenon towards the end of their working week, and this may contribute to higher rates of antibiotic prescribing for dental problems on a Friday.

In the cohort study, patients were statistically more likely to receive an antibiotic on a Monday than during the middle of the week. While the explanation underlying this are not immediately apparent, it may be due to the pressures of an increased workload on the first day of the week or greater symptom severity if patients have been unable to access care over the weekend.

Furthermore, the likelihood of an antibiotic being prescribed was also higher in months when people traditionally take holiday (July, August and September), and during months where there

are bank holidays (April, May and December). This may also be a result of concerns of GMPs regarding patients' access to regular dental care providers, although there was little evidence within the qualitative study to support this assertion and therefore the reasons for these findings are unclear.

In addition, there were differences detected in likelihood of an antibiotic being prescribed depending on the country of consultation. Patients in Scotland were significantly less likely to receive an antibiotic than those in England when all other independent variables were controlled for (Section 5.4.1). Whilst this may be due to differences in the organisation of healthcare between the two countries, it is hard to speculate with any certainty beyond this. However, as there may be features of Scottish general medical practice that may be potentially beneficial to optimising prescribing elsewhere, inter-country differences in prescribing rates for dental conditions should be investigated further.

9.5.5.4 Patient-related factors

Middle aged patients were significantly more likely to receive an antibiotic than those at the extremes of age (Section 5.4.1). This may be a consequence of differing reasons for consulting for a dental problem across different age groups; parents of paediatric patients may be seeking reassurance for disorders of tooth eruption whilst elderly patients, who are more likely to be edentulous, may be consulting due to denture problems. In order to investigate this further, breakdown of diagnostic Read Code by age and antibiotic status could be attempted.

Female patients are marginally less likely to receive an antibiotic than their male counterparts. Whilst no other reports exist of antibiotic use by gender for dental problems in primary care, a study reported that men were slightly more likely to receive an antibiotic for a respiratory tract infections than women once differences in consultation rate were controlled for (Gulliford et al. 2009). It may be that males have a higher symptomatic threshold for consultation and are therefore more likely to have more severe signs and symptoms on presentation. However without information about symptom intensity this remains a hypothesis.

Although as previously discussed, there are limitations with determining the number of previous episodes for dental problems (Section 9.3.2.3), a higher number of previous episodes of dental problems within the study period were predictive of an increased likelihood of a patient receiving an antibiotic. A similar relationship was also found between number of previous

episodes and analgesic prescribing. This could also be a result of confounding by disease severity; patients with poorer oral health being both more likely to consult for dental problems and more likely to have signs indicative of dental disease. However, it could be due to greater patient expectation for antibiotics driven by prior experience of receiving an antibiotic during a dental consultation with a GMP (Bowling et al. 2012, Shlomo et al. 2003).

The general practitioners interviewed described perceived high levels of expectation for antibiotics amongst patients consulting for dental problems. The role of antibiotic expectation in increasing prescribing likelihood is well described (Cockburn and Pit 1997; Macfarlane et al. 1997; Coenen et al. 2000; Akkerman et al. 2005; Coenen et al. 2006). However, the degree to which perceived patient expectation of antibiotics influences prescribing decisions for dental problems in general medical practice is unclear.

9.5.6 Use of prescription analgesics in the management of dental problems in general medical practice

To our knowledge this is the first study to describe analgesic prescribing by GMPs for dental problems. An analgesic was prescribed in 20.1% of consultations within the cohort study of general practice. However this does not include recommendations made by practitioners regarding the purchase of over-the-counter analgesics.

During the study period the proportion of dental consultations resulting in an analgesic increased from 18.7% to 21.5%. Whilst the reasons for this are not immediately apparent, it may be a result of the introduction of free prescriptions in Wales, Scotland and Northern Ireland during the study period and changes in patient expectations or requests for analgesic preparations.

Whilst GMPs and GDPs prescribed antibiotics to roughly similar proportions of patients with dental problems (56.2% vs. 57.4%), GMPs prescribed analgesics to substantially more patients than GDPs (20.1% vs. 4.4%) (Sections 3.5.5 and 5.3.2). This may be a reflection on the larger number of agents available for GMP prescription within the BNF compared to the Dental Practitioners' Formulary. However, it may also be due to differing attitudes and familiarity when prescribing analgesics between the two professions.

Throughout the study period, just over half of analgesic prescriptions by GMPs were for preparations containing opioids. This is contrary to evidence that suggests that NSAIDs are more

effective than opioids in controlling dental pain (Ahmad et al. 1997). Whether GMPs are unaware of this evidence or whether they are prescribing opioids in situations where NSAIDs have been unsuccessful or are contraindicated is unclear, but warrants further consideration.

9.5.7 Factors that influence reconsultation

Treatment with an antibiotic or an analgesic was associated with an increased likelihood of reconsultation for a subsequent episode of dental problems within two years, compared to if neither of these medications were prescribed (Section 5.5.1). It may be that practitioners who attempt to manage their patient's dental problems by prescribing medications are reinforcing beliefs that general practice is an appropriate place to consult for a dental problem. Prescribing antibiotics for sore throat and acute otitis media has been demonstrated to be associated with an increased rates of reattendance (Little et al. 1997, Williamson et al. 2006), and it is thought that prescribing antibiotics encourages belief in their effectiveness, fuelling consultation (Little et al. 1997). However, it should be noted that the association within the current study may be confounded by variables such as severity of dental disease or presence of co-morbidities.

Other factors predictive of reconsultation were patient age and gender. Similar to overall consulting rates, the likelihood of reconsultation was highest amongst patients of working age, which may be a result of lack of access to dental services within this group. Reconsultation rates were also higher in females than males, which again reflects overall rates. However, interaction terms indicated that the effect of receiving an antibiotic or analgesic only on the probability of reconsultation was weaker in female patients than in male. This may indicate that female patients have different motivations for consulting a GMP with dental problems than male patients.

Whilst this study provides some information about factors that influence reconsultation, the final model constructed within the analysis still had a considerable amount of residual patient-level variance. It is possible that duration of illness prior to and following consultation, number of previous consultations for dental problems, dental disease severity, access to dental services, co-morbidities or psychosocial factors also influenced the decision to reconsult, and therefore future studies should attempt to measure and control for these factors in their design.

9.5.8 Professional relationships

GMPs' knowledge of local dental services was limited and they were reluctant to make formal referrals to primary care dentists (Section 8.5). This is corroborated by another study which also highlighted both the absence of formal referral pathways and lack of communication between general medical and dental practitioners (Bell et al. 2008). Furthermore, the reluctance amongst medical practitioners to refer patients to dentists has been described in international studies (Nagarakanti et al. 2013). However, this means that patients attending a general medical practice with dental problems often receive little to no assistance in accessing dental care, despite recommendations from the doctor that they should do so.

Many of the GMPs considered dentists and doctors to have different attributes and approaches to patient-management and perceived a 'divide' between the professions. It has previously been suggested that GMPs have negative perceptions about the way dentists approach care; being more business- than patient-centric (Bissett et al. 2013). Such attitudes were less apparent within the current study, possibly due to the professional identity of the interviewer (AC). However, measures aimed at ameliorating professional tensions and increasing communication between medics and dentists may result in more co-ordinated care for patients with dental problems. Possible models for this could include the Primary Eyecare Assessment and Referral Service (PEARS) or joint meetings between Local Dental and Medical Committees. The benefits of closer co-operation between medical and dental practitioners were highlighted by the small number of GMPs currently engaged in this style of working. They are also confirmed by a study which reported reduced patient information errors, increased dental attendance of patients at the extremes of age and the reduced the need for secondary referrals resulting from that greater integration of primary dental and medical care (Haughney et al. 1998).

9.6 Implications for policy, practice and future work

9.6.1 Implications for policy and practice

9.6.1.1 Antibiotic use for acute dental conditions in general dental practice

This thesis has contributed to the growing body of evidence that suggests that antibiotics are being widely used in the management of acute dental conditions in primary care dentistry, often in limited compliance with clinical guidelines. This raises concerns both in relation to the

emergence of antibiotic resistant bacteria and with regards to the effectiveness of treatment being provided for acute conditions. Interventions are therefore indicated to optimise prescribing within primary dental care.

The observational study highlighted substantial differences between GDPs with regard to their antibiotic prescribing behaviours (Section 3.5.6). The clustering of inappropriate antibiotic use provides an opportunity for targeted interventions to improve prescribing if such practitioners could be identified. There may be other practitioner-level characteristics, not collected as part of this study, or not represented with sufficient frequency within the dataset, that could be used in order to most effectively target resources to optimise prescribing.

Whilst clinical guidelines regarding the use of antimicrobials in dentistry are available, the current study suggests not all practitioners are familiar with their recommendations. Furthermore, some may struggle to interpret their recommendations. This represents a knowledge-gap with respect to antimicrobial use. Previous educational interventions involving educational elements which successfully improved antibiotic prescribing within general dental practice include academic detailing by pharmacists (Seager et al. 2006), and clinical audit (Chate et al. 2006). Since both the current research and previous studies have highlighted strong preferences amongst GDPs for peer-to-peer learning (Stone et al. 2014), combining clinical audit or academic detailing with elements of peer-led education may prove most successful in producing sustainable improvement in prescribing amongst GDPs. Furthermore, a Cochrane Systematic Review has indicated that multifaceted interventions may be most successful at improving antibiotic prescribing practices in primary medical care (Arnold and Straus 2005).

This thesis has advanced previous understanding about intrinsic and extrinsic factors which can influence antibiotic prescribing behaviours. It has become increasingly clear that whilst improving practitioners' understanding of antimicrobial prescribing may overcome knowledge barriers, there may still be obstacles with regard to practitioners' attitudes, patient-related factors and features of the healthcare environment which may prevent optimal antibiotic use. Many of the GDPs within the current study did not consider antibiotic use in dentistry to be a substantial contributor to antimicrobial resistance and thus felt little urgency to alter their prescribing behaviours. If clinicians do not appreciate the purpose and value of improving antibiotic prescribing and the benefits this could have on reducing the burden of antimicrobial resistance, they are unlikely to actively engage in strategies to optimise prescribing. Raising awareness of the potential impact dental prescribing could have on the emergence of resistance may positively influence some practitioners to improve their prescribing practice.

In addition, many of the practitioners in the current study already considered themselves 'better than average' prescribers. Whilst it is generally well known that people generally overestimate their performance (Epley and Dunning 2000), it has also been demonstrated that people who perform well on a task only slightly underestimate their performance, whereas poor performers consistently and greatly overestimate their own performance (Kruger and Dunning 1999). Therefore, providing feedback to clinicians about how they prescribe in relation to other dentists in similar practices may cause some practitioners to reconsider their antibiotic use (Prior et al. 2014). However, since several practitioners report that they would be reluctant to receive feedback, this should be undertaken sensitively, whilst simultaneously providing practitioners with the tools they need to change. Furthermore, individuals identified as having good prescribing practices should be supported so that they can continue to work in this way.

However, some of the practitioners described feelings of resignation to the way acute cases were managed within their practice. This indicates that steps may need to be taken to support and empower practitioners who wish to change the way they manage unscheduled cases and this may require the co-ordinated efforts of practitioners, practice staff and commissioners of dental care.

Furthermore, these factors should be considered during the contracting of dental services. However, financially incentivising operative treatment in acute conditions may not fundamentally change the way dentists are working, but may merely replace one 'treadmill' for another. Therefore efforts which seek to instil a philosophical change with regard to practice may produce the most suitable improvements in prescribing behaviour, although how this may be achieved is unclear.

9.6.1.2 Antibiotic use for dental conditions in general medical practice

This is the largest study to describe the burden of consultations for dental problems within general medical practice in the UK. Although results indicate rates of consultations for dental problems in medical practice are relatively low in comparison to other common infections, such consultations commonly result in the provision of an antibiotic. This raises concerns about both the effectiveness of treatment provided for dental conditions in general medical practice, and the possible impact on rates of antimicrobial resistance.

Whilst it became apparent that many GMPs have limited understanding of the aetiology and management of dental problems, the majority of practitioners were opposed, some strongly, to training or the introduction of resources regarding the management of dental problems in general practice. This creates a dilemma when considering how to improve outcomes of dental consultations. The answer may therefore lie in raising awareness amongst GMPs about dental services for patients with acute conditions that are available in their local area. This may include up-to-date information about access to emergency dental services and details of general dental practices currently accepting new patients. Greater awareness of referral pathways for patients with dental problems may reduce practitioners' feelings of responsibility regarding trying to manage these conditions themselves. This could be supplemented by brief guidelines regarding antibiotic and analgesic use for dental problems or the development of decision aids to guide doctors in the correct management of dental conditions for practitioners who wish to use them. These processes could also be supported by measures aimed at increasing communication between medical and dental professions such as integrated CPD events or joint meetings of Local Medical and Dental Committees.

9.6.1.3 Antibiotic use for dental conditions in primary care: a summary

The current work has identified a number of common factors which may act as barriers to the instigation and maintenance of appropriate prescribing practices for dental problems in primary care. These include knowledge and skill deficiencies, lack awareness of the possible contribution of personal prescribing practices to antimicrobial resistance, diagnostic or prognostic uncertainties, pressures of time and workload, perceived patient expectation for antibiotics, and other features of the patient-practitioner relationship. As similar barriers have been reported in studies exploring prescribing for other common conditions in primary care (Lopez-Vazquez et al. 2012, Teixeira Rodrigues et al. 2013), interventions which have successfully supported judicious antibiotic in those settings may be successfully adapted to use in the current context. Of these, multi-faceted interventions addressing local barriers to change where educational interventions occur on many levels may be most successful in improving prescribing (Arnold and Strauss 2005). Such interventions should be aimed at both prescribers and their patients; educating patients about the most appropriate use of antibiotics in the management of dental conditions, and supporting practitioners so they feel able to enter a dialogue with patients as to whether an antibiotic is required for a dental problem. Uptake of such interventions should be particularly encouraged among practitioners and patients groups most likely to benefit from them, such as

high prescribing practices and patients from socially disadvantaged backgrounds who may have lower health literacy.

9.6.2 Implications for research

9.6.2.1 Antibiotic use for acute dental conditions in general dental practice

Inter-practitioner variability with regards to antibiotic use has not previously been described within primary dental care. Yet, clustering of antibiotic use may be important to consider in the design of interventions to optimise prescribing. In this study only one clinician per practice was enrolled. Further work is indicated to explore whether clinicians working within a practice prescribe in similar ways or whether clustering occurs at the clinician level only.

This thesis also aimed to identify clinician, patient and appointment features predictive of antibiotic prescribing. However, whilst some associations were detected, the study was not powered with this analysis in mind. As a result, where associations were identified, wide confidence intervals existed around odds ratios, making interpretation of the clinical significance of such relationships problematic. Furthermore, qualitative interviews with GPs indicated that there may be associations between certain clinician characteristics and antibiotic prescribing tendencies that were not identified by the multilevel modelling. In light of this uncertainty, and the possibility of Type II errors, specifically-designed, well powered studies are indicated in this area. The potential benefits of accurately identifying predictors of antibiotic use and misuse are that interventions to optimise prescribing may be devised for at-risk practitioners or patients, or designed to modify factors known to increase the likelihood of prescribing.

The availability of clinical time was identified as one of the most significant determinants of the management of acute dental conditions. Therefore, further work is indicated to increase understanding of the effect time and workload pressures can have on the outcomes of dental consultations. This will hopefully inform the organisation of dental services so that patients with acute conditions receive the most efficacious treatment.

Patients' expectations of antibiotics have been shown to be a significant predictor of prescribing in general medical practice. Therefore, whilst the cross-sectional study indicated that requests for antibiotics increased the likelihood that they would be prescribed (Section 3.5.6), further investigation regarding patient expectations for acute dental conditions is indicated. This should also include exploration of patients' views surrounding the management of acute dental

conditions and assessment of whether met or unmet expectations for antibiotics influences patients' satisfaction with care, as this may inform interventions to improve prescribing.

9.6.2.2 Antibiotic use for dental conditions in general medical practice

Whilst this thesis described attendance for dental problems in general medical practice, little is known about the longer-term outcomes of dental consultations. For example, do patients go on access dental care? What is the incidence of head and neck infections within this population? How does consulting a GMP for a dental problems influence patterns of care during subsequent episodes of dental problems? Investigating these questions would no doubt contribute to a more comprehensive understanding of dental consultations in general medical practice.

Furthermore, whilst the results of the qualitative work indicates that GMPs refer only a minority of patients who consult with dental problems, analysis of referral patterns with CPRD would provide more information about the characteristics of patients referred to other healthcare professions. Linking the existing CPRD dataset to a database of Hospital Episode Statistics may also provide a more complete understanding the longer-term outcomes experienced by patients attending their GMP with dental problems.

In addition, although the current work explored perceptions of GMPs regarding patients' reasons for consulting a doctor for dental problem, more patient-centred research is needed if underlying motivations for consultation are to be fully understood. This may be best approached using qualitative methods in which individuals' rationale for consulting a general medical practitioner can be fully explored within the context of their beliefs and attitudes towards dental care and prior health seeking behaviours.

At this point in the work the CPRD dataset still holds a lot of potential for further information that could be analysed to further understanding of dental consultations in general medical practice. The next steps may be to identify patients with co-morbidities known to be associated with oro-dental conditions such as cardiovascular disease, diabetes, immunosuppression or pregnancy and compare whether these factors influence rates of consultation or antibiotic prescribing for dental problems.

9.7 Conclusions

This thesis sought to investigate the use of antibiotics in the management of dental conditions in primary care in the UK. In doing so it described the presentation of patients with dental conditions in general dental and medical practice, described the proportion of consultations resulting in an antibiotic and explored factors that can influence the management of patients with such conditions.

Over half of the adult patients who consulted a GDP with an acute dental problem were prescribed an antibiotic as part of their management although antibiotic use varied considerably between practitioners. Antibiotics were typically prescribed empirically, with frequent use of broad-spectrum agents. A minority of patients who received an antibiotic underwent concurrent dental treatment to relieve or remove the source of infection and inflammation during the same visit and less than 20% of antibiotics were prescribed in compliance with SDCEP and FGDP(UK) guidelines. This indicates that antibiotics are being used as an alternative, not an adjunct, to operative measures such as exodontia or endodontic treatment, particularly when practitioners experience clinical time pressures. Furthermore, over a quarter of antibiotics were prescribed for conditions which are primarily inflammatory in origin such as irreversible pulpitis and symptomatic apical periodontitis and there was substantial variation in the dose, frequency and duration of antibiotic courses prescribed by GDPs. This adds to growing concerns regarding the use of antibiotics in the management of acute dental problems by GDPs and the potential impact this may have on morbidity and antimicrobial resistance.

Dental practitioners were aware of antimicrobial resistance but varied in their assessment of the impact dental prescribing could have on the emergence of resistance. This thesis highlighted that GDPs' antibiotic prescribing decisions are a balancing act between immediate duty to their patient and wider concerns towards public health. The decision to prescribe antibiotics seems to be influenced by clinicians' attitudes towards clinical guidelines and their approach to managing cases where there was diagnostic or prognostic uncertainty. Patient-related factors such as clinical presentation, willingness and ability to accept operative treatment, and requests for antibiotics also modified prescribing behaviours of GDPs. Similarly, pressures of clinical time and workload are also predictors of antibiotic use. Addressing some or all of these issues may provide a way of producing sustainable improvement with regards to antibiotic use in dentistry.

There were approximately 7 dental consultations per 1000 patient-years in general medical practice in the UK between 2004 and 2011, with young adults and female patients being more

likely to attend with a tooth-related problem. Although rates varied between practices, overall levels of consultations for dental problems changed relatively little in the study period. Rates of consultation were higher in England and Wales than in Scotland and Northern Ireland. Decreases in consultation rates for dental problems were observed in the period following the introduction of the new NHS Dental Contract in England and Wales in 2006. However, due to the observational nature of these data, it is not possible to determine whether this is a causal relationship.

Over half of the patients who consulted a GMP with a dental problem were prescribed an antibiotic as part of their management, and a fifth received analgesics. Treatment with an antibiotic or an analgesic was associated with an increased likelihood of reconsultation for a subsequent episode of dental problems within two years, compared to if neither of these medications were prescribed. Attitudes towards the use of antibiotics in the management of dental conditions varied considerably between practitioners; the decision to prescribe an antibiotic was based on how GMPs balanced the immediate needs of the patients against their desire to motivate patients to seek more appropriate care. Prescribing decisions may also be influenced by patients' clinical presentation and their ability to access local dental services, as well as the GMPs' attitude towards managing dental problems.

This work has advanced understanding regarding the use of antibiotics in the management of dental problems in primary care. It has contributed to a growing body of evidence indicating the antibiotics are being routinely used in the management of acute dental problems in primary care, often in situations where they are likely to provide little clinical value. Interventions are therefore urgently required to support the effective management of patients with acute dental conditions and to promote prudent use of antibiotic agents in this context. Such interventions should be designed to address local barriers which exist with regard to appropriate prescribing, and support both practitioners and their patients in making optimal decisions regarding the management of acute dental conditions. Future research should seek to describe the patient experience of accessing care for acute dental conditions and to better understand in patients' motivations and expectations of care so that they may be best involved in future strategies to optimise prescribing.

References

- AAE Consensus Conference Recommended Diagnostic Terminology (2009) *Journal of Endodontics*, **35**, 1634.
- Abbott, A. A., Koren, L. Z., Morse, D. R., Sinai, I. H., Doo, R. S. and Furst, M. L. (1988) A prospective randomized trial on efficacy of antibiotic prophylaxis in asymptomatic teeth with pulpal necrosis and associated periapical pathosis. *Oral Surgery, Oral Medicine, Oral Pathology*, **66**, 722-33.
- Abbott, P. V. (2004) Classification, diagnosis and clinical manifestations of apical periodontitis. *Endodontic Topics*, **8**, 36-54.
- Abbott, P. V. and Yu, C. (2007) A clinical classification of the status of the pulp and the root canal system. *Australian Dental Journal*, **52**, S17-S31.
- Adriaenssen, C. F. (1998) Comparison of the efficacy, safety and tolerability of azithromycin and co-amoxiclav in the treatment of acute periapical abscesses. *Journal of International Medical Research*, **26**, 257-65.
- Ahl, D. R., Hilgeman, J. L. and Snyder, J. D. (1986) Periodontal emergencies. *Dental Clinics of North America*, **30**, 459-72.
- Ahmad, N., Grad, H. A., Haas, D. A., Aronson, K. A., Jokovic, A. and Locker, D. (1997) The efficacy of nonopioid analgesics for postoperative dental pain: a meta-analysis. *Anesthesia Progress*, **44**, 119-26.
- Akkerman, A. E., Kuyvenhoven, M. M., van der Wouden, J. C. and Verheij, T. J. (2005) Determinants of antibiotic overprescribing in respiratory tract infections in general practice. *Journal of Antimicrob Chemotherapy*, **56**, 930-6.
- Al-Belasy, F. A. and Hairam, A. R. (2003) The efficacy of azithromycin in the treatment of acute infraorbital space infection. *Journal of Oral and Maxillofacial Surgery*, **61**, 310-6.
- Al-Haroni, M. and Skaug, N. (2006) Knowledge of prescribing antimicrobials among Yemeni general dentists. *Acta Odontologica Scandinavica*, **64**, 274-80.
- Al-Haroni, M. and Skaug, N. (2007) Incidence of antibiotic prescribing in dental practice in Norway and its contribution to national consumption. *Journal of Antimicrobial Chemotherapy*, **59**, 1161-6.
- Al-Huwayrini, L., Al-Furiji, S., Al-Dhurgham, R., Al-Shawaf, M. and Al-Muhaiza, M. (2013) Knowledge of antibiotics among dentists in Riyadh private clinics. *Saudi Dental Journal*, **25**, 119-24.
- Al-Nawas, B., Walter, C., Morbach, T., Seitner, N., Siegel, E., Maeurer, M. and Krummenauer, F. (2009) Clinical and microbiological efficacy of moxifloxacin versus amoxicillin/clavulanic acid in severe odontogenic abscesses: a pilot study. *European Journal of Clinical Microbiology and Infectious Diseases*, **28**, 75-82.

- Aleksejuniene, J., Eriksen, H. M., Sidaravicius, B. and Haapasalo, M. (2000) Apical periodontitis and related factors in an adult Lithuanian population. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, **90**, 95-101.
- Anderson, R., Richmond, S. and Thomas, D. W. (1999) Patient presentation at medical practices with dental problems: an analysis of the 1996 General Practice Morbidity Database for Wales. *British Dental Journal*, **186**, 297-300.
- Anderson, R., Calder, L. and Thomas, D. W. (2000) Antibiotic prescribing for dental conditions: general medical practitioners and dentists compared. *British Dental Journal*, **188**, 398-400.
- Arnold, S. R. and Straus, S. E. (2005) Interventions to improve antibiotic prescribing practices in ambulatory care. *Cochrane Database of Systematic Reviews*, **4**, CD003539.
- Ashworth, M., Charlton, J., Ballard, K., Latinovic, R. and Gulliford, M. (2005) Variations in antibiotic prescribing and consultation rates for acute respiratory infection in UK general practices 1995-2000. *British Journal of General Practice*, **55**, 603-8.
- Bell, G. W., Smith, G. L. F., Rodgers, J. M., Flynn, R. W. and Malone, C. H. (2008) Patient choice of primary care practitioner for orofacial symptoms. *British Dental Journal*, **204**, 669-73.
- Bergenholtz, G., Hörsted-Bindslev, P. and Reit, C. (2010) *Textbook of Endodontology*. 2nd ed. Chichester: Wiley-Blackwell.
- Berkovitz, B. K. B., Holland, G. R. and Moxham, B. J. (2009) *Oral anatomy, histology and embryology*. 4th ed., London: Mosby Elsevier.
- Bharathiraja, R., Sridharan, S., Chelliah, L. R., Suresh, S. and Senguttuvan, M. (2005) Factors affecting antibiotic prescribing pattern in pediatric practice. *Indian Journal of Pediatrics*, **72**, 877-9.
- Bint, A. (2008) NHS dentistry: General practitioners are doing dentists' work. *British Medical Journal*, **336**, 1088.
- Bissett, S. M., Stone, K. M., Rapley, T. and Preshaw, P. M. (2013) An exploratory qualitative interview study about collaboration between medicine and dentistry in relation to diabetes management. *BMJ Open*, **3**, e002192.
- Bland, J. and Altman, D. (2000) The odds ratio. *British Medical Journal*, **320**, 1468.
- Bowling, A., Rowe, G., Lambert, N., Waddington, M., Mahtani, K. R., Kenten, C., Howe, A. and Francis, S. A. (2012) The measurement of patients' expectations for health care: a review and psychometric testing of a measure of patients' expectations. *Health Technology Assessment*, **16**, 1-509.
- Boyatzis, R. E. (1998) *Transforming qualitative information: Thematic analysis and code development*. Los Angeles: SAGE Publications.
- Braun, V. and Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, **3**, 77-101.

Brennan, M. T., Runyon, M. S., Batts, J. J., Fox, P. C., Kent, M. L., Cox, T. L., Norton, H. J. and Lockhart, P. B. (2006) Odontogenic signs and symptoms as predictors of odontogenic infection: a clinical trial. *Journal of the American Dental Association*, **137**, 62-6.

British Dental Association (2012) *General practice focus groups*. [Online]. Available from: http://www.bda.org/Images/associate_focus_groups_2010.pdf [Accessed 18th October 2014].

Brown, J. D. (2012) Understanding the better than average effect: motives (still) matter. *Personality and Social Psychology Bulletin*, **38**, 209-19.

Butler, C. C., Rollnick, S., Pill, R., Maggs-Rapport, F. and Stott, N. (1998) Understanding the culture of prescribing: qualitative study of general practitioners' and patients' perceptions of antibiotics for sore throats. *British Medical Journal*, **317**, 637-42.

Butler, C. C., Robling, M., Prout, H., Hood, K. and Kinnersley, P. (2002) Management of suspected acute viral upper respiratory tract infection in children with intranasal sodium cromoglicate: A randomised controlled trial. *The Lancet*, **359**, 2153-8.

Cabana, M. D., Rand, C. S., Powe, N. R., Wu, A. W., Wilson, M. H., Abboud, P. A. C. and Rubin, H. R. (1999) Why don't physicians follow clinical practice guidelines?: A framework for improvement. *Journal of the American Medical Association*, **282**, 1458-65.

Campbell, J., Dedman, D. J., Eaton, S. C., Gallagher, A. M. and Williams, T. J. (2013) Is the CPRD GOLD population comparable to the U.K. population? *Pharmacoepidemiology and Drug Safety*, **22**, 280-1.

Candamourty, R., Venkatachalam, S., Babu, M. R. and Kumar, G. S. (2012) Ludwig's angina - an emergency: A case report with literature review. *Journal of Natural Science Biology and Medicine*, **3**, 206-8.

Carrotte, P. (2004) Endodontics: part 3. Treatment of endodontic emergencies. *British Dental Journal*, **197**, 299-305.

Carter, L. and Lewis, E. (2007) Death from overwhelming odontogenic sepsis: a case report. *British Dental Journal*, **203**, 241-2.

Chate, R. A. C., White, S., Hale, L. R. O., Howat, A. P., Bottomley, J., Barnet-Lamb, J., Lindsay, J., Davies, T. I. and Heath, J. M. (2006) The impact of clinical audit on antibiotic prescribing in general dental practice. *British Dental Journal*, **201**, 635-41.

Cherry, W. R., Lee, J. Y., Shugars, D. A., White, R. P. and Vann, W. F. (2012) Antibiotic use for treating dental infections in children A survey of dentists' prescribing practices. *The Journal of the American Dental Association*, **143**, 31-8.

Chestnutt, I. G., Davies, L. and Thomas, D. R. (2009) Practitioners' perspectives and experiences of the new National Health Service dental contract. *British Dental Journal*, **206**, E18.

Cleen, M. J. H. D., Schuurs, A. H. B., Wesselink, P. R. and Wu, M. K. (1993) Periapical status and prevalence of endodontic treatment in an adult Dutch population. *International Endodontic Journal*, **26**, 112-9.

- Coates, A., Hu, Y., Bax, R. and Page, C. (2002) The future challenges facing the development of new antimicrobial drugs. *Nature Reviews Drug Discovery*, **1**, 895-910.
- Cockburn, J. and Pit, S. (1997) Prescribing behaviour in clinical practice: patients' expectations and doctors' perceptions of patients' expectations - a questionnaire study. *British Medical Journal*, **315**, 520-3.
- Coenen, S., Van Royen, P., Vermeire, E., Hermann, I. and Denekens, J. (2000) Antibiotics for coughing in general practice: a qualitative decision analysis. *Family Practice*, **17**, 380-5.
- Coenen, S., Michiels, B., Renard, D., Denekens, J. and Van Royen, P. (2006) Antibiotic prescribing for acute cough: the effect of perceived patient demand. *British Journal of General Practice*, **56**, 183-90.
- Coenen, S., Francis, N., Kelly, M., Hood, K., Nuttall, J., Little, P., Verheij, T. J., Melbye, H., Goossens, H., Butler, C. C. and Group, G. P. (2013) Are patient views about antibiotics related to clinician perceptions, management and outcome? A multi-country study in outpatients with acute cough. *PLoS One*, **8**, e76691.
- Cohen, D. and Crabtree, B. (2006) *Qualitative Research Guidelines Project*. [Online]. Available from: <http://www.qualres.org/HomeCrit-3517.html> [Accessed 26th March 2014].
- Cohen, L. A., Bonito, A. J., Eicheldinger, C., Manski, R. J., Macek, M. D., Edwards, R. R. and Khanna, N. (2011) Comparison of patient visits to emergency departments, physician offices, and dental offices for dental problems and injuries. *Journal of Public Health Dentistry*, **71**, 13-22.
- Copeland, K. T., Checkoway, H., McMichael, A. J. and Holbrook, R. H. (1977) Bias due to misclassification in the estimation of relative risk. *American Journal of Epidemiology*, **105**, 488-95.
- Cosgrove, S. E. (2006) The relationship between antimicrobial resistance and patient outcomes: mortality, length of hospital stay, and health care costs. *Clinical Infectious Diseases*, **42**, S82-S89.
- Costelloe, C., Metcalfe, C., Lovering, A., Mant, D. and Hay, A. (2010) Effect of antibiotic prescribing in primary care on antimicrobial resistance in individual patients: systematic review and meta-analysis. *British Medical Journal*, **340**, c2096.
- Creswell, J. W. and Plano Clark, V. L. (2011) *Designing and conducting mixed methods research*. 2nd ed., Los Angeles: SAGE Publications.
- Currie, C. J., Berni, E., Jenkins-Jones, S., Poole, C. D., Ouwens, M., Driessen, S., de Voogd, H., Butler, C. C. and Morgan, C. L. (2014) Antibiotic treatment failure in four common infections in UK primary care 1991-2012: longitudinal analysis. *British Medical Journal*, **349**, g5493.
- Dailey, Y. M. and Martin, M. V. (2001) Are antibiotics being used appropriately for emergency dental treatment? *British Dental Journal*, **191**, 391-3.
- Daly, J., Kellehear, A. and Gliksman, M. (2007) *The public health researcher: a methodological approach*. Melbourne: Oxford University Press.
- Davies, S. C. (2013) *Annual Report of the Chief Medical Officer, Volume Two, 2011. Infections and the rise of antimicrobial resistance*. London: Department of Health.

Davis, W. M., Jr. and Balcom, J. H., 3rd (1969) Lincomycin studies of drug absorption and efficacy. An evaluation by double-blind technique in treatment of odontogenic infections. *Oral Surgery, Oral Medicine and Oral Pathology*, **27**, 688-96.

Delgado-Rodríguez, M. and Llorca, J. (2004) Bias. *Journal of Epidemiology and Community Health*, **58**, 635-41.

Demirbas, F., Gjermo, P. E. and Preus, H. R. (2006) Antibiotic prescribing practices among Norwegian dentists. *Acta Odontologica Scandinavica*, **64**, 355-9.

Dental and Eye Care Services (2010) *NHS Dental Contract: Proposals for Pilots*. London: Department of Health.

Dummer, P. M. H., Hicks, R. and Huws, D. (1980) Clinical signs and symptoms in pulp disease. *International Endodontic Journal*, **13**, 27-35.

Duncan, E. A. S. and Nicol, M. M. (2004) Subtle realism and occupational therapy: an alternative approach to knowledge generation and evaluation. *The British Journal of Occupational Therapy*, **67**, 453-6.

Eick, S., Pfister, W. and Straube, E. (1999) Antimicrobial susceptibility of anaerobic and capnophilic bacteria isolated from odontogenic abscesses and rapidly progressive periodontitis. *International Journal of Antimicrobial Agents*, **12**, 41-6.

Ellenberg, J. H. (1994) Selection bias in observational and experimental studies. *Statistics in Medicine*, **13**, 557-67.

Elliott, H. L. (1996) Post hoc analysis: use and dangers in perspective. *Journal of Hypertension*, **14**, S21-4.

Ellison, S. J. (2009) The role of phenoxymethylpenicillin, amoxicillin, metronidazole and clindamycin in the management of acute dentoalveolar abscesses - a review. *British Dental Journal*, **206**, 357-62.

Epley, N. and Dunning, D. (2000) Feeling "holier than thou": are self-serving assessments produced by errors in self- or social prediction? *Journal of Personality and Social Psychology*, **79**, 861-75.

Epstein, J. B., Chong, S. and Le, N. D. (2000) A survey of antibiotic use in dentistry. *Journal of the American Dental Association*, **131**, 1600-9.

Estrela, C. (2009) *Endodontic science*. 2nd ed., Sao Paulo: Artes Medica Ltda.

European Centre for Disease Prevention and Control (ECDC) / European Medicines Agency (EMA) (2009) *The bacterial challenge: time to react*. [Online]. Stockholm, ECDC. Available from http://www.ecdc.europa.eu/en/publications/Publications/0909_TER_The_Bacterial_Challenge_Time_to_React.pdf [Accessed 26th November 2014]

Evcil, M. S., Kele, A. and Uzun, I. (2006) Evaluation of the combination of amoxicillin trihydrate, diclofenac potassium and ornidazol for the management of endodontic pain. *The Pain Clinic*, **18**, 181-5.

- Farrier, J. N., Kittur, M. A. and Sugar, A. W. (2007) Necrotising fasciitis of the submandibular region; a complication of odontogenic origin. *British Dental Journal*, **202**, 607-9.
- Fedorowicz, Z., van Zuuren, E. J., Farman, A. G., Agnihotry, A. and Al-Langawi, J. H. (2013) Antibiotic use for irreversible pulpitis. *Cochrane Database of Systematic Reviews*, **12**, CD004969.
- Feinstein, A. R. (1985) The 'chagrin factor' and qualitative decision analysis. *Archives of Internal Medicine*, **145**, 1257-9.
- Florio-Ruane, S. (1991) Conversation and narrative in collaborative research. In: Witherell, C. and Noddings, N., eds. *Stories tell lives: narrative dialogue in education*. New York: Teachers College Press
- Flynn, T. R. (2011) What are the antibiotics of choice for odontogenic infections, and how long should the treatment course last?'. *Oral and Maxillofacial Surgery Clinics of North America*, **23**, 519-36.
- Fouad, A. F. (2009) *Endodontic microbiology*. Hoboken: Wiley-Blackwell.
- Fouad, A. F., Rivera, E. M. and Walton, R. E. (1996) Penicillin as a supplement in resolving the localized acute apical abscess. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endontology*, **81**, 590-5.
- Francke, A. L., Smit, M. C., de Veer, A. J. and Mistiaen, P. (2008) Factors influencing the implementation of clinical guidelines for health care professionals: a systematic meta-review. *BMC Medical Informatics and Decision Making*, **8**, 38.
- Freeman, R. (1999) The psychology of dental patient care. Barriers to accessing dental care: patient factor. *British Dental Journal*, **187**, 141-4.
- Frerichs, R. R. (2004) Cluster sampling. [Online], Available from: http://www.ph.ucla.edu/epi/rapidsurveys/RScourse/chap5rapid_2004.pdf [Accessed 27th November 2014]
- Galdas, P. M., Cheater, F. and Marshall, P. (2005) Men and health help-seeking behaviour: literature review. *Journal of Advanced Nursing*, **49**, 616-23.
- Gale, N., Heath, G., Cameron, E., Rashid, S. and Redwood, S. (2013) Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, **13**, 1-8.
- Gallagher, D. M., Erickson, K. and Hollin, S. A. (1981) Fatal brain-abscess following periodontal therapy – a case report. *Mount Sinai Journal of Medicine*, **48**, 158-60.
- Gallatin, E., Reader, A., Nist, R. and Beck, M. (2000) Pain reduction in untreated irreversible pulpitis using an intraosseous injection of Depo-Medrol. *Journal of Endodontics*, **26**, 633-8.
- Garg, A. K., Agrawal, N., Tewari, R. K., Kumar, A. and Chandra, A. (2014) Antibiotic prescription pattern among Indian oral healthcare providers: a cross-sectional survey. *Journal of Antimicrobial Chemotherapy*, **69**, 526-8.

- Garton, S. and Copland, F. (2010) 'I like this interview; I get cakes and cats!': the effect of prior relationships on interview talk. *Qualitative Research*, **10**, 533-51.
- Gelman, A. and Hill, J. (2007) Sample size and power calculations. In: *Data Analysis Using Regression and Multilevel/Hierarchical Models (Analytical Methods for Social Research)*. Cambridge: Cambridge University Press.
- General Medical Council (2010) *List of Registered Medical Practitioners*. [Online]. Available from: <http://www.gmc-uk.org/> [Accessed 27th November 2014]
- Gill, Y. and Scully, C. (2006) Attitudes and awareness of final-year predoctoral dental and medical students to medical problems in dentistry. *Journal of Dental Education*, **70**, 991-5.
- Gilmore, W. C., Jacobus, N. V., Gorbach, S. L., Doku, H. C. and Tally, F. P. (1988) A prospective double-blind evaluation of penicillin versus clindamycin in the treatment of odontogenic infections. *Journal of Oral and Maxillofacial Surgery*, **46**, 1065-70.
- Glaziou, P. (2005) Sampsiz. [Online] Available from: <http://sampsiz.sourceforge.net/iface/index.html> [Accessed 27th November 2014]
- Glickman, G. N. (2009) AAE Consensus Conference on Diagnostic Terminology: Background and Perspectives. *Journal of Endodontics*, **35**, 1619-20.
- Gonzalez-Martinez, R., Cortell-Ballester, I., Herraiz-Vilas, J. M., Arnau-de Bolos, J. M. and Gay-Escoda, C. (2012) Antibiotic prescription in the treatment of odontogenic infection by health professionals: a factor to consensus. *Medicina Oral, Patología Oral y Cirugía Bucal*, **17**, e452-6.
- Goossens, H., Ferech, M., Vander Stichele, R. and Elseviers, M. (2005) Outpatient antibiotic use in Europe and association with resistance: a cross-national database study. *The Lancet*, **365**, 579-87.
- Green, J. and Thorogood, N. (2004) Generating and analysing data. In: *Qualitative Methods for Health Research*. London: SAGE Publications.
- Grix, J. (2010) *Foundations of Research*. New York: Palgrave Macmillan.
- Guba, E. G. (1981) Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Technology Research and Development*, **29**, 75-91.
- Guillemot, D., Carbon, C., Balkau, B., Geslin, P., Lecoeur, H., Vauzelle-Kervroëdan, F., Bouvenot, G. and Eschwège, E. (1998) Low dosage and long treatment duration of beta-lactam: risk factors for carriage of penicillin-resistant *Streptococcus pneumoniae*. *Journal of the American Medical Association*, **279**, 365-70.
- Gulliford, M., Latinovic, R., Charlton, J., Little, P., van Staa, T. and Ashworth, M. (2009) Selective decrease in consultations and antibiotic prescribing for acute respiratory tract infections in UK primary care up to 2006. *Journal of Public Health*, **31**, 512-20.
- Haapasalo, M., Ranta, H., Ranta, K. and Shah, H. (1986) Black-pigmented *Bacteroides* spp. in human apical periodontitis. *Infection and Immunity*, **53**, 149-53.

- Hafferty, F. W. (1998) Beyond curriculum reform: confronting medicine's hidden curriculum. *Academic Medicine*, **73**, 403-7.
- Haggerty, C. J. and Tender, G. C. (2012) Actinomycotic brain abscess and subdural empyema of odontogenic origin: case report and review of the literature. *Journal of Oral and Maxillofacial Surgery*, **70**, e210-3.
- Hammersley, M. (1992) *What's Wrong With Ethnography? - Methodological Explorations*. London: Routledge.
- Hannan, P. J., Murray, D. M., Jacobs Jr, D. R. and McGovern, P. G. (1994) Parameters to aid in the design and analysis of community trials: Intraclass correlations from the Minnesota Heart Health Program. *Epidemiology* **5**, 88–95.
- Hargreaves, K. M. and Cohen, S. (2011) *Cohen's pathways of the pulp*. 10th ed., St. Louis: Mosby Elsevier.
- Harris, R. (2003) .Access to NHS dentistry in South Cheshire: a follow up of people using telephone helplines to obtain NHS dental care. *British Dental Journal*, **195**, 457-61.
- Hart, A. M., Pepper, G. A. and Gonzales, R. (2006) Balancing acts: deciding for or against antibiotics in acute respiratory infections. *Journal of Family Practice*, **55**, 320-5.
- Haughney, M. G., Devennie, J. C., Macpherson, L. M. and Mason, D. K. (1998) Integration of primary care dental and medical services: a three-year study. *British Dental Journal*, **184**, 343-7.
- Health and Social Care Information Centre (2008) *Prescribing by Dentists, 2007: England*. [Online]. Available from: <http://www.hscic.gov.uk/catalogue/PUB01373/pres-den-eng-2007-rep.pdf> [accessed 26th November 2014]
- Health and Social Care Information Centre (2009) *Prescribing by Dentists – England, 2008*. [Online]. Available from: <http://www.hscic.gov.uk/catalogue/PUB01390/pres-den-eng-2008-rep.pdf> [accessed 26th November 2014]
- Health and Social Care Information Centre (2010) *Prescribing by Dentists, 2009: England*. [Online]. Available from: <http://www.hscic.gov.uk/catalogue/PUB01422/pres-den-eng-2009-rep.pdf> [accessed 26th November 2014]
- Health and Social Care Information Centre (2011) *Prescribing by Dentists, 2010: England*. [Online]. Available from: <http://www.hscic.gov.uk/catalogue/PUB01911/pres-dent-eng-2010-rep.pdf> [accessed 26th November 2014]
- Health and Social Care Information Centre (2012) *Prescribing by Dentists, England - 2011*. [Online]. Available from: <http://www.hscic.gov.uk/catalogue/PUB05841/pres-dent-eng-2011-rep.pdf> [accessed 26th November 2014]
- Health and Social Care Information Centre (2013) *Prescribing by Dentists – England, 2012*. [Online]. Available from: <http://www.hscic.gov.uk/catalogue/PUB10751/pres-dent-eng-2012-rpt.pdf> [accessed 26th November 2014]

Health and Social Care Information Centre (2014) *Prescribing by Dentists, England - 2013*. [Online]. Available from: <http://www.hscic.gov.uk/catalogue/PUB14016/pres-dent-eng-2013-rpt.pdf> [accessed 26th November 2014]

Henry, M., Reader, A. and Beck, M. (2001) Effect of penicillin on postoperative endodontic pain and swelling in symptomatic necrotic teeth *Journal of Endodontics*, **27**, 117-23.

Herrera, D., Alonso, B., de Arriba, L., Santa Cruz, I., Serrano, C. and Sanz, M. (2014) Acute periodontal lesions. *Periodontology 2000*, **65**, 149-177.

Herrera, D., Roldan, S., Gonzalez, I. and Sanz, M. (2000) The periodontal abscess (I). Clinical and microbiological findings. *Journal of Clinical Periodontology*, **27**, 387-394.

Hesse-Biber, S. N. and Leavy, P. (2011) An Invitation to Qualitative Research. In: Hesse-Biber, S. N. and Leavy, P., eds., *The Practice of Qualitative Research*. 2nd ed., Thousand Oaks: SAGE Publishing.

Higgins, J. P. T. and Green, S. (eds) (2011) *Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]*. [Online] Chichester: The Cochrane Collaboration and John Wiley & Sons Ltd. Available from: www.cochrane-handbook.org [Accessed 18th January 2012].

Hippisley-Cox, J. and Vinogradova, Y. (2009) *Trends in Consultation Rates in General Practice 1995 to 2008: Analysis of the QResearch® database*. Leeds: QResearch®, University of Nottingham, and The Health and Social Care Information Centre.

Hogg, M. and Vaughan, G. (2005) *Social Psychology*, London: Prentice-Hall.

Holstein, J. A. and Gubrium, J. F. (2004) Active Interviewing. In: Silverman, D., ed. *Qualitative Research: Theory, Method and Practice*. London: SAGE Publishing.

Holyfield, G. and Karki, A. (2009) *Review of prescribing by dentists in Wales*. National Public Health Service for Wales.

Hope, J. (2008) Seven million patients can't find a dentist on the NHS for two years. [Online]. *Daily Mail*, 16th Jan. Available from <http://www.dailymail.co.uk/news/article-508496/Seven-million-patients-dentist-NHS-years.html> [Accessed 27th November 2014].

Howitt, D. (2010) *Introduction to Qualitative Methods in Psychology*. 2nd ed., Harrow: Pearson Education Limited.

Idsoe, O., Guthe, T., Willcox, R. R. and de Weck, A. L. (1968) Nature and extent of penicillin side-reactions, with particular reference to fatalities from anaphylactic shock. *Bulletin of the World Health Organization*, **38**, 159-88.

Ingham, H. R., Hood, F. J. C., Bradnum, P., Tharagonnet, D. and Selkon, J. B. (1977) Metronidazole compared with penicillin in the treatment of acute dental infections. *British Journal of Oral Surgery*, **14**, 264-9.

Ingle, J. I., Bakland, L. K. and Baumgartner, J. C. (2008) *Ingle's endodontics*. 6th ed., Hamilton: BC Decker.

- Irvine, A., Drew, P. and Sainsbury, R. (2013) 'Am I not answering your questions properly?' Clarification, adequacy and responsiveness in semi-structured telephone and face-to-face interviews. *Qualitative Research*, **13**, 87-106.
- Jaunay, T., Sambrook, P. and Goss, A. (2000) Antibiotic prescribing practices by South Australian general dental practitioners. *Australian Dental Journal*, **45**, 179-86.
- Jiménez-Pinzón, A., Segura-Egea, J. J., Poyato-Ferrera, M., Velasco-Ortega, E. and Ríos-Santos, J. V. (2004) Prevalence of apical periodontitis and frequency of root-filled teeth in an adult Spanish population. *International Endodontic Journal*, **37**, 167-73.
- Johri, A. and Piecuch, J. F. (2011) Should teeth be extracted immediately in the presence of acute infection. *Oral & Maxillofacial Surgery Clinics of North America*, **23**, 507-11.
- Joint Formulary Committee (2012) Dental Practitioners' Formulary. In: *British National Formulary*. 64th ed., London: British Medical Association and Pharmaceutical Society of Great Britain.
- Kaplan, S. L. and Mason, E. O., Jr. (1998) Management of infections due to antibiotic-resistant *Streptococcus pneumoniae*. *Clinical Microbiology Reviews*, **11**, 628-44.
- Kaptan, R. F., Haznedaroglu, F., Basturk, F. B. and Kayahan, M. B. (2013) Treatment approaches and antibiotic use for emergency dental treatment in Turkey. *Therapeutics and Clinical Risk Management*, **9**, 443—9.
- Kass-Hout, T. A., Xu, Z., McMurray, P., Park, S., Buckeridge, D. L., Brownstein, J. S., Finelli, L. and Groseclose, S. L. (2012) Application of change point analysis to daily influenza-like illness emergency department visits. *Journal of the American Medical Informatics Association*, **19**, 1075-81.
- Kerekes, K. and Olsen, I. (1990) Similarities in the microfloras of root canals and deep periodontal pockets. *Endodontics & Dental Traumatology*, **6**, 1-5.
- Khan, N. F., Harrison, S. E. and Rose, P. W. (2010) Validity of diagnostic coding within the General Practice Research Database: a systematic review. *British Journal of General Practice*, **60**, e128.
- Kiddee, W., Preechawai, P. and Hirunpat, S. (2010) Bilateral septic cavernous sinus thrombosis following the masticator and parapharyngeal space infection from the odontogenic origin: a case report. *Journal of the Medical Association of Thailand*, **93**, 1107-11.
- Kobayashi, T., Hayashi, A., Yoshikawa, R., Okuda, K. and Hara, K. (1990) The microbial flora from root canals and periodontal pockets of non-vital teeth associated with advanced periodontitis. *International Endodontic Journal*, **23**, 100-6.
- Kruger, J. and Dunning, D. (1999) Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, **77**, 1121-34.
- Kudiyirickal, M. G. and Hollinshead, F. (2011) Antimicrobial prescribing practice by dentists: a study from two primary care centres in UK. *Minerva Stomatologica*, **60**, 495-500.

- Kumar, S., Little, P. and Britten, N. (2003) Why do general practitioners prescribe antibiotics for sore throat? Grounded theory interview study. *British Medical Journal*, **326**, 138.
- Kuriyama, T., Nakagawa, K., Karasawa, T., Saiki, Y., Yamamoto, E. and Nakamura, S. (2000) Past administration of beta-lactam antibiotics and increase in the emergence of beta-lactamase-producing bacteria in patients with orofacial odontogenic infections. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, **89**, 186-92.
- Kuriyama, T., Karasawa, T., Nakagawa, K., Nakamura, S. and Yamamoto, E. (2002) Antimicrobial susceptibility of major pathogens of orofacial odontogenic infections to 11 β -lactam antibiotics. *Oral Microbiology and Immunology*, **17**, 285-9.
- Kuriyama, T., Absi, E. G., Williams, D. W. and Lewis, M. A. O. (2005) An outcome audit of the treatment of acute dentoalveolar infection: impact of penicillin resistance. *British Dental Journal*, **198**, 759-63.
- Lang, N., Soskolne, W. A., Greenstein, G., Cochran, D., Corbet, E., Meng, H. X., Newman, M., Novak, M. J. and Tenenbaum, H. (1999) Consensus Report: Abscesses of the Periodontium. *Annals of Periodontology*, **4**, 83.
- Laxminarayan, R., Duse, A., Wattal, C., Zaidi, A. K., Wertheim, H. F., Sumpradit, N., Vlieghe, E., Hara, G. L., Gould, I. M., Goossens, H., Greko, C., So, A. D., Bigdeli, M., Tomson, G., Woodhouse, W., Ombaka, E., Peralta, A. Q., Qamar, F. N., Mir, F., Kariuki, S., Bhutta, Z. A., Coates, A., Bergstrom, R., Wright, G. D., Brown, E. D. and Cars, O. (2013) Antibiotic resistance-the need for global solutions. *The Lancet Infectious Diseases*, **13**, 1057-98.
- Leckie, G. and Charlton, C. (2013) Runmlwin: A program to run the MLwiN multilevel modeling software from within Stata. *Journal of Statistical Software*, **52**, 1-40.
- Levin, K. A. (2006) Study design III: Cross-sectional studies. *Evidence-based Dentistry*, **7**, 24-5.
- Lewis, M. A., McGowan, D. A. and MacFarlane, T. W. (1986) Short-course high-dosage amoxicillin in the treatment of acute dento-alveolar abscess. *British Dental Journal*, **161**, 299-302.
- Lewis, M. A., Meechan, C., MacFarlane, T. W., Lamey, P. J. and Kay, E. (1989) Presentation and antimicrobial treatment of acute orofacial infections in general dental practice. *British Dental Journal*, **166**, 41-5.
- Lewis, M. A., Carmichael, F., MacFarlane, T. W. and Milligan, S. G. (1993) A randomised trial of co-amoxiclav (Augmentin) versus penicillin V in the treatment of acute dentoalveolar abscess. *British Dental Journal*, **175**, 169-74.
- Lindeboom, J. A., Frenken, J. W., Valkenburg, P. and van den Akker, H. P. (2005) The role of preoperative prophylactic antibiotic administration in periapical endodontic surgery: a randomized, prospective double-blind placebo-controlled study. *International Endodontic Journal*, **38**, 877-81.
- Linder, J. A., Doctor, J. N., Friedberg, M. W., Reyes Nieva, H., Birks, C., Meeker, D. and Fox, C. R. (2014) Time of day and the decision to prescribe antibiotics. [Online] *JAMA Internal Medicine*, in press, corrected proof, 6th October 2014. Available from:

- <http://archinte.jamanetwork.com/article.aspx?articleid=1910546> [Accessed 27th November 2014].
- Little, P., Gould, C., Williamson, I., Warner, G., Gantley, M. and Kinmonth, A. L. (1997) Reattendance and complications in a randomised trial of prescribing strategies for sore throat: the medicalising effect of prescribing antibiotics. *British Medical Journal*, **315**, 350-2.
- Liu, G. G. and Christensen, D. B. (2002) The continuing challenge of inappropriate prescribing in the elderly: an update of the evidence. *Journal of the American Pharmacists' Association*, **42**, 847-57.
- Lopez-Vazquez, P., Vazquez-Lago, J. M. and Figueiras, A. (2012) Misprescription of antibiotics in primary care: a critical systematic review of its determinants. *Journal of Evaluation in Clinical Practice*, **18**, 473-84.
- Lundy, T. and Standley, H. R. (1969) Correlation of pulpal histopathology and clinical symptoms in human teeth subjected to experimental irritation. *Oral Surgery, Oral Medicine, and Oral Pathology*, **27**, 187-201.
- Macfarlane, J., Holmes, W., Macfarlane, R. and Britten, N. (1997) Influence of patients' expectations on antibiotic management of acute lower respiratory tract illness in general practice: questionnaire study. *British Medical Journal*, **315**, 1211-4.
- Macionis, J. J. P. K. (2005) *Sociology: A Global Introduction*. [Online]. Available from: http://wps.pearsoned.co.uk/ema_uk_he_plummer_sociology_3/40/10342/2647681.cw/content/index.html [Accessed 10th October 2014].
- Mainjot, A., D'Hoore, W., Vanheusden, A. and Van Nieuwenhuysen, J. P. (2009) Antibiotic prescribing in dental practice in Belgium. *International Endodontic Journal*, **42**, 1112-7.
- Mangundjaja, S. and Hardjwinata, K. (1990) Clindamycin versus ampicillin in the treatment of odontogenic infections. *Clinical Therapeutics*, **12**, 242-9.
- Mansour, M. H. and Cox, S. C. (2006) Patients presenting to the general practitioner with pain of dental origin. *Medical Journal of Australia*, **185**, 64-7.
- Mason, M. (2010) Sample size and saturation in PhD studies using qualitative interviews. *Qualitative Research*, **11**, 8.
- Mata, E., Koren, L. Z., Morse, D. R. and Sinai, I. H. (1985) Prophylactic use of penicillin V in teeth with necrotic pulps and asymptomatic periapical radiolucencies. *Oral Surgery, Oral Medicine, Oral Pathology*, **60**, 201-7.
- Matijević, S., Lazić, Z., Kuljić-Kapulica, N. and Nonković, Z. (2009a) Empirical antimicrobial therapy of acute dentoalveolar abscess. *Vojnosanitetski Pregled*, **66**, 544-50.
- Matijević, S., Lazić, Z. and Nonković, Z. (2009b) 'Clinical efficacy of ampicillin in treatment of acute odontogenic abscess', *Klinička efikasnost ampicilina u lečenju akutnih dentogenih apscesa*. *Vojnosanitetski Pregled*, **66**, 123-8.

Matthews, D. C., Sutherland, S. and Basrani, B. (2003) Emergency management of acute apical abscesses in the permanent dentition: a systematic review of the literature. *Journal of the Canadian Dental Association*, **69**, 660-660i.

Matthews, D. and Sutherland, S. (2004) Clinical practice guidelines on emergency management of acute apical periodontitis and acute apical abscess. *Evidence-Based Dentistry*, **5**, 84.

Matthews-King, A. (2013). *Nine out of ten GPs feel 'under pressure' from patients with dental complaints*. [Online] Available from: http://www.pulsetoday.co.uk/news/clinical-news/nine-out-of-ten-gps-feel-under-pressure-from-patients-with-dental-complaints/20005094.article#.VEo8t_l4rYg [Accessed 17th October 2014].

McCann, P. J., Sweeney, M. P., Gibson, J. and Bagg, J. (2005) Training in oral disease, diagnosis and treatment for medical students and doctors in the United Kingdom. *British Journal of Oral & Maxillofacial Surgery*, **43**, 61-4.

McCarthy, P. J., McClanahan, S., Hodges, J. and Bowles, W. R. (2010) Frequency of localization of the painful tooth by patients presenting for an endodontic emergency. *Journal of Endodontics*, **36**, 801-5.

McNulty, C., Boyle, P., Nichols, T., Clappison, P. and Davey, P. (2007). The public's attitudes to and compliance with antibiotics. *Journal of Antimicrobial Chemotherapy*, **60**, i63-i68.

Meng, H. X. (1999) Periodontal Abscess. *Annals of Periodontology*, **4**, 79-82.

Merriam, S. B. (1998) *Qualitative research and case study applications in education*. San Francisco: Jossey-Bass.

Moller, J. K., Bak, A. L., Stenderup, A., Zachariae, H. and Afzelius, H. (1977) Changing patterns of plasmid-mediated drug resistance during tetracycline therapy. *Antimicrobial Agents Chemotherapy*, **11**, 388-91.

Moloney, J. and Stassen, L. F. (2009) Pericoronitis: treatment and a clinical dilemma. *Journal of the Irish Dental Association*, **55**, 190-2.

Morgan, M. (2012a) *Cardiff and Vale University Health Board - Oral Health Profile 2012*. Cardiff: Welsh Oral Health Information Unit, Public Health Wales.

Morgan, M. (2012b) *Cwm Taf Health Board - Oral Health Profile 2012*. Cardiff: Welsh Oral Health Information Unit, Public Health Wales.

Morrow, S. G. (2012) Use and Abuse of Antibiotics. [Online] Available from: http://www.aae.org/uploadedfiles/publications_and_research/endodontics_colleagues_for_excellence_newsletter/ecfewinter12final.pdf [Accessed 27th November 2014].

Morse, D. R., Furst, M. L., Belott, R. M., Lefkowitz, R. D., Spritzer, I. B. and Sideman, B. H. (1987) Infectious flare-ups and serious sequelae following endodontic treatment: A prospective randomized trial on efficacy of antibiotic prophylaxis in cases of asymptomatic pulpal-periapical lesions. *Oral Surgery, Oral Medicine, Oral Pathology*, **64**, 96-109.

Morse, D. R., Furst, M. L., Belott, R. M., Lefkowitz, R. D., Spritzer, I. B. and Sideman, B. H. (1988) Prophylactic penicillin versus penicillin taken at the first sign of swelling in cases of asymptomatic

- pulpal-periapical lesions: A comparative analysis. *Oral Surgery, Oral Medicine, Oral Pathology*, **65**, 228-32.
- Morse, J. M. (1995) The significance of saturation. *Qualitative Health Research*, **5**, 147-9.
- Morse, J. M. (2000) Determining sample size. *Qualitative Health Research*, **10**, 3-5.
- Muraven, M. and Baumeister, R. F. (2000) Self-regulation and depletion of limited resources: does self-control resemble a muscle? *Psychol Bulletin*, **126**, 247-59.
- Murti, A. and Morse, Z. (2007) Dental antibiotic prescription in Fijian adults. *International Dental Journal*, **57**, 65-70.
- Mustafa, M., Wood, F., Butler, C. C. and Elwyn, G. (2014) Managing expectations of antibiotics for upper respiratory tract infections: a qualitative study. *Annals Family Medicine*, **12**, 29-36.
- Muthukrishnan, A., Walters, H. and Douglas, P. S. (1996) An audit of antibiotic prescribing by general practitioners in the initial management of acute dental infection. *Dental Update*, **23**, 316-8.
- Nabavizadeh, M. R., Sahebi, S. and Nadian, I. (2011) Antibiotic prescription for endodontic treatment: general dentist knowledge and practice in Shiraz. *Iranian Endodontic Journal*, **6**, 54-9.
- Nagarakanti, S., Epari, V. and Athuluru, D. (2013) Knowledge, attitude, and practice of medical doctors towards periodontal disease. *Journal of the Indian Society of Periodontology*, **17**, 137-9.
- Nagle, D., Reader, A., Beck, M. and Weaver, J. (2000) Effect of systemic penicillin on pain in untreated irreversible pulpitis. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, **90**, 636-40.
- Nair, P. N. R. (1997) Apical periodontitis: a dynamic encounter between root canal infection and host response. *Periodontology 2000*, **13**, 121-48.
- National Leadership and Innovation Agency for Healthcare (2012) *Analysis of the Dental Workforce in Wales*. [Online]. Available from <http://wales.gov.uk/docs/phhs/publications/140703dentalworkforce2012en.pdf> [Accessed 27th November 2014].
- National Institute for Health and Care Excellence (2000) *NICE technology appraisal guidance number 1. Guidance on the extraction of wisdom teeth*. London: National Institute for Health and Care Excellence.
- NHS Wales (2012). *Health in Wales Directory*. [Online]. Available from: <http://www.wales.nhs.uk/ourservices/directory> [Accessed 27th November 2012].
- Nudzor, H. P. (2009) A critical commentary on combined methods approach to researching educational and social issues. *Issues in Educational Research*, **19**, 114-27.
- Nuttal, N., Freeman, R., Bevan-Seymour, C. and Hill, K. (2011) *8: Access and barriers to care - a report from the Adult Dental Health Survey 2009*. Leeds: Health and Social Care Information Centre.

Office for National Statistics (2013a) *2011 Rural-Urban Classification for small area geographies*. [Online]. Available from: <http://www.ons.gov.uk/ons/guide-method/geography/products/area-classifications/2011-rural-urban/index.html> [Accessed 27th November 2014].

Office for National Statistics (2013b) *Revised Annual Mid-year Population Estimates, 2001 to 2010*. [Online]. Available from: <http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/mid-2001-to-mid-2010-revised/stb---mid-2001-to-mid-2010-uk-revised-population-estimates.html#tab-Mid-2001-to-mid-2010-UK-population-estimates> [Accessed 27th November 2014].

Okunseri, C., Okunseri, E., Thorpe, J. M., Xiang, Q. and Szabo, A. (2012) Medications prescribed in emergency departments for nontraumatic dental condition visits in the United States. *Medical Care*, **50**, 508-12.

Oosterink, F. M., de Jongh, A. and Aartman, I. H. (2008) .What are people afraid of during dental treatment? Anxiety-provoking capacity of 67 stimuli characteristic of the dental setting. *European Journal of Oral Sciences*, **116**, 44-51.

Orstavik, D. and Ford, T. P. (2008) *Essential endodontology: prevention and treatment of apical periodontitis*. 2nd ed., Oxford: Blackwell Munksgaard Ltd.

Palmer, N. and Martin, M. (1998) An investigation of antibiotic prescribing by general dental practitioners: a pilot study. *Primary Dental Care*, **5**, 11-4.

Palmer, N. A., Pealing, R., Ireland, R. S. and Martin, M. V. (2000a) A study of therapeutic antibiotic prescribing in National Health Service general dental practice in England. *British Dental Journal*, **188**, 554-8.

Palmer, N. A., Dailey, Y. M. and Martin, M. V. (2001a) Can audit improve antibiotic prescribing in general dental practice? *British Dental Journal*, **191**, 253-5.

Palmer, N. A. O. and Dailey, Y. M. (2002) General dental practitioners' experiences of a collaborative clinical audit on antibiotic prescribing: A qualitative study. *British Dental Journal*, **193**, 46-9.

Palmer, N. O., Martin, M. V., Pealing, R. and Ireland, R. S. (2000b) An analysis of antibiotic prescriptions from general dental practitioners in England. *Journal of Antimicrobial Chemotherapy*, **46**, 1033-5.

Palmer, N. O., Martin, M. V., Pealing, R. and Ireland, R. S. (2001b) Paediatric antibiotic prescribing by general dental practitioners in England. *International Journal of Paediatric Dentistry*, **11**, 242-8.

Palmer, N. O. and Batchelor, P. A. (2004) An audit of antibiotic prescribing by vocational dental practitioners. *Primary Dental Care*, **11**, 77-80.

Palmer, N. O. A., Martin, M. V., Pealing, R., Ireland, R. S., Roy, K., Smith, A. and Bagg, J. (2001c) Antibiotic prescribing knowledge of National Health Service general dental practitioners in England and Scotland. *Journal of Antimicrobial Chemotherapy*, **47**, 233-7.

- Palmer, N. O. A., Longman, L., Randall, C. and Pankhurst, C. L. (2012) *Antimicrobial prescribing for general dental practitioners*. 2nd ed., London: Faculty of General Dental Practice (UK).
- Patton, M. Q. (2002) *Qualitative Research & Evaluation Methods*. Thousand Oaks: SAGE Publishing.
- Pau, A., Croucher, R., Marcenes, W. and Leung, T. (2005) Development and validation of a dental pain-screening questionnaire. *Pain*, **119**, 75-81.
- Pearle, M. S. and Wendel, E. F. (1993) Necrotizing cavernositis secondary to periodontal abscess. *Journal of Urology*, **149**, 1137-8.
- Pickenpaugh, L., Reader, A., Beck, M., Meyers, W. J. and Peterson, L. J. (2001) Effect of prophylactic amoxicillin on endodontic flare-up in asymptomatic, necrotic teeth. *Journal of Endodontics*, **27**, 53-6.
- Pildal, J., Hrobjartsson, A., Jorgensen, K. J., Hilden, J., Altman, D. G. and Gotzsche, P. C. (2007) Impact of allocation concealment on conclusions drawn from meta-analyses of randomized trials. *International Journal of Epidemiology*, **36**, 847-57.
- Pipalova, R., Vlcek, J. and Slezak, R. (2014) The trends in antibiotic use by general dental practitioners in the Czech Republic (2006–2012). *International Dental Journal*, **64**, 138-43.
- Pitts, N. B. (2003) NHS Dentistry: Options for Change in context--a personal overview of a landmark document and what it could mean for the future of dental services. *British Dental Journal*, **195**, 631-5.
- Pocock, S. J. (1983) *Clinical Trials: A Practical Approach*. New York: Wiley.
- Preus, H. R., Albandar, J. M. and Gjermo, P. (1992) Antibiotic prescribing practices among Norwegian dentists. *Scandinavian Journal of Dental Research*, **100**, 232-5.
- Prior, M., Elouafkaoui, P., Elders, A., Young, L., Duncan, E. M., Newlands, R., Clarkson, J. E., Ramsay, C. R., Black, I., Bonetti, D., Eldridge, S., Francis, J. J., Grimshaw, J. M., McKee, L., Michie, S., Pitts, N., Stirling, D., Tilley, C., Torgerson, C., Treweek, S., Vale, L. and Walker, A. (2014) Evaluating an audit and feedback intervention for reducing antibiotic prescribing behaviour in general dental practice (the RAPID trial): A partial factorial cluster randomised trial protocol. *Implementation Science*, **9**, 50.
- Psaty, B. M., Koepsell, T. D., Lin, D., Weiss, N. S., Siscovick, D. S., Rosendaal, F. R., Pahor, M. and Furberg, C. D. (1999) Assessment and control for confounding by indication in observational studies. *Journal of the American Geriatrics Society*, **47**, 749-54.
- Rasbash, J., Charlton, C., Browne, W. J., Healy, M. and Cameron, B. (2013) *MLwiN Version 2.28*. [computer programme] Centre for Multilevel Modelling, University of Bristol.
- Rasbash, J., Steele, F., Browne, W. J. and Goldstein, H. (2012) *A User's Guide to MLwiN*, v2.26. Centre for Multilevel Modelling, University of Bristol.
- Reisine, S. and Locker, D. (1995) Social, psychological and economic impacts of oral conditions treatments. In: L. K. Cohen, L. K. and H. C. Gift (eds.) *Disease prevention and oral health promotion: social–dental sciences in action*. Copenhagen: Munksgaard.

Ritchie, J. and Lewis, J. (2003) *Qualitative Research Practice: A Guide for Social Science Students and Researchers*. London: SAGE Publications.

Rosado, P., Gallego, L., Junquera, L. and de Vicente, J. C. (2009) Lemierre's syndrome: a serious complication of an odontogenic infection. *Medicina Oral Patologia Oral y Cirugia Bucal*, **14**, e398-401.

Roulston, K. J., Baker, C. D. and Liljestrom, A. (2001) Analyzing the researcher's work in generating data: the case of complaints. *Qualitative Inquiry*, **7**, 745-72.

Roy, K. M. and Bagg, J. (2000) Antibiotic prescribing by general dental practitioners in the Greater Glasgow Health Board, Scotland. *British Dental Journal*, **188**, 674-6.

Rubin, H. J. and Rubin, I. S. (2012) *Qualitative Interviewing: The Art of Hearing Data*. London: SAGE Publications.

Runyon, M. S., Brennan, M. T., Batts, J. J., Glaser, T. E., Fox, P. C., Norton, H. J., Kent, M. L., Cox, T. L. and Lockhart, P. B. (2004) Efficacy of penicillin for dental pain without overt infection', *Academic Emergency Medicine*, **11**, 1268-71.

Salako, N. O., Rotimi, V. O., Adib, S. M. and Al-Mutawa, S. (2004) Pattern of antibiotic prescription in the management of oral diseases among dentists in Kuwait. *Journal of Dentistry*, **32**, 503-9.

Sarna, T., Sengupta, T., Miloro, M. and Kolokythas, A. (2012) Cervical necrotizing fasciitis with descending mediastinitis: literature review and case report. *Journal of Oral and Maxillofacial Surgery*, **70**, 1342-50.

Scottish Dental Clinical Effectiveness Programme (2011) *Drug prescribing for dentistry: dental clinical guidance*. 2nd ed., Dundee: Scottish Dental Clinical Effectiveness Programme.

Seager, J. M., Howell-Jones, R. S., Dunstan, F. D., Lewis, M. A. O., Richmond, S. and Thomas, D. W. (2006) A randomised controlled trial of clinical outreach education to rationalise antibiotic prescribing for acute dental pain in the primary care setting. *British Dental Journal*, **201**, 217-22.

Seale, C. (1999) Quality in Qualitative Research. *Qualitative Inquiry*, **5**, 465-78.

Seale, C. (2010) Using computers to analyse qualitative data. In: Silverman, D., ed. *Doing qualitative research*. London: SAGE Publishing.

Segura-Egea, J. J., Velasco-Ortega, E., Torres-Lagares, D., Velasco-Ponferrada, M. C., Monsalve-Guil, L. and Llamas-Carreras, J. M. (2010) Pattern of antibiotic prescription in the management of endodontic infections amongst Spanish oral surgeons. *International Endodontic Journal*, **43**, 342-50.

Seltzer, S., Bender, I. B. and Zionitz, M. (1963) The dynamics of pulp inflammation: correlation between diagnostic data and actual histologic findings in the pulp. *Oral Surgery, Oral Medicine and Oral Pathology*, **16**, 846-71.

Selwitz, R. H., Ismail, A. I. and Pitts, N. B. (2007) Dental caries. *The Lancet*, **369**, 51-9.

- Seppanen, L., Lemberg, K. K., Lauhio, A., Lindqvist, C. and Rautemaa, R. (2011) Is dental treatment of an infected tooth a risk factor for locally invasive spread of infection? *Journal of Oral & Maxillofacial Surgery*, **69**, 986-93.
- Shenton, A. K. (2004) Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, **22**, 63-75.
- Shlomo, V., Adi, R. and Eliezer, K. (2003) The knowledge and expectations of parents about the role of antibiotic treatment in upper respiratory tract infection--a survey among parents attending the primary physician with their sick child. *BMC Family Practice*, **4**, 20.
- Silverman, D. (1997) Towards an aesthetics of research. In: Silverman, D., ed. *Qualitative research: Theory, method and practice*. London: SAGE Publications.
- Simon, J. H., Glick, D. H. and Frank, A. L. (1972) The relationship of endodontic-periodontic lesions. *Journal of Periodontology*, **43**, 202-8.
- Simpson, S. A., Wood, F. and Butler, C. C. (2007) General practitioners' perceptions of antimicrobial resistance: a qualitative study. *Journal of Antimicrobial Chemotherapy*, **59**, 292-6.
- Sindet-Pedersen, S., Petersen, J. K. and Götzsche, P. C. (1985) Incidence of pain conditions in dental practice in a Danish county. *Community Dentistry and Oral Epidemiology*, **13**, 244-6.
- Skucaite, N., Peciuliene, V., Maneliene, R. and Maciulskiene, V. (2010) Antibiotic prescription for the treatment of endodontic pathology: a survey among Lithuanian dentists. *Medicina (Kaunas)*, **46**, 806-13.
- Skudutyte-Rysstad, R., Eriksen, H. M. and Bjertness, E. (2012) Oral health among 35-year-olds in Oslo, Norway. A summary of time trends 1973-2003. *Norsk Epidemiologi*, **22**, 39-46.
- Slaus, G. and Bottenberg, P. (2002) A survey of endodontic practice amongst Flemish dentists. *International Endodontic Journal*, **35**, 759-67.
- Standing Medical Advisory Committee Sub-Group on Antimicrobial Resistance. *The path of least resistance*. [Online]. Available from : http://webarchive.nationalarchives.gov.uk/20080905234748/dh.gov.uk/en/publicationsandstatistics/publications/publicationspolicyandguidance/dh_4009357 [Accessed 28th November 2014]
- Statistics for Wales (2011) *Welsh Index of Multiple Deprivation (WIMD)*. [Online], available: <http://wales.gov.uk/statistics-and-research/welsh-index-multiple-deprivation/?lang=en#/statistics-and-research/welsh-index-multiple-deprivation/?lang=en> [Accessed 24th November 2014].
- Steed, M. and Gibson, J. (1997) An audit of antibiotic prescribing in general dental practice. *Primary Dental Care*, **4**, 66-70.
- Steele, F. (2014) *Multilevel Modelling of Repeated Measures Data. LEMMA VLE Module 15, 1-62* [Online]. Available from: <http://www.cmm.bris.ac.uk/lemma/> [Accessed 27th November 2014].
- Steele, J. (2009) *NHS dental services in England*. London: Department of Health.

Stone, S. J., Holmes, R. D., Heasman, P. A. and McCracken, G. I. (2014) Continuing professional development and application of knowledge from research findings: a qualitative study of general dental practitioners. *British Dental Journal*, **216**, E23.

Strauss, A. and Corbin, J. (1998) *Basics of qualitative research: Techniques and procedures for developing grounded theory*. 2nd ed., Thousand Oaks: SAGE Publications.

Strom, B. L., Kimmel, S. E. and Hennessy, S. (2013) *Textbook of Pharmacoepidemiology*. 2nd ed., New York City: John Wiley & Sons.

Sturges, J. and Hanrahan, K. (2004) Comparing telephone and face-to-face qualitative interviewing: A research note. *Qualitative Research*, **4**, 107-118.

Sunitha, V. R., Emmadi, P., Namasivayam, A., Thyegarajan, R. and Rajaraman, V. (2008) The periodontal - endodontic continuum: A review. *Journal of Conservative Dentistry*, **11**, 54-62.

Sutherland, S. and Matthews, D. C. (2003) Emergency management of acute apical periodontitis in the permanent dentition: a systematic review of the literature. *Journal of the Canadian Dental Association*, **69**, 160-160i.

Sweeney, L. C., Dave, J., Chambers, P. A. and Heritage, J. (2004) Antibiotic resistance in general dental practice—a cause for concern? *Journal of Antimicrobial Chemotherapy*, **53**, 567-76.

Swennen, M. H., van der Heijden, G. J., Boeije, H. R., van Rheenen, N., Verheul, F. J., van der Graaf, Y. and Kalkman, C. J. (2013) Doctors' perceptions and use of evidence-based medicine: a systematic review and thematic synthesis of qualitative studies. *Academic Medicine*, **88**, 1384-96.

Tate, A. R., Beloff, N., Al-Radwan, B., Wickson, J., Puri, S., Williams, T., Van Staa, T. and Bleach, A. (2014) Exploiting the potential of large databases of electronic health records for research using rapid search algorithms and an intuitive query interface. *Journal of the American Medical Informatics Association*, **21**, 292-8.

Teixeira Rodrigues, A., Roque, F., Falcão, A., Figueiras, A. and Herdeiro, M. T. (2013) Understanding physician antibiotic prescribing behaviour: a systematic review of qualitative studies. *International Journal of Antimicrobial Agents*, **41**, 203-12.

Teng, L. J., Hsueh, P. R., Chen, Y. C., Ho, S. W. and Luh, K. T. (1998) Antimicrobial susceptibility of viridans group streptococci in Taiwan with an emphasis on the high rates of resistance to penicillin and macrolides in *Streptococcus oralis*. *Journal of Antimicrobial Chemotherapy*, **41**, 621-7.

The Lancet Infectious Diseases (2013) Antibiotic resistance: long-term solutions require action now. *The Lancet Infectious Diseases*, **13**, 995.

Thomas, D. W., Satterthwaite, J., Absi, E. G., Lewis, M. A. and Shepherd, J. P. (1996) Antibiotic prescription for acute dental conditions in the primary care setting. *British Dental Journal*, **181**, 401-4.

Torabinejad, M., Cymerman, J. J., Frankson, M., Lemon, R. R., Maggio, J. D. and Schilder, H. (1994a) Effectiveness of various medications on postoperative pain following complete instrumentation. *Journal of Endodontics*, **20**, 345-54.

- Torabinejad, M., Dorn, S. O., Eleazer, P. D., Frankson, M., Jouhari, B., Mullin, R. K. and Soluti, A. (1994b) Effectiveness of various medications on postoperative pain following root canal obturation. *Journal of Endodontics*, **20**, 427-31.
- Trivedy, C., Kodate, N., Ross, A., Al-Rawi, H., Jaiganesh, T., Harris, T. and Anderson, J. E. (2012) The attitudes and awareness of emergency department (ED) physicians towards the management of common dentofacial emergencies. *Dental Traumatology*, **28**, 121-6.
- Tulip, D. E. and Palmer, N. O. A. (2008) A retrospective investigation of the clinical management of patients attending an out of hours dental clinic in Merseyside under the new NHS dental contract. *British Dental Journal*, **205**, 659-64.
- Vellinga, A., Murphy, A. W., Hanahoe, B., Bennett, K. and Cormican, M. (2010) A multilevel analysis of trimethoprim and ciprofloxacin prescribing and resistance of uropathogenic *Escherichia coli* in general practice. *Journal of Antimicrobial Chemotherapy*, **65**, 1514-20.
- Vessal, G., Khabiri, A., Mirkhani, H., Cookson, B. D. and Askarian, M. (2011) Study of antibiotic prescribing among dental practitioners in Shiraz, Islamic Republic of Iran. *Eastern Mediterranean Health Journal*, **17**, 763-9.
- Von Konow, L., Kondell, P. A., Nord, C. E. and Heimdahl, A. (1992) Clindamycin versus phenoxymethylpenicillin in the treatment of acute orofacial infections. *European Journal of Clinical Microbiology and Infectious Diseases*, **11**, 1129-35.
- Von Konow, L. and Nord, C. E. (1983) Ornidazole compared to phenoxymethylpenicillin in the treatment of orofacial infections. *Journal of Antimicrobial Chemotherapy*, **11**, 207-15.
- Wales Deanery (2012) *An Audit of Antimicrobial Prescribing for Dentists working in General Practice*. [Online]. Available from: <http://www.walesdeanery.org/index.php/en/dentistry-cpd-programmes/1567-an-audit-of-antimicrobial-prescribing-for-dentists-working-in-general-practice.html> [Accessed 27th November 2014].
- Weine, F. S. (1989) *Endodontic therapy*. Maryland Heights: Mosby.
- Whitten, B. H., Gardiner, D. L., Jeansonne, B. G. and Lemon, R. R. (1996) Current trends in endodontic treatment: report of a national survey. *Journal of the American Dental Association*, **127**, 1333-41.
- Williams, P. R. (2013) Fat faces and swellings. *British Dental Journal*, **214**, 48.
- Williams, T., van Staa, T., Puri, S. and Eaton, S. (2012) Recent advances in the utility and use of the General Practice Research Database as an example of a UK Primary Care Data resource. *Therapeutic Advances in Drug Safety*, **3**, 89-99.
- Williamson, I., Benghe, S., Mullee, M. and Little, P. (2006) Consultations for middle ear disease, antibiotic prescribing and risk factors for reattendance: a case-linked cohort study. *British Journal of General Practice*, **56**, 170-5.
- Wood, F., Simpson, S. and Butler, C. C. (2007) Socially responsible antibiotic choices in primary care: a qualitative study of GPs' decisions to prescribe broad-spectrum and fluoroquinolone antibiotics. *Family Practice*, **24**, 427-34.

World Health Organization (1995) *Application of the international classification of diseases to dentistry and stomatology: ICD-DA*. [Online]. 3rd ed. Geneva: World Health Organization.

Available from:

http://extranet.who.int/iris/restricted/bitstream/10665/40919/1/9241544678_eng.pdf?ua=1
[Accessed 26th November 2014]

World Health Organization (2000) *World Health Organisation report on infectious diseases 2000: overcoming antimicrobial resistance*. Geneva: World Health Organization.

Zhang, Y. and Wildemuth, B. M. (2009) Unstructured interviews. In: *Applications of Social Research Methods to Questions in Information and Library Science* Westport: Libraries Unlimited.

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Appendix I - Cochrane Systematic Review, chapter 1

[Intervention Review]

Systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults

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ABSTRACT

Background

Dental pain can have a considerable detrimental effect on an individual's quality of life. Symptomatic apical periodontitis and acute apical abscess are common causes of dental pain and arise from an inflamed or necrotic dental pulp, or infection of the pulpless root canal system. Clinical guidelines recommend that the first-line treatment for teeth with symptomatic apical periodontitis or an acute apical abscess should be removal of the source of inflammation or infection by local, operative measures, and that systemic antibiotics are currently only recommended for situations where there is evidence of spreading infection (cellulitis, lymph node involvement, diffuse swelling) or systemic involvement (fever, malaise). Despite this, there is evidence that dentists continue to prescribe antibiotics for these conditions. There is concern that this could contribute to the development of antibiotic-resistant bacterial colonies both within the individual and within the community as a whole.

Objectives

To evaluate the effects of systemic antibiotics provided with or without surgical intervention (such as extraction, incision and drainage of a swelling or endodontic treatment), with or without analgesics, for symptomatic apical periodontitis or acute apical abscess in adults.

Search methods

We searched the following electronic databases: Cochrane Oral Health Group's Trials Register (to 1 October 2013); Cochrane Central Register of Controlled Trials (*The Cochrane Library* 2013, Issue 9); MEDLINE via OVID (1946 to 1 October 2013); EMBASE via OVID (1980 to 1 October 2013) and CINAHL via EBSCO (1980 to 1 October 2013). We searched the World Health Organization (WHO) International Trials Registry Platform and the US National Institutes of Health Trials Registry (ClinicalTrials.gov) on 1 October 2013 to identify ongoing trials. We searched for grey literature using OpenGrey (to 1 October 2013) and ZETOC Conference Proceedings (1993 to 1 October 2013). We placed no restrictions on the language or date of publication when searching the electronic databases.

Systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults (Review)
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Selection criteria

Randomised controlled trials of systemic antibiotics in adults with a clinical diagnosis of symptomatic apical periodontitis or acute apical abscess, with or without surgical intervention (considered in this situation to be extraction, incision and drainage or endodontic treatment) and with or without analgesics.

Data collection and analysis

Two review authors screened the results of the searches against inclusion criteria, extracted data and assessed risk of bias independently and in duplicate. We calculated mean differences (MD) (standardised mean difference (SMD) when different scales were reported) and 95% confidence intervals (CI) for continuous data and, where results were meta-analysed, we used a fixed-effect model as there were fewer than four studies. We contacted study authors to obtain missing information.

Main results

We included two trials in this review, with 62 participants included in the analyses. Both trials were conducted in university dental schools in the USA and compared the effects of oral penicillin V potassium (penicillin VK) versus a matched placebo given in conjunction with a surgical intervention (total or partial pulpectomy) and analgesics to adults with acute apical abscess or symptomatic necrotic tooth (no signs of spreading infection or systemic involvement (fever, malaise)). We assessed one study as having a high risk of bias and the other study as having unclear risk of bias.

The primary outcome variables presented were participant-reported pain and swelling (one trial also reported participant-reported percussion pain). One study reported the type and number of analgesics taken by participants. One study recorded the incidence of postoperative endodontic flare-ups (people who returned with symptoms that necessitated further treatment). Adverse effects as reported in one study were diarrhoea (one participant, placebo group) and fatigue and reduced energy postoperatively (one participant, antibiotic group). No studies reporting quality of life measurements were suitable for inclusion.

Objective 1: systemic antibiotics versus placebo with surgical intervention and analgesics for symptomatic apical periodontitis or acute apical abscess.

Two studies provided data for the comparison between systemic antibiotics (penicillin VK) and a matched placebo for adults with acute apical abscess or a symptomatic necrotic tooth. Participants in one study all underwent a total pulpectomy of the affected tooth while participants in the other study had their tooth treated by either partial or total pulpectomy. Participants in both trials received oral analgesics. There were no statistically significant differences in participant-reported measures of pain or swelling at any of the time points assessed within the review. The MD for pain (short ordinal numerical scale 0 to 3) was -0.03 (95% CI -0.53 to 0.47) at 24 hours; 0.32 (95% CI -0.22 to 0.86) at 48 hours and 0.08 (95% CI -0.38 to 0.54) at 72 hours. The SMD for swelling was 0.27 (95% CI -0.23 to 0.78) at 24 hours; 0.04 (95% CI -0.47 to 0.55) at 48 hours and 0.02 (95% CI -0.49 to 0.52) at 72 hours. The body of evidence was assessed as at very low quality.

Objective 2: systemic antibiotics without surgical intervention for adults with symptomatic apical periodontitis or acute apical abscess.

We found no studies that compared the effects of systemic antibiotics with a matched placebo delivered without a surgical intervention for symptomatic apical periodontitis or acute apical abscess in adults.

Authors' conclusions

There is very low quality evidence that is insufficient to determine the effects of systemic antibiotics on adults with symptomatic apical periodontitis or acute apical abscess.

PLAIN LANGUAGE SUMMARY

The effects of antibiotics on toothache caused by inflammation or infection at the root of the tooth in adults

This review, carried out by authors of the Cochrane Oral Health Group, has been produced to assess the effects of antibiotics on pain and swelling in two conditions commonly responsible for causing dental pain when given with or without dental treatment (such as extraction, drainage of a swelling or root canal treatment).

Background

Systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults (Review)
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Dental pain is a common problem and can arise when the nerve within a tooth dies due to progressing decay or severe trauma. The tissue around the end of the root then becomes inflamed and this can lead to acute pain, which gets worse on biting. Without treatment, bacteria can infect the dead tooth and cause a dental abscess, which can lead to swelling and spreading infection that may be life threatening.

The recommended treatment of this form of toothache is the removal of the dead nerve and associated bacteria. This is usually done by dental extraction or root canal treatment. Antibiotics should only be prescribed when there is severe infection that has spread from the tooth. However, some dentists still routinely prescribe oral antibiotics to people with acute dental conditions that have no signs of spreading infection.

Minimising inappropriate antibiotic prescribing plays a key role in limiting the development of antibiotic-resistant bacteria. Since dentists prescribe approximately 8% to 10% of all primary care antibiotics in developed countries, dental prescribing may contribute to antibiotic resistance. Therefore, it is important that antibiotics should only be used when they are clinically beneficial for the person.

Study characteristics

The evidence on which this review is based was up to date as of 1 October 2013. We searched scientific databases and found two trials, with a total of 62 participants included in the analysis. Both trials were conducted at university dental schools in the USA and evaluated the use of oral antibiotics in the reduction of pain and swelling reported by adults after having the first stage of root canal treatment under local anaesthetic. The antibiotic used in both trials was penicillin VK and all participants also received painkillers.

Key results

The two studies included in the review reported that there were no clear differences in the pain or swelling reported by participants who received oral antibiotics compared with a placebo (a dummy treatment) when provided in conjunction with the first stage of root canal treatment and painkillers, but the studies were small and we could not exclude potentially important differences between groups. Neither study examined the effect of antibiotics delivered by themselves, without dental treatment.

One trial reported side effects among participants: one person who received the placebo medication had diarrhoea and one person who received antibiotics experienced tiredness and reduced energy after their operation.

Quality of evidence

We judged the quality of evidence to be very low. There is currently insufficient evidence to be able to determine the effects of antibiotics in these conditions.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON [Explanation]

Systemic antibiotics with a surgical intervention and analgesics for the management of symptomatic apical periodontitis and acute apical abscess in adults

Patient or population: adults with a symptomatic necrotic tooth or localised acute apical abscess (no signs of spreading infection or systemic involvement)
Settings: university dental schools, USA
Intervention: systemic antibiotics, partial or total pulpectomy and analgesics
Comparison: matched placebo, partial or total pulpectomy and analgesics

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Matched placebo, partial or total pulpectomy and analgesics	Systemic antibiotics, partial or total pulpectomy and analgesics				
Pain at 24 hours Short ordinal numerical scale. Scale from: 0 to 3	The mean pain at 24 hours ranged across control groups from: 1.0 to 1.68	The mean pain at 24 hours in the intervention groups was 0.03 lower (0.53 lower to 0.47 higher)	-	61 (2 studies)	⊕○○○ very low ^{1,2,3}	-
Pain at 48 hours Short ordinal numerical scale. Scale from: 0 to 3	The mean pain at 48 hours ranged across control groups from: 0.8 to 0.95	The mean pain at 48 hours in the intervention groups was 0.32 higher (0.22 lower to 0.86 higher)	-	61 (2 studies)	⊕○○○ very low ^{1,2,3}	-
Pain at 72 hours Short ordinal scale. Scale from: 0 to 3	The mean pain at 72 hours ranged across control groups from: 0.3 to 0.82	The mean pain at 72 hours in the intervention groups was 0.08 higher (0.38 lower to 0.54 higher)	-	61 (2 studies)	⊕○○○ very low ^{1,2,3}	-

		higher)				
Swelling at 24 hours Different short ordinal numerical scales	The mean swelling at 24 hours in the control groups was 0.59 ¹	The mean swelling at 24 hours in the intervention groups was 0.27 standard deviations higher (0.23 lower to 0.78 higher)	-	62 (2 studies)	⊕○○○ very low ^{1,2,3}	This converts back into a 36% increase (95% CI 31% decrease to 105% increase) of control mean for antibiotics (based on 1 study at unclear risk of bias)
Swelling at 48 hours different short ordinal numerical scales	The mean swelling at 48 hours in the control groups was 0.73 ¹	The mean swelling at 48 hours in the intervention groups was 0.04 standard deviations higher (0.47 lower to 0.55 higher)	-	61 (2 studies)	⊕○○○ very low ^{1,2,3}	This converts back into a 4% increase (95% CI 49% decrease to 58% increase) of control mean for antibiotics (based on 1 study at unclear risk of bias)
Swelling at 72 hours different short ordinal numerical scales	The mean swelling at 72 hours in the control groups was 0.59 ¹	The mean swelling at 72 hours in the intervention groups was 0.02 standard deviations higher (0.49 lower to 0.52 higher)	-	61 (2 studies)	⊕○○○ very low ^{1,2,3}	This converts back into a 2% increase (95% CI 55% decrease to 59% increase) of control mean for antibiotics (based on 1 study at unclear risk of bias)
Adverse effects	During the 3-day follow-up period in Fouad 1996, 1 participant in the placebo group reported diarrhoea and 1 participant in the antibiotic group reported fatigue and reduced energy postoperatively					

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).
CI: confidence interval.

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

¹ One study with high risk of bias and small group sizes.

² One study with unclear risk of bias and small group sizes.

³ Different surgical interventions employed. Participants in one study had partial or total pulpectomy (there was no way of distinguishing between the two treatment modalities) while participants in the other all had total pulpectomy.

⁴ Re-expressed from the standardised mean difference into the short ordinal numerical scale used by Henry 2001. Results should be interpreted with caution since back-translation of the effect size is based on the results of only one study.

BACKGROUND

Description of the condition

Dental pain can have a considerable detrimental effect on an individual's social functioning and quality of life (Reisine 1995; Pau 2005). In the Adult Dental Health Survey of 2009 conducted in the UK, 29% of individuals reported experiencing dental pain 'occasionally' or 'fairly/very often' during the preceding 12 months. Within the survey, prevalence of dental pain was 9%, with higher values reported for younger individuals and among lower socioeconomic groups (Steele 2011). Of these individuals, approximately 30% will have symptomatic apical periodontitis and a further 13% will have an acute apical abscess (Sindet-Pedersen 1985; Estrela 2011).

Apical periodontitis arises following injury to the pulpal tissues of a tooth due to dental caries, tooth fracture, trauma or iatrogenic damage. While the dental pulp can recover from reversible pulpitis resulting from a mild to moderate injury, persistent or extensive damage results in irreversible levels of inflammation within the pulpal tissues. Should this occur, people may experience symptoms of irreversible pulpitis. Without treatment, irreversibly inflamed teeth then undergo pulpal necrosis and bacterial colonisation of the root canal system (Abbott 2004; Bergenholz 2010).

Apical periodontitis (also known as periapical periodontitis) is an inflammatory lesion of the periradicular tissues that arises principally due to the egress of irritants such as bacteria and toxins from an inflamed or necrotic pulp (Torabinejad 1994). Its evolutionary role is protective: to contain the root canal bacteria and prevent the spread of infection. While the vast majority of cases are asymptomatic, exacerbations of apical periodontitis can present as symptomatic apical periodontitis or an acute apical abscess (Bergenholz 2010).

Symptomatic apical periodontitis can arise either from a formerly healthy tooth that has subsequently undergone pulpal breakdown or from a tooth with a previously asymptomatic apical periodontitis. It is characterised by a dull or throbbing pain that is exacerbated by biting. The affected tooth usually has a negative or delayed positive response to vitality testing and is often highly sensitive to percussive forces (Bergenholz 2010).

It should be noted that in determining the health of pulpal tissues, the term 'vitality testing' is commonly used. True 'vitality' tests attempt to examine the presence of pulp blood flow, while 'sensitivity' tests employ the use of thermal or electrical stimuli to elicit a response from innervated tissue (Chen 2009). Although neither can definitively indicate the health of the dental pulp, they remain useful diagnostic aids, commonly used in both clinical practice and scientific studies.

Acute apical abscesses develop in the presence of a pre-existing apical periodontitis (Carrotte 2004). Persistent presence of infective material within the pulpless root canal system and around the apex of a tooth can lead to a massive influx of polymorphonuclear

leukocytes into the periradicular tissues, leading to tissue liquefaction and pus formation (Bergenholz 2010). Also known as a periapical, dentoalveolar or alveolar abscess, an apical abscess is characterised by the accumulation of pus in the periradicular tissues and can present as either an acute or chronic lesion. People with acute apical abscesses complain of a rapid onset, spontaneous pain, tenderness of the tooth to pressure, pus formation and swelling of associated tissues (Glickman 2009). Left untreated, the abscess may spread resulting in a serious, potentially life-threatening head and neck infection accompanied by fever, malaise and lymph node involvement (Abbott 2004). Since symptomatic apical periodontitis and acute apical abscess represent a continuum of the same disease process, it is appropriate to consider both conditions in this review (Sutherland 2004).

Description of the intervention

Clinical guidelines recommend that the first-line treatment for teeth with either symptomatic apical periodontitis or an acute apical abscess is the removal of the source of inflammation or infection by local, operative measures (Glenny 2004; SDCEP 2011). This involves either the extraction of the offending tooth, extirpation (removal) of the pulpal tissues, possibly in combination with the incision and drainage of any swelling present. Systemic antibiotics are currently only recommended for situations where there is evidence of spreading infection (cellulitis, lymph node involvement, diffuse swelling) or systemic symptoms (fever, malaise) (SDCEP 2011; Palmer 2012).

Several studies appear to indicate that antibiotics do not reduce the pain or swelling arising from teeth with symptomatic apical pathology in the absence of evidence of systemic involvement (Fouad 1996; Henry 2001). Nevertheless, 69% of individuals attending a British out-of-hours dental clinic with symptomatic apical periodontitis received a prescription for systemic antibiotics, many in the absence of a surgical intervention (Dailey 2001). Furthermore, the authors of the paper suggested that clinicians providing emergency dental treatment may be prescribing antibiotics as the first-line treatment for people with dental pain (Dailey 2001). In a survey of Spanish oral surgeons, over 70% reported that they would prescribe systemic antibiotics for people with moderate to severe pre-operative symptoms from a tooth with a necrotic pulp and acute apical periodontitis (Segura-Egea 2010). Comparatively, in a survey of members of the American Association of Endodontists, only 54% of respondents reported that they would prescribe antibiotics for the same condition, highlighting differences between practitioners of nationalities and specialities (Yingling 2002).

How the intervention might work

Doctors and dentists may prescribe systemic antibiotics to minimise the signs and symptoms of symptomatic apical periodontitis

or acute apical abscess, and to treat or prevent the development of a serious orofacial swelling with systemic involvement. Antibiotics can be prescribed as an adjunctive or stand-alone treatment. People prescribed antibiotics may be given analgesics at the same time.

Why it is important to do this review

There is international concern about the overuse of antibiotics and the emergence of antibiotic-resistant bacterial strains (World Health Organization 2000). Since approximately 8% to 10% of antibiotics dispensed in primary care in developed countries are prescribed by a dentist, it is important not to underestimate the potential contribution of the dental profession to the development of antibiotic resistance (Al-Haroni 2007; Holyfield 2009; Prescribing and Primary Care Services 2013). Inappropriate use of antibiotics not only drives antibiotic resistance and misuses resources, it increases the risk of potentially fatal anaphylactic reactions and exposes people to unnecessary side effects (Gonzales 2001; Costelloe 2010). Furthermore, antibiotic prescribing for common medical problems increases patient expectations for antibiotics, leading to a vicious cycle of increased prescribing in order to meet expectations (Little 1997; Coenen 2006).

If systemic antibiotics are effective in the treatment of symptomatic apical periodontitis or acute apical abscess then it is important that the nature of any benefits be quantified. However, if antibiotics are ineffective, people may be unnecessarily exposed to harmful side effects and the increased possibility of developing antibiotic-resistant bacterial colonies. It is important that antibiotics be prescribed for dental conditions only when they are likely to result in clinical benefit for the person. Therefore, the objective of this review was to evaluate the effects of systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults.

OBJECTIVES

To evaluate the effects of systemic antibiotics provided with or without surgical intervention (such as extraction, incision and drainage of a swelling or endodontic treatment), with or without analgesics, for symptomatic apical periodontitis or acute apical abscess in adults.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised controlled trials (RCTs) with parallel group design in the review. We excluded cluster RCTs.

Types of participants

Studies of adults (over the age of 18 years), male or female, who presented with a single tooth with a clinical diagnosis of either symptomatic apical periodontitis or acute apical abscess.

Types of interventions

Active intervention

Administration of any systemic antibiotic (either oral or intravenous) at any dosage prescribed in the symptomatic phase of apical periodontitis or acute apical abscess (with or without analgesics, and with or without surgical intervention (extraction, incision and drainage or endodontic treatment).

Control

Administration of a matched placebo prescribed in the symptomatic phase of apical periodontitis or acute apical abscess (with or without analgesics, and with or without surgical intervention).

Types of outcome measures

Primary outcomes

1. Measures of participant-reported pain and swelling, gauged on either a continuous scale, such as visual analogue scale (VAS), or using binary or dichotomous outcomes.
2. Clinician-reported measures of infection, such as swelling, temperature, trismus (reduced mouth opening), regional lymphadenopathy or cellulitis. These outcomes may have been reported as continuous, categorical or dichotomous variables.

Secondary outcomes

1. Participant-reported quality of life measures.
2. Type, dose and frequency of analgesics used.
3. Any adverse effects or harm (hypersensitivity or other reactions) attributed to antibiotics or analgesics, complications of surgical treatment or hospitalisations.

Search methods for identification of studies

For the identification of studies included or considered for this review, we developed a detailed search strategy for each database searched. These were based on the search strategy developed for MEDLINE but revised appropriately for each database to take account of differences in controlled vocabulary and syntax rules.

The search strategy combined the subject search with the Cochrane Highly Sensitive Search Strategy for identifying reports of RCTs (2008 revision), as published in Box 6.4.c in the *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011) (Higgins 2011). The subject search used a combination of controlled vocabulary and free text-terms based on the search strategy for searching MEDLINE. The search of EMBASE was linked to the Cochrane Oral Health Group filters for identifying RCTs.

Electronic searches

We searched the following databases:

- Cochrane Oral Health Group's Trials Register (to 1 October 2013);
- Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2013, Issue 9);
- MEDLINE via OVID (1946 to 1 October 2013);
- EMBASE via OVID (1980 to 1 October 2013);
- CINAHL via EBSCO (1980 to 1 October 2013).

See Appendix 1 for details of all search strategies used. All databases were searched from their inception to October 2013 and we applied no restrictions on language of publication in the electronic searches.

Searching other resources

We searched the following trials registers for ongoing studies:

- World Health Organization (WHO) International Trials Registry Platform (to 1 October 2013) (www.who.int/ictip/en/);
- US National Institutes of Health Trials Registry (ClinicalTrials.gov) (to 1 October 2013).

We searched for grey literature using the following resources:

- OpenGrey (to 1 October 2013);
- ZETOC Conference Proceedings (1993 to 1 October 2013).

We checked the reference lists of all included and excluded studies to identify any further trials.

Data collection and analysis

Selection of studies

Two review authors (Anwen Cope (AC) and Mala Mann (MM)) independently assessed the titles and abstracts (where available) of the articles identified by the search strategy and made decisions regarding eligibility. Full-text versions were obtained for all articles being considered for inclusion, as were those with insufficient information in the title or abstract to make a clear decision. We resolved any disagreements by discussion. We excluded studies later

found not to meet the inclusion criteria and recorded them in the Characteristics of excluded studies table.

Data extraction and management

We entered study details into the Characteristics of included studies table. AC and MM independently extracted the outcome data from the included studies using a standard data extraction form. The review authors discussed the results and resolved any disagreements by discussion or with a third review author (Ivor G Chestnutt (IGC)). In cases where uncertainties persisted, we contacted the study authors for clarification.

We extracted the following characteristics of the studies.

1. Study methodology: study design, methods of allocation, method of randomisation, randomisation concealment, blinding, time of follow-up, loss to follow-up, country conducted in, number of centres, recruitment period and funding source.
2. Participants: sampling frame, diagnostic criteria, inclusion criteria, exclusion criteria, number of participants in each group, baseline group demographics and clinical diagnosis.
3. Intervention: type of antibiotic, dose, frequency and duration of course. Information about co-interventions, for example, surgical treatment or analgesia.
4. Outcomes: primary outcomes at 24, 48 and 72 hours and seven days, and secondary outcomes as previously described (see Primary outcomes; Secondary outcomes).

Assessment of risk of bias in included studies

Two review authors (AC and MM) independently assessed the risk of bias of the included studies and resolved any disagreements by discussion with a third review author (IGC). We completed a 'Risk of bias' table for each included study following the recommended methods for assessing the risk of bias in studies included in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). This was a two-part tool addressing specific key domains including sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting and other bias. We tabulated relevant information describing what happened, as reported in the study or revealed by correspondence with the study authors, for each included study, along with a judgement of low, high or unclear risk of bias for each individual domain.

A summary assessment of the risk of bias of each included study was made as follows:

- low risk of bias (plausible bias unlikely to seriously alter the results) if we assessed all key domains to be at low risk of bias;
- unclear risk of bias (plausible bias that raises some doubt about the results) if we assessed one or more key domains as unclear;
- high risk of bias (plausible bias that seriously weakens confidence in the results) if we assessed one or more key domains to be at high risk of bias.

We completed a 'Risk of bias' table for each included study. We also presented the results graphically.

Measures of treatment effect

For dichotomous outcomes, we expressed the estimate of effect of the intervention as risk ratios (RR) together with 95% confidence intervals (CI). For continuous outcomes (such as mean VAS scores), we reported mean differences (MD) (or standardised mean differences (SMD) when different scales measuring the same concept) and their corresponding 95% CI.

Unit of analysis issues

We anticipate that, by the nature of the outcome variables being recorded, studies included in future updates may involve repeat observations. Results from more than one time point for each study cannot be combined in a standard meta-analysis without a unit-of-analysis error. Therefore, we assessed outcomes at 24, 48 and 72 hours and seven days postoperatively, as the data allowed. We included no clustered trials in the review.

Given the nature of the conditions and intervention under review, it is high unlikely any cross-over trials will be suitable for inclusion in the future.

In updates, we will consider multi-arm studies for inclusion in the review, in accordance with recommendations in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011), we will combine all relevant experimental groups and considered them as a single group and compared them with a combined group of all the control groups, if present.

Dealing with missing data

We contacted the original investigators in cases of missing data.

Assessment of heterogeneity

We planned to assess heterogeneity using the Chi^2 test (P value < 0.10 regarded as statistically significant). For studies judged as clinically homogeneous, we test heterogeneity using the I^2 statistic, as recommended in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). The I^2 statistic describes the percentage of variability in effect estimates that is due to heterogeneity rather than sampling error. An I^2 of 0% to 40% might not be important, 30% to 60% may represent moderate heterogeneity, 50% to 90% may have substantial heterogeneity and 75% to 100% studies has substantial heterogeneity.

Assessment of reporting biases

We examined within-study selective outcome reporting as a part of the overall risk of bias assessment and contacted study authors for clarification.

If there had been at least 10 studies included in a meta-analysis, we would have assessed between-study reporting bias by creating a funnel plot of effect estimates against their standard errors. If we had found asymmetry of the funnel plot by inspection and confirmed this by statistical tests, we would have considered possible explanations and taken into account in the interpretation of the overall estimate of treatment effects.

Data synthesis

We only carried out meta-analysis where studies of similar comparisons, reported similar outcomes, for people with similar clinical conditions. We combined MDs (or SMDs where studies had used different scales) for continuous outcomes, and combined RRs for dichotomous outcomes, using a fixed-effect model if there were only two or three studies, or a random-effects model if there were four or more studies.

Subgroup analysis and investigation of heterogeneity

We planned to investigate clinical heterogeneity by examining the following subgroups should sufficient data have been available.

1. Different antibiotic class (e.g. penicillins versus macrolides).
2. The effects of accompanying surgical intervention (extraction, incision and drainage or endodontic treatment).

Sensitivity analysis

Provided there were sufficient studies for each outcome and intervention, we had planned to undertake sensitivity analysis based on trials judged to be of low risk of bias.

Presentation of main results

We developed a 'Summary of findings' table for the primary outcomes of this review using GRADEPro software, with the GRADE assessment of the quality of the body of evidence.

RESULTS

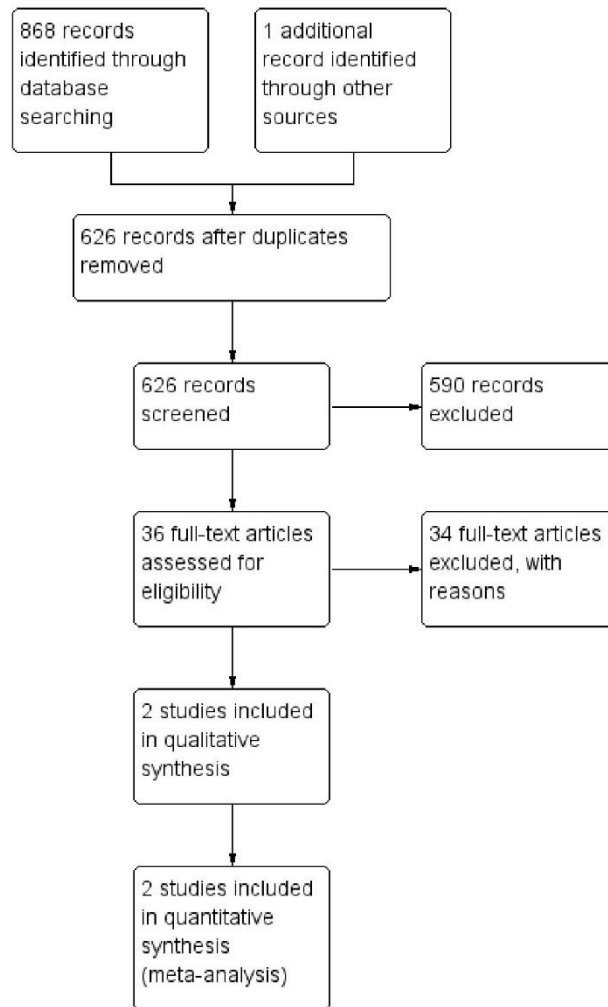
Description of studies

Results of the search

After de-duplication, electronic searches yielded 625 references. We identified one additional trial by checking the bibliographies of the selected trials and reviews (Al-Belasy 2003). After examination of the titles, and abstracts where available, we excluded 590 references from further analysis. We obtained full-text copies

of the remaining 36 studies, translated them where required, and subjected them to further evaluation. At this stage, we excluded 34 studies and recorded their characteristics (Characteristics of excluded studies; Figure 1).

Figure 1. Study flow diagram.



Included studies

Two randomised controlled trials (RCTs) satisfied the inclusion criteria (Fouad 1996; Henry 2001). See Characteristics of included studies table for further details.

Characteristics of trial designs and settings

Both studies were of parallel group design, one had three arms (Fouad 1996), and the other had two arms (Henry 2001). Both studies were conducted at university dental schools in the USA and were based at a single centre. One study was supported by a university research fund and the other did not declare funding sources. Neither study reported sample size calculations.

Characteristics of participants

We included 62 participants in the analysis for this review, with 21 people analysed in Fouad 1996, and 41 people analysed in Henry 2001. Both studies were conducted on otherwise healthy adults. Participants in one study had a mean age of 36.0 years (standard deviation (SD) 13.7 years) and had a clinical diagnosis of acute apical abscess with pulpal necrosis, periapical pain or swelling, or both (Additional Table 1; Fouad 1996). Participants in the other study had a mean age of 37 years (SD 16.5 years) in the penicillin arm and 38 years (SD 18.8 years) in the placebo arm (Additional Table 2; Henry 2001). All had a symptomatic necrotic tooth with a periapical radiolucency and no mucosal sinus tract (Henry 2001). One trial had more male participants (Fouad 1996) and the other had similar numbers of male and female participants (Henry 2001). There were no significant differences in the intra-study baseline characteristics of participants (Additional Table 1; Additional Table 2).

Characteristics of intervention

Objective 1: systemic antibiotics versus a matched placebo provided in conjunction with a surgical intervention

In one trial, participants underwent total or partial pulpectomy under local anaesthesia with temporary restoration at the baseline visit (Fouad 1996). In the other trial, all participants underwent total pulpectomy with temporary restoration at the baseline visit (Henry 2001).

In the study by Fouad 1996, participants in the penicillin group received oral penicillin (phenoxymethyl) VK 1 g following treatment and then 500 mg, every six hours for seven days. Participants

in the placebo group received an oral matched placebo taken according to the same regimen. In the trial by Henry 2001, participants in the penicillin group received oral penicillin VK tablets (Wyeth Laboratories, Philadelphia, PA) 500 mg, every six hours for seven days and participants in the placebo group received an oral matched placebo (lactose) taken according to the same regimen.

In one trial, all participants also received ibuprofen 600 mg immediately before treatment, on four occasions during the next 24 hours and then as required (Fouad 1996). In the other trial, all participants received a bottle of ibuprofen 200 mg tablets (Advil, Whitehall Laboratories, New York, NY) with instructions to take two tablets every four to six hours as required. Each participant also received a labelled bottle of paracetamol (acetaminophen) with codeine (Tylenol #3, McNeil Consumer Products, Fort Washington, PA) with dosing instructions, to take if two ibuprofen did not relieve their discomfort. One participant was given Percocet (oxycodone plus paracetamol (acetaminophen)) instead (Henry 2001).

Objective 2: systemic antibiotics versus a matched placebo provided without a surgical intervention

We found no studies comparing systemic antibiotics versus a matched placebo provided without a surgical intervention.

Heterogeneity of interventions

There was heterogeneity with respect to the operative treatment, doses of antibiotics given to participants in the intervention arms and type, dose and frequency of analgesics provided to participants between the two studies.

Characteristics of the outcome measures

Primary outcomes

Both studies reported participant-reported pain. Both utilised a short ordinal numerical scale graded from 0 to 3. In Fouad 1996, this score was determined by converting the value from a VAS on the post-treatment card into a whole number rank. Pain was measured at the following data points in each study:

- six hours, 12 hours, 24 hours, 48 hours and 72 hours (Fouad 1996);
- day one, day two, day three, day four, day five, day six, day seven (Henry 2001).

Both studies reported participant-reported swelling. In Henry 2001, investigators utilised a short ordinal numerical scale graded

from 0 to 3. In Fouad 1996, increase or decrease in swelling compared with baseline was recorded on a short ordinal numerical scale graded from 0 to 4. Swelling was measured at the following data points in each study:

- six hours, 12 hours, 24 hours, 48 hours and 72 hours (Fouad 1996);
- day one, day two, day three, day four, day five, day six, day seven (Henry 2001).

One study included percussion pain (Henry 2001). This was measured on a short ordinal numerical scale graded from 0 to 3.

One study included incidence of endodontic flare-up (Fouad 1996). This was measured dichotomously and was clinician-assessed based on the presence of: no relief or an increase in the severity of pain; no resolution or an increase in the size of swelling, fever, trismus or difficulty swallowing; signs of a drug allergy or any other abnormal symptoms.

Secondary outcomes

One study included the number and type of analgesics required (Henry 2001). In Fouad 1996, participants recorded whether they

required additional analgesia; however, this information was not reported and was not available after contacting the investigators. One study reported adverse effects (Fouad 1996).

Handling of data/data assumptions made in the review

For objective 1, we compared pain and swelling scores at 24, 48 and 72 hours and seven days postoperatively. For the purposes of the analysis, we made the assumption that the data points from Henry 2001 (day one, day two and day three) were sufficiently analogous to those measure in Fouad 1996 to be combined.

Excluded studies

We excluded the majority of references as they were not RCTs. Other excluded studies did not report relevant health outcomes, had no placebo control or had other characteristics that did not satisfy the inclusion criteria (*see Characteristics of excluded studies table*).

Risk of bias in included studies

The review authors' judgements about each risk of bias item for each included study are given in Figure 2.

Figure 2. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Fouad 1996	+	+	+	+	-	?	+
Henry 2001	+	+	+	+	?	+	+

Allocation

Randomisation

We considered both studies to be at low risk of bias for random sequence generation.

Allocation concealment

We assessed both studies to have adequate concealment of allocation prior to assignment. In Fouad 1996, individuals enrolling

participants into the trial were not aware of the upcoming allocation sequence; envelopes were sequentially numbered, opaque and sealed; envelopes for the penicillin and placebo groups were identical in appearance and weight and were only opened after being assigned to the participant. In Henry 2001, participants were given sequentially numbered drug containers of identical appearance in accordance with the randomisation sequence produced prior to the experiment.

Blinding

We judged both studies to have employed adequate measures to ensure that active and placebo tablets had identical appearance, and, therefore, we considered risk of performance bias to be low for both studies. Similarly, we considered both studies to have low risk of detection bias as blinding was unlikely to have been broken.

Incomplete outcome data

We considered Fouad 1996 to be at high risk of attrition bias. Rates of withdrawal were in excess of 20% in across groups, with higher rates of withdrawal from the placebo than the penicillin group. We judged differential attrition as likely to be related to treatment outcomes. In Henry 2001, we were unable to judge risk of bias due to insufficient reporting of relative attrition rates and reasons for withdrawal and, therefore, this risk for this domain is 'unclear'.

Selective reporting

We judged one study to be at unclear risk of reporting bias, as investigators did not report whether the need for additional analgesia differed between the two trial arms, although this information was collected on the post-treatment card (Fouad 1996). There was no evidence of selective reporting within Henry 2001 and all expected outcomes were presented. We judged this study to be at low risk of reporting bias.

Other potential sources of bias

We judged both trials to be at low risk of other potential sources of bias.

Overall risk of bias

One study had high overall risk of bias (Fouad 1996), and one had unclear risk of bias (Henry 2001) (Figure 2).

Effects of interventions

See: **Summary of findings for the main comparison** Systemic antibiotics with a surgical intervention and analgesics for the management of symptomatic apical periodontitis and acute apical abscess in adults

Objective 1: systemic antibiotics versus a matched placebo provided in conjunction with a surgical intervention

Two studies, one at unclear risk of bias (Henry 2001), and one at high risk of bias (Fouad 1996), provided data for this comparison. Both compared oral penicillin VK against a matched placebo when provided alongside partial or total pulpectomy for adults with

localised acute apical abscess or symptomatic necrotic tooth in otherwise healthy adults.

Primary outcomes

Pain

The analysis of participant-reported pain at data points 24, 48 and 72 hours was based on data from two studies (61 participants), one at high risk of bias (Fouad 1996), and one at unclear risk of bias (Henry 2001). Analysis of the seven-day time point was based on data from one study (41 participants) at unclear risk of bias (Henry 2001).

For the antibiotic group:

- mean difference (MD) at 24 hours -0.03 (95% confidence interval (CI) -0.53 to 0.47);
- MD at 48 hours 0.32 (95% CI -0.22 to 0.86);
- MD at 72 hours 0.08 (95% CI -0.38 to 0.54);
- MD at seven days -0.05 (95% CI -0.41 to 0.30, P value = 0.77).

Swelling

The analysis of participant-reported swelling at data points 24 hours (61 participants), 48 hours (62 participants) and 72 hours (61 participants) was based on data from two studies, one at high risk of bias (Fouad 1996), and one at unclear risk of bias (Henry 2001). Analysis of seven-day time point was based on data from one study at unclear risk of bias (Henry 2001). Standardised mean difference (SMD) was used to combine the different scales used for the 24-, 48- and 72-hour data points.

For the antibiotic group:

- SMD at 24 hours 0.27 (95% CI -0.23 to 0.78). This converts back into a 36% increase (95% CI 31% decrease to 105% increase) of control mean for antibiotics. Re-expressed from the SMD into the short ordinal numerical scale used by Henry 2001. Results should be interpreted with caution since back-translation of the effect size was based on the results of only one study.
- SMD at 48 hours 0.04 (95% CI -0.47 to 0.55). This converts back into a 4% increase (95% CI 49% decrease to 58% increase) of control mean for antibiotics. Re-expressed from the SMD into the short ordinal numerical scale used by Henry 2001. Results should be interpreted with caution since back-translation of the effect size was based on the results of only one study.
- SMD at 72 hours 0.02 (95% CI -0.49 to 0.52). This converts back into a 2% increase (95% CI 55% decrease to 59% increase) of control mean for antibiotics. Re-expressed from the SMD into the short ordinal numerical scale used by Henry 2001. Results should be interpreted with caution since back-translation of the effect size was based on the results of only one study.

- MD at seven days 0.02 (95% CI -0.28 to 0.32, P value = 0.90)

Percussion pain

The analysis of participant-reported percussion data at data points 24, 48 and 72 hours was based on data from one study (41 participants) at unclear risk of bias (Henry 2001).

For the antibiotic group:

- MD at 24 hours -0.32 (95% CI -0.85 to 0.21, P value = 0.24);
- MD at 48 hours 0.09 (95% CI -0.44 to 0.62, P value = 0.74);
- MD at 72 hours 0.05 (95% CI -0.55 to 0.65, P value = 0.87);
- MD at seven days 0.06 (95% CI -0.29 to 0.41, P value = 0.73).

Endodontic flare-up

The analysis of clinician-assessed incidence of endodontic flare-up over three-day follow-up period was based on data from one study at high risk of bias (20 participants) (Fouad 1996).

For the antibiotic group:

- risk ratio (RR) of endodontic flare-up 0.27 (95% CI 0.01 to 4.90, P value = 0.37).

Secondary outcomes

Analgesics

The analysis of the number of analgesic tablets required during the seven-day follow-up period was based on data from one study (41 participants) at unclear risk of bias (Henry 2001).

For the antibiotic group:

- MD for total number of ibuprofen tablets 1.58 (95% CI -4.55 to 7.71, P value = 0.62).
- MD for total number of paracetamol (acetaminophen) with codeine tablets -0.31 (95% CI -3.94 to 3.32, P value = 0.87).

Adverse effects

During the three-day follow-up period in Fouad 1996 (20 participants, high risk of bias), one participant in the placebo group reported diarrhoea and one participant in the antibiotic group reported fatigue and reduced energy postoperatively.

Objective 2: systemic antibiotics versus a matched placebo provided without a surgical intervention

We found no studies comparing systemic antibiotics versus a matched placebo provided without a surgical intervention.

DISCUSSION

Summary of main results

The review process identified two studies suitable for inclusion, both of which assessed the effects of penicillin VK compared with a matched placebo in adults with localised apical abscess or a symptomatic necrotic tooth (no signs of spreading infection or systemic involvement) when provided in conjunction with partial or total pulpectomy conducted under local anaesthesia and analgesics. There were no statistically significant differences in primary outcomes (participant-reported pain, swelling or percussion pain or incidence of endodontic flare-up) or secondary outcomes (analgesic use or incidence of adverse events) between participants who had received antibiotics and participants who had received a matched placebo. We considered this body of evidence (two studies, one at unclear risk of bias and one at high risk of bias) to be of very low quality and it should be interpreted with caution.

We found no studies that reported the effects of systemic antibiotics versus a matched placebo for symptomatic apical periodontitis when provided in conjunction with a surgical intervention. We found no studies that reported the effects of systemic antibiotics versus a matched placebo for symptomatic apical periodontitis or acute apical abscess when provided without a surgical intervention.

Overall completeness and applicability of evidence

We employed a comprehensive search strategy and we are confident that the majority of published trials are included in this review. We made efforts to identify all relevant studies and excluded no studies due to language.

The two included trials partially addressed the first of the two objectives (Fouad 1996; Henry 2001), which both investigated the effect of systemic antibiotics for acute apical abscess or symptomatic necrotic tooth provided in conjunction with total or partial pulpectomy in adults. However, there were no trials that assessed the effects of antibiotics for symptomatic apical periodontitis when used in conjunction with a surgical intervention. Furthermore, we found no trials assessing the second objective, which sought to compare antibiotics and a placebo for symptomatic apical periodontitis or acute apical abscess when provided without a surgical intervention.

The participants included in the two trials can be considered broadly representative of people who would consult a dentist due to an acute apical abscess or symptomatic necrotic tooth who do not have evidence of spreading infection or systemic involvement - participants came from a wide age range, were about equal gender mix and the majority had moderate pain at the baseline visit. However, both the trials excluded participants with co-morbidities.

ties or who may have been immunocompromised. Therefore, the results of this review may not be generalisable to a group of people who may be at higher risk of infection. While future trials should endeavour to obtain the most representative sample possible, it is unlikely to be feasible or ethical to conduct placebo-controlled trials in these groups of people.

One trial excluded participants with signs of spreading infection and systemic involvement (Fouad 1996), and the other trial included only a small number of participants with evidence of severe infections at baseline (Henry 2001). Therefore, the results of this review may or may not be generalisable to people with severe swelling or other signs of spreading infection or systemic involvement.

Both of the included studies were conducted at university dental schools and, in both trials, endodontic treatment was completed by practitioners who either worked in the Department of Endodontics (Fouad 1996), or were senior endodontic graduate students (Henry 2001). It would be reasonable to consider that both groups of practitioners had endodontic skills in excess of those of an average primary care dentist. The specialist settings in which the trials were conducted were unlikely to face the time constraints encountered in routine clinical practice. Therefore, the intervention provided within these studies may only have limited applicability to the treatment routinely provided at emergency appointments in general dental practice, where treatment decisions are often dictated by time pressures (Palmer 2000). Therefore, more trials in a primary care setting would enhance the evidence base for answering the questions posed by this review.

We found no trials assessing the effect of other surgical interventions, such as dental extraction or incision and drainage of a swelling. Since dental extraction is a common treatment for both symptomatic apical periodontitis and acute apical abscess, and incision and drainage of acute apical abscess is also frequently undertaken, the effects of these interventions could be considered in future trials.

The outcomes reported by the two trials measured the harms as well as the benefits of interventions. This is important as antibiotics can have adverse effects such as hypersensitivity reactions and gastrointestinal upset. Many of the outcome measures in the two included trials were participant-centred, such as pain, percussion pain and swelling. Since both pain and discomfort are known to impact an individual's quality of life (Skevington 1998), future trials should also consider formally measuring oral health-related quality of life outcomes to assess the beneficial and harmful effects of this intervention in more detail.

Quality of the evidence

The quality of the evidence, as summarised in Summary of findings for the main comparison for the main comparison, was rated as very low.

Given the considerable number of antibiotics prescribed by dentists to adults with acute dental conditions and the problems associated with indiscriminate use of antibiotics, the paucity of high-quality trials evaluating the effects of systemic antibiotics in the management of symptomatic apical periodontitis and acute apical abscess is disappointing. Only two studies met the inclusion criteria for this review; we judged one to be at high risk of bias and the

other to be of unclear risk of bias. Both had methodological flaws with respect to attrition bias and the overall quality of evidence was very low. Furthermore, small group sizes mean that both studies were likely to lack the statistical power to detect differences between intervention and placebo groups. Sample size calculations were not reported in either study. Therefore, caution should be exercised when interpreting the results presented in this review.

Potential biases in the review process

Two independent review authors extracted data and assessed the methodological quality of each study, minimising potential bias. We are confident that the extensive literature search used in this review has captured relevant literature and minimised the likelihood that we missed any relevant trials.

In the event of incomplete or unclear reporting of trial data, we contacted the trial authors to obtain any unpublished data or clarification of results. We applied no language or publication restrictions in our search.

Despite these efforts, it must be acknowledged that there is a small possibility that there were additional studies (published and unpublished) that we did not identify. It is possible that additional literature searches, such as searching non-English language databases and handsearching relevant journals, would have found additional studies.

Agreements and disagreements with other studies or reviews

Systematic reviews of the emergency management of acute apical periodontitis and acute apical abscess in the permanent dentition were published in 2003 (Mathews 2003; Sutherland 2003). These reviews had wider inclusion criteria and included trials of analgesics, local pharmacotherapeutics and surgical interventions in addition to antibiotic trials. Sutherland 2003 concluded that "the use of antibiotics in the management of AAP [acute apical periodontitis] is not recommended" and Mathews 2003 recommended that "the use of antibiotics in the management of *localized* AAA [acute apical abscess] over and above establishing drainage of the abscess, is *not* recommended".

AUTHORS' CONCLUSIONS

Implications for practice

Based on the current available data, which are of very low quality, there was insufficient evidence to determine the effects of the administration of systemic antibiotics to adults with symptomatic apical periodontitis or acute apical abscess.

Since antibiotic use is recognised as a major contributor to antimicrobial resistance, dental professionals should be judicious in their use of these agents and should refer to evidence-based best practice guidelines when managing people with acute dental conditions.

Implications for research

Large-scale, adequately powered and well-designed randomised controlled trials are needed to clarify the effectiveness of systemic antibiotics in the treatment of symptomatic apical periodontitis and acute apical abscess. However, all future trials should be carefully designed to ensure the potential benefits of providing systemic antibiotics to participants outweigh risks associated with antibiotic usage, both adverse effects and the possible contribution to antibiotic resistance.

Future studies should consider both utilising validated participant- and clinician-reported outcome measures, and report results according to the Consolidated Standards of Reporting Trials (CON-

SORT) guidelines (www.consort-statement.com/).

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REFERENCES

References to studies included in this review

- Fouad 1996** *[published and unpublished data]*
Fouad AF, Rivera EM, Walton RE. Penicillin as a supplement in resolving the localized acute apical abscess. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology* 1996;**81**(5):590–5.
- Henry 2001** *[published and unpublished data]*
Henry M, Reader A, Beck M. Effect of penicillin on postoperative endodontic pain and swelling in symptomatic necrotic teeth. *Journal of Endodontics* 2001;**27**(2):117–23.

References to studies excluded from this review

- Achard 1967** *[published data only]*
Achard GJ, Rouit M. Pulpo-apical infection in the age of antibiotics [in French]. *Information Dentaire* 1967;**49**(19):1937–49.
- Al-Belasy 2003** *[published data only]*
Al-Belasy FA, Hairam AR. The efficacy of azithromycin in the treatment of acute infraorbital space infection. *Journal of Oral & Maxillofacial Surgery* 2003;**61**(3):310–6.
- Alves 2000** *[published data only]*
Alves DF. Clinical evaluation of the competence of some antimicrobials drugs on the treatment of the periapical abscess in evolution. *Journal of Dental Research* 2000;**79**(5):1077 (Abs No A-068).
- Angelini 1983** *[published data only]*
Angelini F, Ferrieres G, Lesous J. Clinical profile of a new bioprecursor [in French]. *Revue d'Odonto-Stomatologie* 1983;**12**(5):387–91.
- Anonymous 1968** *[published data only]*
Anonymous. Jaw abscesses [in Dutch]. *Nederlands Tijdschrift voor Geneeskunde* 1968;**112**(32):1456–7.
- Banoczy 1985** *[published data only]*
Banoczy J, Nyarasky I, Ferenczi I. Research on the effectiveness of metronidazole in the treatment of root infections [in French]. *Chirurgien-Dentiste de France* 1985;**55**(277):37–9.
- Baratieri 1968** *[published data only]*
Baratieri A. Present progress in biologic therapy of septic-degenerative conditions of the dental pulp and of periapical affections [in French]. *Revue Belge de Medecine Dentaire* 1968;**23**(2):181–98.
- Brabant 1968** *[published data only]*
Brabant H, Ketelbant R. Clinical studies of the use in stomatology of a new antibiotic: doxycycline [in French]. *Revue de Stomatologie et de Chirurgie Maxillo-Faciale* 1968;**69**(1):43–8.
- Brennan 2006** *[published data only]*
Brennan MT, Runyon MS, Batts JJ, Fox PC, Kent ML, Cox TL, et al. Odontogenic signs and symptoms as predictors

- of odontogenic infection: a clinical trial. *Journal of the American Dental Association* 2006;**137**(1):62–6.
- Citoler Gutierrez 1969** *[published data only]*
Citoler Gutierrez G. Clinical trial with the use of doxycycline in dentistry [in Spanish]. *Anales Españoles de Odontostomatología* 1969;**28**(5):372–7.
- Cumming 1984** *[published data only]*
Cumming CG, Ross PW, Smith GF, Lough H, Moyes A. The use of cefadroxil in the treatment of acute orofacial infections. *Journal of Dentistry* 1984;**12**(3):247–51.
- D'Atri 1973** *[published data only]*
D'Atri G, Silvano G. Results with a new antibiotic (cephalexin) in cases of odontogenic inflammation [in Italian]. *Minerva Stomatologica* 1973;**22**(1):8–17.
- Davis 1969** *[published data only]*
Davis WM Jr, Balcom JH 3rd. Lincomycin studies of drug absorption and efficacy. An evaluation by double-blind technique in treatment of odontogenic infections. *Oral Surgery, Oral Medicine, Oral Pathology* 1969;**27**(5):688–96.
- Deffez 1992** *[published data only]*
Deffez JP, Scheimberg A, Rezvani Y. Multicenter double-blind study of the efficacy and tolerance of roxithromycin versus erythromycin ethylsuccinate in acute orofacial infection in adults. *Diagnostic Microbiology and Infectious Disease* 1992;**15**(4 Suppl):1335–75.
- De Vries 1974** *[published data only]*
De Vries J, Francis LE. Penicillin substitutes - erythromycin and clindamycin. *Dental Journal - Journal Dentaire* 1974;**40**(4):295–8.
- Diamantes-Kepiotis 1974** *[published data only]*
Diamantes-Kepiotis A, Sykaras SN. Clinical study on the effect of corticosteroid-antibiotic compound in the prevention and treatment of acute apical periodontitis [in Greek]. *Odontostomatologike Proodos* 1974;**28**(1):26–33.
- Dolci 1982** *[published data only]*
Dolci G, Ricca L, Vergnani M. Evaluation of the analgesic effect of fosfomicin in odontostomatological infections [in Italian]. *Clinica Terapeutica* 1982;**102**(1):59–65.
- Flood 1977** *[published data only]*
Flood MK. Clinical evaluation of troleandomycin for dental abscesses [in French]. *Acta Stomatologica Belgica* 1977;**74**(1):49–52.
- Gabka 1968** *[published data only]*
Gabka J. Antibacterial activity of lincomycin in diseases of the maxillofacial region [in German]. *Arzneimittel-Forschung* 1968;**18**(11):1453–7.
- Groshikov 1970** *[published data only]*
Groshikov MI. The treatment of apical periodontitis [in Russian]. *Stomatologia* 1970;**49**(2):66–70.
- Haapasalo 1986** *[published data only]*
Haapasalo M, Ranta H, Ranta K, Shah H. Black-pigmented Bacteroides spp. in human apical periodontitis. *Infection & Immunity* 1986;**53**(1):149–53.
- Hood 1978** *[published data only]*
Hood FJ. The place of metronidazole in the treatment of acute oro-facial infection. *Journal of Antimicrobial Chemotherapy* 1978;**4** Suppl C:71–3.
- Hooley 1969** *[published data only]*
Hooley JR. Cloxacillin in the treatment of dental infection. *Oral Surgery, Oral Medicine, Oral Pathology* 1969;**28**(4):485–7.
- Khosla 1970** *[published data only]*
Khosla VM. Lincomycin in oral surgery. *Oral Surgery, Oral Medicine, Oral Pathology* 1970;**29**(4):485–90.
- Krzywicki 1975** *[published data only]*
Krzywicki R, Olejnik A. Evaluation of oxytetracin in the treatment of odontogenic inflammatory conditions [in Polish]. *Czasopismo Stomatologiczne* 1975;**28**(9):921–5.
- Lewis 1986** *[published data only]*
Lewis MA, McGowan DA, MacFarlane TW. Short-course high-dosage amoxicillin in the treatment of acute dentoalveolar abscess. *British Dental Journal* 1986;**161**(8):299–302.
- Lin 2006** *[published data only]*
Lin S, Levin L, Emodi O, Abu El-Naaj E, Peled M. Etodolac versus dexamethasone effect in reduction of postoperative symptoms following surgical endodontic treatment: a double-blind study. *Oral Surgery, Oral Medicines, Oral Pathology, Oral Radiology, and Endodontics* 2006;**101**:814–7.
- Lindeboom 2005** *[published data only]*
Lindeboom JA, Frenken JW, Valkenburg P, van den Akker HP. The role of preoperative prophylactic antibiotic administration in periapical endodontic surgery: a randomized, prospective double-blind placebo-controlled study. *International Endodontic Journal* 2005;**38**(12):877–81.
- Lorber 1967** *[published data only]*
Lorber CG. Antibiotics and sulfonamides in stomatology [in German]. *Stoma* 1967;**20**(2):110–20.
- Matijevic 2009** *[published data only]*
Matijevic S, Lazic Z, Kuljic-Kapulica N, Nonkovic Z. Empirical antimicrobial therapy of acute dentoalveolar abscess. *Vojnosanitetski Pregled* 2009;**66**(7):544–50.
- Nowakowska 1974** *[published data only]*
Nowakowska A, Olko S, Poniewska A. Oleflavit in the treatment of periodontal abscesses [in Polish]. *Czasopismo Stomatologiczne* 1974;**27**(10):1139–41.
- Oeda 1985** *[published data only]*
Oeda N, Mimura T, Yoshimine S, Tanaka T, Kiwaki M. Use of bacampicillin in acute infections in the mouth [in Japanese]. *Shikai Tenbo - Dental Outlook* 1985;**65**(3):671–7.
- Ranta 1988** *[published data only]*
Ranta H, Haapasalo M, Ranta K, Kontinen S, Kerosuo E, Valtonen V, et al. Bacteriology of odontogenic apical periodontitis and effect of penicillin treatment. *Scandinavian Journal of Infectious Diseases* 1988;**20**(2):187–92.

Re 1988 [published data only]

Re G, Barbero P, Briccarello MP, Manzoni W, Zoccola GC. Oral amoxicillin 1g b.i.d vs 1g t.i.d. in the treatment of oral periodontitis. Randomized and double-blind pilot trial [in Italian]. *Minerva Stomatologica* 1988;**37**(6):507–9.

Additional references

Abbott 2004

Abbott PV. Classification, diagnosis and clinical manifestations of apical periodontitis. *Endodontic Topics* 2004;**8**(1):36–54.

Al-Haroni 2007

Al-Haroni M, Skaug N. Incidence of antibiotic prescribing in dental practice in Norway and its contribution to national consumption. *Journal of Antimicrobial Chemotherapy* 2007;**59**(6):1161–6.

Bergenholtz 2010

Bergenholtz G, Horsted-Bindslev P, Reit C, editors. *Textbook of Endodontology*. 2nd Edition. Chichester: Wiley-Blackwell, 2010.

Carrotte 2004

Carrotte P. Endodontics: part 3. Treatment of endodontic emergencies. *British Dental Journal* 2004;**197**(6):299–305.

Chen 2009

Chen E, Abbott PV. Dental pulp testing: a review. *International Journal of Dentistry* 2009;**2009**:365785.

Coenen 2006

Coenen S, Michiels B, Renard D, Denekens J, Van Royen P. Antibiotic prescribing for acute cough: the effect of perceived patient demand. *British Journal of General Practice* 2006;**56**(524):183–90.

Costelloe 2010

Costelloe C, Metcalfe C, Lovering A, Mant D, Hay A. Effect of antibiotic prescribing in primary care on antimicrobial resistance in individual patients: systematic review and meta-analysis. *BMJ* 2010;**340**:c2096.

Dailey 2001

Dailey YM, Martin MV. Are antibiotics being used appropriately for emergency dental treatment?. *British Dental Journal* 2001;**191**(7):391–3.

Estrela 2011

Estrela C, Guedes OA, Silva JA, Leles CR, Estrela CR, Pecora JD. Diagnostic and clinical factors associated with pulpal and periapical pain. *Brazilian Dental Journal* 2011;**22**(4):306–11.

Glenny 2004

Glenny AM, Simpson T. Clinical practice guideline on emergency management of acute apical periodontitis (AAP) in adults. *Evidence-Based Dentistry* 2004;**5**(1):7–11.

Glickman 2009

Glickman GN. AAE Consensus Conference on Diagnostic Terminology: background and perspectives. *Journal of Endodontics* 2009;**35**(12):1619–20.

Gonzales 2001

Gonzales R, Malone DC, Maselli JH, Sande MA. Excessive antibiotic use for acute respiratory infections in the United States. *Clinical Infectious Diseases* 2001;**33**(6):757–62.

Higgins 2011

Higgins JPT, Green S (editors). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from www.cochrane-handbook.org.

Holyfield 2009

Holyfield G, Karki A. Review of prescribing by dentists in Wales. National Public Health Service for Wales 2009.

Little 1997

Little P, Gould C, Williamson I, Warner G, Gantley M, Kinmonth AL. Reattendance and complications in a randomised trial of prescribing strategies for sore throat: the medicalising effect of prescribing antibiotics. *BMJ* 1997;**315**(7104):350–2.

Matthews 2003

Matthews DC, Sutherland S, Basrani B. Emergency management of acute apical abscess in the permanent dentition: a systematic review of the literature. *Journal of the Canadian Dental Association* 2003;**69**(10):660.

Palmer 2000

Palmer NA, Peeling R, Ireland RS, Martin MV. A study of therapeutic antibiotic prescribing in National Health Service general dental practice in England. *British Dental Journal* 2000;**188**(10):554–8.

Palmer 2012

Palmer NO, editor. *Antimicrobial Prescribing for General Dental Practitioners*. London: FGDP(UK), 2012.

Pau 2005

Pau A, Croucher R, Marcenes W, Leung T. Development and validation of a dental pain-screening questionnaire. *Pain* 2005;**119**(1-3):75–81.

Prescribing and Primary Care Services 2013

Prescribing and Primary Care Services, Health and Social Care Information Centre. Prescribing by dentists: England 2012. Health and Social Information Centre 2013.

Reisine 1995

Reisine S, Locker D. Social, psychological and economic impacts of oral conditions treatments. In: Cohen LK, Gift HC editor(s). *Disease Prevention and Oral Health Promotion: Social-Dental Sciences in Action*. Copenhagen: Munksgaard, 1995:33–71.

SDCEP 2011

Scottish Dental Clinical Effectiveness Programme. *Drug prescribing for dentistry: dental clinical guidance*. 2nd Edition. Dundee: Scottish Dental Clinical Effectiveness Programme, 2011.

Segura-Egea 2010

Segura-Egea JJ, Velasco-Ortega E, Torres-Lagares D, Velasco-Ponferrada MC, Monsalve-Guil L, Llamas-Carreras JM. Pattern of antibiotic prescription in the management

- of endodontic infections amongst Spanish oral surgeons. *International Endodontic Journal* 2010;**43**(4):342–50.
- Sindet-Pedersen 1985**
Sindet-Pedersen S, Petersen JK, Götzsche PC. Incidence of pain conditions in dental practice in a Danish county. *Community Dentistry and Oral Epidemiology* 1985;**13**(4):244–6.
- Skevington 1998**
Skevington SM. Investigating the relationship between pain and discomfort and quality of life, using the WHOQOL. *Pain* 1998;**76**(3):395–406.
- Steele 2011**
Steele J, Pitts N, Fuller E, Treasure E. 3: Urgent conditions - a report from the Adult Dental Health Survey 2009. The Health and Social Care Information Centre 2011.
- Sutherland 2003**
Sutherland S, Matthews DC. Emergency management of acute apical periodontitis in the permanent dentition: a systematic review of the literature. *Journal of the Canadian Dental Association* 2003;**69**(3):160.
- Sutherland 2004**
Sutherland SE, Matthews DC. Conducting systematic reviews and creating clinical practice guidelines in dentistry: lessons learned. *Journal of the American Dental Association* 2004;**135**(6):747–53.
- Torabinejad 1994**
Torabinejad M. Mediators of acute and chronic periradicular lesions. *Oral Surgery, Oral Medicine, and Oral Pathology* 1994;**78**(4):511–21.
- World Health Organization 2000**
World Health Organization. *World Health Organization Report on Infectious Diseases 2000: Overcoming Antimicrobial Resistance*. Geneva: World Health Organization, 2000.
- Yingling 2002**
Yingling NM, Byrne BE, Hartwell GR. Antibiotic use by members of the American Association of Endodontists in the year 2000: report of a national survey. *Journal of Endodontics* 2002;**28**(5):396–404.
- * Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Fouad 1996

Methods	RCT Number of centres: 1 (Department of Endodontics, University of Iowa, USA) Recruitment period: 3.5 years Design: parallel group 3-arm RCT
Participants	Adults presenting for emergency treatment Group 1 (penicillin) Mean age 34.92 years (SD 17.33 years). Gender: 4 women, 8 men (1 gender not recorded) . Mean baseline pain (SD): 2.40 (1.08). Mean baseline swelling (SD): 1.91 (1.51) Group 2 (placebo) Mean age 37.17 years (SD 9.40 years). Gender: 6 women, 7 men (2 gender not recorded) . Mean baseline pain (SD): 2.00 (1.10). Mean baseline swelling (SD): 2.00 (1.48) Included participants had a clinical diagnosis of acute apical abscess with pulpal necrosis with periapical pain or swelling, or both Participants were excluded if they had: elevated temperature (above 37.8 °C (100 °F) ; malaise; fascial space involvement; allergy to penicillin or cephalosporins; diseases or medications compromising the immune system; renal failure or any other significant renal or hepatic impairment; people who had taken antibiotics in the 2-week period prior to their visit; pregnant or lactating or taking oral contraceptives Number of participants at randomisation: group 1 = 13; group 2 = 15 Number of participants included in the analysis: group 1 = 10; group 2 = 11
Interventions	Endodontic treatment: all participants had the affected tooth treated by total or partial pulpectomy on day 0. This involved delivery of local anaesthesia, assessment of the tooth, determination of working length, partial/total cleaning and shaping of the canals with copious irrigation with 2.6% sodium hypochlorite. Canals were dried and calcium hydroxide paste applied and the access cavity temporised with Cavit TM (a light-cured temporary sealing compound for temporary restoration of cavities) or IRM® (intermediate restorative material is a polymer-reinforced zinc oxide-eugenol composition restorative material designed for intermediate restorations). Some participants also underwent incision and drainage of a localised intraoral swelling, if judged to be clinically indicated Participants were then assigned to a trial arm: Group 1: oral penicillin (phenoxymethyl) VK 500 mg, 1 g after endodontic treatment followed by 500 mg 6-hourly for 7 days Group 2: oral matched placebo taken according to the same regimen Group 3: neither medication group Analgesics: all participants received ibuprofen 600 mg immediately before treatment, 4 times daily for 24 hours and then as needed
Outcomes	Primary outcomes Participants were required to complete a post-treatment card recording their experiences up to 3 days postoperatively. This card was then returned to the authors via post. Pain was assessed using a VAS, which was then converted into a short ordinal numerical scale from 0 to 3: 0 indicated pain of no clinical significance; 1 = mild pain; 2 = moderate pain;

	<p>3 = severe pain. Postoperative swelling relief was recorded on a simple categorical scale ('no swelling', 'much less', 'slightly less', 'same', 'slightly more') with participants required to compare current levels of swelling to those they had experienced preoperatively. The categorical scale was then given scores from 0 to 4: 0 = no swelling; 1 = significant reduction in swelling; 2 = slight decrease in swelling; 3 = same size swelling as before; 4 = an increase in the size of swelling</p> <p>Incidence of flare-up: measured dichotomously and was clinician-assessed based on the presence of: no relief or an increase in the severity of pain; no resolution or an increase in the size of swelling, fever, trismus or difficulty swallowing; signs of a drug allergy or any other abnormal symptoms</p> <p>Secondary outcomes Incidence of participant-reported side effects; type and frequency of additional analgesic medication</p>	
Notes	<p>Funding source: not stated Sample size calculation: not stated</p>	
Risk of bias		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "A statistician provided random numbers" (email from author) Comment: the participants appeared to be equally distributed between the penicillin and placebo groups
Allocation concealment (selection bias)	Low risk	Author confirmed that there was no way for the individual(s) enrolling participants into the trial to know the upcoming allocation sequence; study envelopes were sequentially numbered, opaque and sealed; and study envelopes were only opened once the participant was enrolled onto the trial
Blinding of participants and personnel (performance bias) All outcomes	Low risk	Author confirmed that the placebo looked exactly the same as the penicillin tablets
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Participants recorded the outcome measures and were blinded to their group assignment
Incomplete outcome data (attrition bias) All outcomes	High risk	Following randomisation, there were 13 participants in the penicillin group and 15 in the placebo group. 3 participants in each group did not return their post-treatment card and were judged to have dropped out. A further 2 participants in the placebo

Fouad 1996 (Continued)

		<p>group were withdrawn (1 at 6 hours and 1 at 24 hours) after returning with symptoms necessitating further treatment. The missing data related to these 2 participants was likely to be related to treatment outcomes (levels of pain or swelling, or both). Attrition for both arms of the trial was in excess of 20%, and was higher in the placebo than the penicillin group</p> <p>Furthermore, following personal communication with trial authors, it was identified that there was incomplete baseline data (age, gender, baseline pain or swelling) for 5 study participants across the 2 trial arms. Since the numbers of participants recruited to each group were low, baseline characteristics of these 5 individuals may have led to differences between the penicillin and placebo groups</p>
Selective reporting (reporting bias)	Unclear risk	Primary outcome measures reported, 1 secondary outcome (additional analgesia) not reported
Other bias	Low risk	No other sources of bias identified

Henry 2001

Methods	<p>RCT</p> <p>Number of centres: 1 (The Ohio State University College of Dentistry, USA)</p> <p>Recruitment period: not stated</p> <p>Design: parallel group 3-arm RCT</p>
Participants	<p>Adults presenting for emergency treatment</p> <p>Group 1 (penicillin)</p> <p>Mean age 37 years (SD 16.5 years). Gender: 10 women, 9 men. Median baseline pain (SD): 2.00 (2.00). Median baseline percussion pain (SD): 2.00 (2.00). Median baseline swelling (SD): 1.00 (2.00)</p> <p>Group 2 (placebo)</p> <p>Mean age 38 years (SD 18.8 years). Gender: 10 women, 12 men. Median baseline pain (SD): 2.00 (1.00). Median baseline percussion pain (SD): 2.00 (2.00). Median baseline swelling (SD): 0 (1.00)</p> <p>Included participants had a symptomatic necrotic tooth and actively had spontaneous pain. To be eligible the affected tooth had to test negative to an electric pulp test (Analytic Technology Corp., Redmond, WA) and ice; have a periapical radiolucency and not have had previous endodontic treatment. Included participants were in good health (as determined by written and verbal history), had not received antibiotics in the 30 days prior to enrolment to the trial and did not have a probable or actively draining sinus</p>

Henry 2001 (Continued)

	tract Number of participants at randomisation: not stated in paper, approximately 51 (from personal communication) Number of participants included in the analysis: group 1 = 19; group 2 = 22	
Interventions	Endodontic treatment: all participants underwent total pulpectomy of the affected tooth on day 0. Canals were prepared using a step-back preparation and K-type files (L.D. Caulk, Inc., Milford, DE) and irrigated with 2.62% hypochlorite. Following instrumentation, canals were dried and a temporary restoration placed (Cavit TM (a light-cured temporary sealing compound for temporary restoration of cavities)) Participants were then assigned to a trial arm Group 1: oral penicillin (phenoxymethyl) VK 500 mg, 6-hourly for 7 days Group 2: oral matched placebo taken according to the same regimen Analgesics: all participants received a supply of ibuprofen and were advised to take 400 mg (2 x 200 mg tablets) every 4-6 hours, as required. Each participant also received a labelled bottle of paracetamol (acetaminophen) with codeine (30 mg), which they were instructed to take 1 or 2 tablets every 4 hours only if 2 ibuprofen tablets did not relieve their discomfort	
Outcomes	Primary outcomes Participant-reported pain, percussion pain and swelling experience at the baseline visit and upon rising for 7 days after treatment on categorical scales. Participants received a 7-day diary to record postoperative symptoms upon rising each day. This was returned at the obturation appointment (typically the end of root canal treatment). Pain was assessed using a short ordinal numerical scale from 0 to 3: 0 = no pain; 1 = mild pain; 2 = moderate pain; 3 = severe pain. Participants used the same scale to rate pain to percussion (achieve by tapping the affected tooth with a finger). Swelling was assessed on a similar ordinal numerical scale from 0 to 3: 0 = no swelling; 1 = mild swelling, a mild puffiness that was not bothersome; 2 = moderate swelling that caused facial distortion and was bothersome; 3 = a severe swelling that caused serious facial distortion and was very bothersome Secondary outcomes The number and type of pain medication taken	
Notes	Funding source: Graduate Endodontic Student Research Fund and Goldberg Memorial Fund, Graduate Endodontics, College of Dentistry, The Ohio State University Sample size calculation: not stated	
Risk of bias		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	
Allocation concealment (selection bias)	Low risk	
Blinding of participants and personnel (performance bias) All outcomes	Low risk	

Henry 2001 (Continued)

Blinding of outcome assessment (detection bias) All outcomes	Low risk	Primary outcome measures were participant-assessed and it was highly unlikely blinding was broken
Selective reporting (reporting bias)	Low risk	
Other bias	Low risk	

RCT: randomised controlled trial; SD: standard deviation; VAS: visual analogue scale.

Characteristics of excluded studies [ordered by study ID]

Study	Reason for exclusion
Achard 1967	Not an RCT
Al-Belasy 2003	No placebo control
Alves 2000	No placebo control
Angelini 1983	Not an RCT
Anonymous 1968	Not an RCT
Banoczy 1985	Not an RCT
Baratieri 1968	Not an RCT
Brabant 1968	Not an RCT
Brennan 2006	Not all participants met inclusion criteria for clinical diagnosis. No subgroup data presented
Citoler Gutierrez 1969	Not an RCT
Cumming 1984	Not an RCT
D'Atri 1973	Not an RCT
Davis 1969	Sample included children
De Vries 1974	Not an RCT
Deffez 1992	No placebo control

(Continued)

Diamantes-Kepiotes 1974	Intervention did not include a systemic antibiotic
Dolci 1982	Not an RCT
Flood 1977	Not an RCT
Gabka 1968	Not an RCT
Groshikov 1970	Not an RCT
Haapasalo 1986	Not an RCT
Hood 1978	Not an RCT
Hooley 1969	Not an RCT
Khosla 1970	Not an RCT
Krzywicki 1975	Not an RCT
Lewis 1986	No placebo control
Lin 2006	Intervention did not include a systemic antibiotic
Lindeboom 2005	Prevention study not fulfilling inclusion criteria
Lorber 1967	Not an RCT
Matijevic 2009	Sample included children
Nowakowska 1974	Not an RCT
Oeda 1985	No placebo control
Ranta 1988	Not all participants met inclusion criteria for clinical diagnosis. No subgroup data presented
Re 1988	No placebo control

RCT: randomised controlled trial.

DATA AND ANALYSES

Comparison 1. Pain

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Pain at 24 hours	2	61	Mean Difference (IV, Fixed, 95% CI)	-0.03 [-0.53, 0.47]
2 Pain at 48 hours	2	61	Mean Difference (IV, Fixed, 95% CI)	0.32 [-0.22, 0.86]
3 Pain at 72 hours	2	61	Mean Difference (IV, Fixed, 95% CI)	0.08 [-0.38, 0.54]
4 Pain at 7 days	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 2. Swelling

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Swelling at 24 hours	2	62	Std. Mean Difference (IV, Fixed, 95% CI)	0.27 [-0.23, 0.78]
2 Swelling at 48 hours	2	61	Std. Mean Difference (IV, Fixed, 95% CI)	0.04 [-0.47, 0.55]
3 Swelling at 72 hours	2	61	Std. Mean Difference (IV, Fixed, 95% CI)	0.02 [-0.49, 0.52]
4 Swelling at 7 days	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 3. Percussion pain

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Percussion pain at 24 hours	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Percussion pain at 48 hours	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
3 Percussion pain at 72 hours	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
4 Percussion pain at 7 days	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

Comparison 4. Endodontic flare-up

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Incidence of endodontic flare-up	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Comparison 5. Analgesics

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Total number of ibuprofen tablets	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected
2 Total number of paracetamol (acetaminophen) with codeine tablets	1		Mean Difference (IV, Fixed, 95% CI)	Totals not selected

ADDITIONAL TABLES

Table 1. Baseline characteristics for penicillin and placebo trial arms (Fouad 1996)

Trial arm	Penicillin (n = 13)	Placebo (n = 15)	P value
Gender	4W:8M*	6W:7M**	-
Mean age in years (SD)	34.92 (17.33)	37.17 (9.40)	0.696
Mean baseline pain (SD)	2.40 (1.08)	2.00 (1.10)	0.410
Mean baseline swelling (SD)	1.91 (1.51)	2.00 (1.48)	0.866

M: men; n: number in group; SD: standard deviation; W: women.

Unpublished data from personal communication.

* Gender of 1 participant not recorded.

** Gender of 2 participants not recorded.

Table 2. Baseline characteristics for penicillin and placebo trial arms (Henry 2001)

Variable	Penicillin (n = 19)	Placebo (n = 22)	P value
Age in years (SD)	37 (16.5)	38 (18.8)	0.884
Gender	10W:9M	10W:12M	0.647
Weight in pounds (SD)	172 (28.4)	170 (41.3)	0.874
Estimated lesion area in mm (SD)	14.0 (16.5)	24.8 (22.6)	0.105
Median baseline pain (SD)	2.00 (2.00)	2.00 (1.00)	0.463
Median baseline percussion pain (SD)	2.00 (2.00)	2.00 (2.00)	0.868

Systemic antibiotics for symptomatic apical periodontitis and acute apical abscess in adults (Review)
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30

Table 2. Baseline characteristics for penicillin and placebo trial arms (Henry 2001) (Continued)

Median baseline swelling (SD)	1.00 (2.00)	0 (1.00)	0.097
-------------------------------	-------------	----------	-------

M: men; n: number in group; SD: standard deviation; W: women.

CONTRIBUTIONS OF AUTHORS

- Anwen Cope initiated the review, drafted the protocol, extracted the data, performed risk of bias assessment and wrote the final review.
- Nick Francis and Fiona Wood initiated the review, made amendments to the protocol and were involved in writing the final review.
- Ivor Chestnutt initiated the review, made amendments to the protocol, was the arbiter during study selection and data extraction, and was involved in writing the final review.
- Mala Mann drafted the protocol, extracted the data, performed risk of bias assessment and was involved in writing the final review.

DECLARATIONS OF INTEREST

Anwen Cope, Nick Francis, Fiona Wood, Mala Mann, Ivor Chestnutt: no interests to declare.

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Internal sources

- No sources of support supplied

External sources

- Wales School for Primary Care Research, UK.

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- Cochrane Oral Health Group Global Alliance, UK.

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Disclaimer:

The views and opinions expressed therein are those of the authors and do not necessarily reflect those of the NIHR, NHS or the Department of Health.

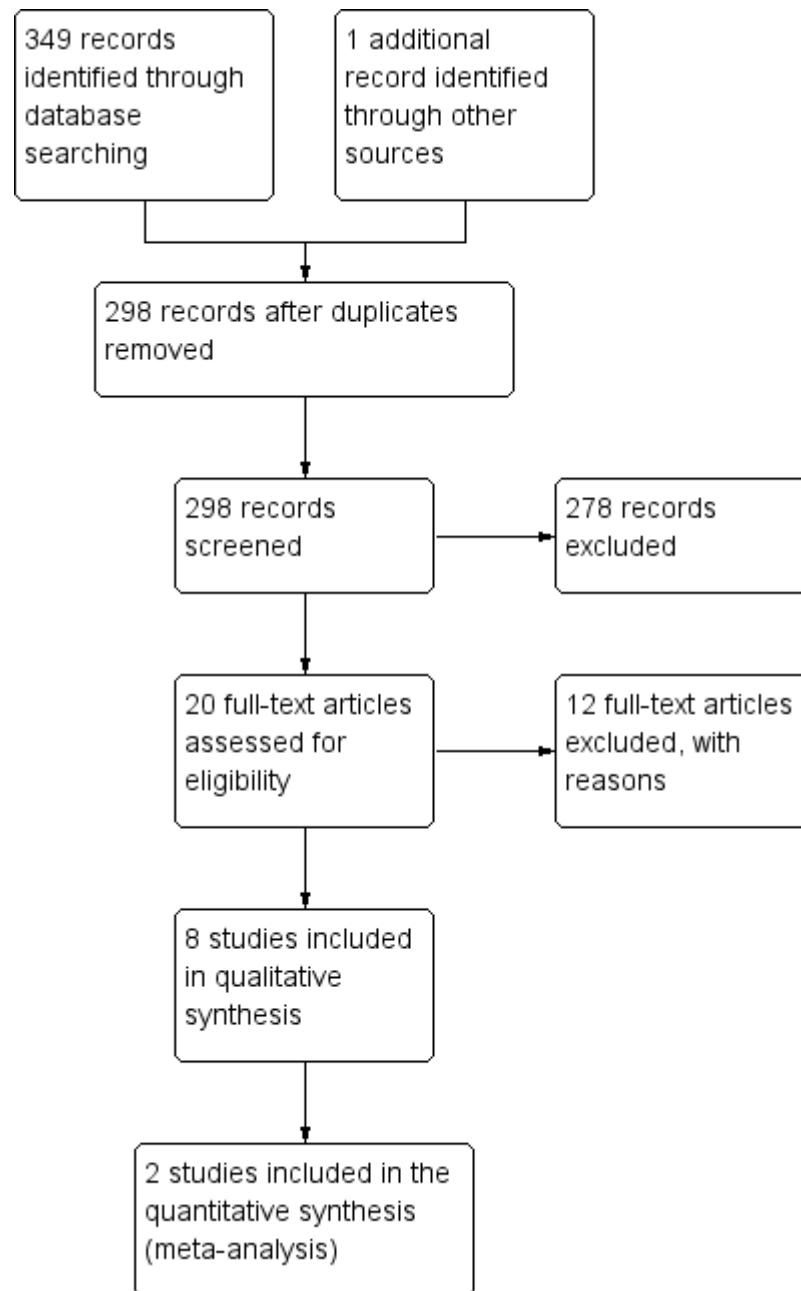
DIFFERENCES BETWEEN PROTOCOL AND REVIEW

- We have made a minor alteration to the objectives to specify the difference between antibiotics provided with a surgical intervention and those without.
- We used a fixed-effect model in the meta-analysis not a random-effects model as specified by the protocol. This was because fewer trials were suitable for inclusion than we initially anticipated.

Appendix II – Search strategy 1, chapter 1

1. exp Antibiotics/
2. exp Penicillins/
3. (antibiotic\$ or anti-biotic\$ or anti biotic\$).tw.
4. (antibacterial\$ or anti-bacterial\$ or anti bacterial\$).tw.
5. (penicillin\$ or amox?cillin\$ or erythromycin\$ or metronidazole\$ or clindamycin\$).tw.
6. or/1-5
7. exp Periapical diseases/
8. exp Pulpitis/
9. exp Dental abscess/
10. exp Apical periodontitis/
11. exp Periodontal abscess/
12. exp Pericoronitis/
13. pulpitis.tw.
14. (periapical periodontitis or apical periodontitis).tw.
15. (periapical abscess or dentoalveolar abscess or apical abscess or dental abscess).tw.
16. periodontal abscess.tw.
17. pericoronitis.tw.
18. dental pain.tw.
19. or/7-18
20. randomi?ed controlled trial.pt.
21. controlled clinical trial.pt.
22. randomi?ed.tw.
23. trial.ab.
24. or/20-23
25. 6 and 19 and 24

Appendix III – Study flow diagram 1, chapter 1



Appendix IV – Characteristics of excluded studies table, chapter 1

Reference	Study Design	Participants	Diagnosis	Intervention	Outcomes	Reason for exclusion
(Abbott et al. 1988)	Randomised prospective clinical trial in an endodontic department of a university dental hospital in the USA.	195 adults (91 M, 104 F), mean age 31.7 years.	Asymptomatic teeth with pulpal necrosis (negative to electric pulp testing) with an associated periapical radiolucency lesion. <i>Asymptomatic apical periodontitis</i> .	Active 1 (n=65) - Pen V 2g pre-op then 1g 6 hours later. Active 2 (n=65) – erythromycin stearate 1g pre-op then 500mg 6 hours later and analgesia. Active 3 (n=65) – erythromycin base 1g pre-op then 500mg 6 hours later and analgesia. Control – placebo group of another study used.	1° - patient-reported measures of pain, and swelling. 2° - patient reported measures of hypersensitivity reactions and side-effects. Measured at 24 hours and 1 week.	Control group did not meet inclusion criteria
(Brennan et al. 2006)	Randomised double-blind placebo controlled clinical trial in the emergency department of an urban teaching hospital in the USA.	195 adults enrolled, data available for 134 (69%).	Dental pain without signs of overt dental infection (fever, swelling, purulence or trismus). Characterised as <i>irreversible pulpitis, abscess, advanced periodontal disease or 'unknown'</i> (41 patients)	Active (n=64) – penicillin 500mg QDS 7/7 plus analgesia. Control (n=70) – placebo QDS 7/7 plus analgesia.	1° - signs of overt dental infection (fever, extraoral swelling, intraoral swelling, purulence or trismus). 2° - incidence of pain, compliance to medication regime and adverse effects	Same trial as reported by Runyon (2006). Not primary study publication.

Reference	Study Design	Participants	Diagnosis	Intervention	Outcomes	Reason for exclusion
(Davis and Balcom 1969)	Randomised double-blind clinical trial in an outpatient dental clinic in the USA.	58 patients (M 30, F 28). Age range 10-59.	<i>Acute apical abscess</i>	Active 1 (n=30) – linomycin 600mg IM for 2/7 and 500mg PO QDS. Active 2 (n=28) – pen G 600000 units IM for 2/7 and 250000 unit pen G PO QDS. No control/placebo group.	1° - clinician-reported measures of swelling, induration, fluctuation, drainage, pain and temperature. 2° - incidence of side effects.	Control group did not meet inclusion criteria
(Evcil et al. 2006)	Randomised controlled trial conducted in a university dental hospital in Turkey.	30 adult patients.	<i>Irreversible pulpitis</i> with spontaneous moderate-to-severe pain.	All patients underwent total pulpectomy. Active (n=15) - 50mg of diclofenac potassium, 500mg of amoxicillin trihydrate and 250mg ornidazol combination. Control (n=15) – no placebo, just endodontic treatment.	1° - patient-reported pain at 6hrs and 1 week.	Antibiotic given in a mixture with other medicines – unable to evaluate effect of antibiotic alone.
(Haapasalo et al. 1986)	Randomised control trial in an endodontic department of a Finnish university dental hospital.	57 adults, mean age M 36, F 42.	<i>Apical periodontitis</i> (only 56% symptomatic)	All patients underwent total pulpectomy. Active (42) – Pen V 650mg TDS 7/7. Control (13) – no placebo, only pulpectomy.	1° - clinician- interpreted measures of pain, swelling and clinician-reported presence open sinus tract and tenderness to percussion at 1 week.	Participants did not meet inclusion criteria

Reference	Study Design	Participants	Diagnosis	Intervention	Outcomes	Reason for exclusion
(Mata et al. 1985)	Prospective double-blind clinical trial at a university dental hospital in the USA.	100 adults	Necrotic pulp (confirmed by thermal and EPT) and asymptomatic association periapical radiolucencies. <i>Asymptomatic apical periodontitis.</i>	All patients underwent total pulpectomy. Active (n=50) – penicillin V 4x500mg doses then 250mg QDS ‘until all tablets were taken’. Control (n=50) – placebo QDS.	1° - patient-reported measures of pain at intervals up to 48 hrs. 2° - incidence of ‘flare-up’.	Participants were not randomly assigned to an experimental group and participants did not meet inclusion criteria
(Morse et al. 1987)	Prospective clinical trial in a dental health centre in the USA.	315 participants (M 146, F 169). Mean age 34.2 years, age range 12-74.	Asymptomatic teeth with necrotic pulps (confirmed with an EPT) and associated periapical lesions (confirmed by radiograph). <i>Asymptomatic apical periodontitis.</i>	Standard endodontic therapy. Active 1 (n=105) - Pen V 2g pre-op then 1g 6 hours later. Active 2 (n=105) – erythromycin stearate 1g pre-op then 500mg 6 hours later and analgesia. Active 3 (n=105) – erythromycin base 1g pre-op then 500mg 6 hours later and analgesia. Control – results compared to that of another study.	1° - incidence of ‘flare-up’ at 1 day, 1 week and 1 month. 2° - patient reported measures of pain; incidence of side effects or hypersensitivity reactions.	Participants did not meet inclusion criteria

Reference	Study Design	Participants	Diagnosis	Intervention	Outcomes	Reason for exclusion
(Morse et al. 1988)	Prospective clinical trial in a dental health centre in the USA.	200 participants (M 101, F 99). Mean age 34.2 years, age range 10-78.	Asymptomatic teeth with necrotic pulps (confirmed with an EPT) and associated periapical lesions (confirmed by radiograph). <i>Asymptomatic apical periodontitis.</i>	Orthograde endodontic therapy. Active 1 (n=100) – cefadroxil 1g pre-op and placebo tablet 6 hours later and analgesia. Active 2 (n=50) – erythromycin stearate 1g pre-op then 500mg 6 hours later and analgesia. Active 3 (n=50) – erythromycin base 1g pre-op then 500mg 6 hours later and analgesia. Control – results compared to that of another study.	1° - incidence of 'flare-up' at 1 day, 1 week and 1 month. 2° - patient reported measures of pain; incidence of side effects or hypersensitivity reactions.	Participants did not meet inclusion criteria
(Pickenpaugh et al. 2001)	Randomised double-blind placebo controlled clinical trial in a university dental hospital in the USA.	70 adults	<i>Asymptomatic apical periodontitis or chronic apical abscess.</i> Tooth (negative response to EPT and ice) with associated periapical radiolucency of at least 3mm x 3mm. Some patients had a sinus tract.	Active (n=34) – pre-op 3g penicillin. Total pulpectomy. Analgesics. Control (n=36) – pre-op 3g placebo. Total pulpectomy. Analgesics.	1° - incidence of 'flare-up' 2° - patient-reported pain, percussion pain, swelling and number/type of analgesics used.	Participants did not meet inclusion criteria

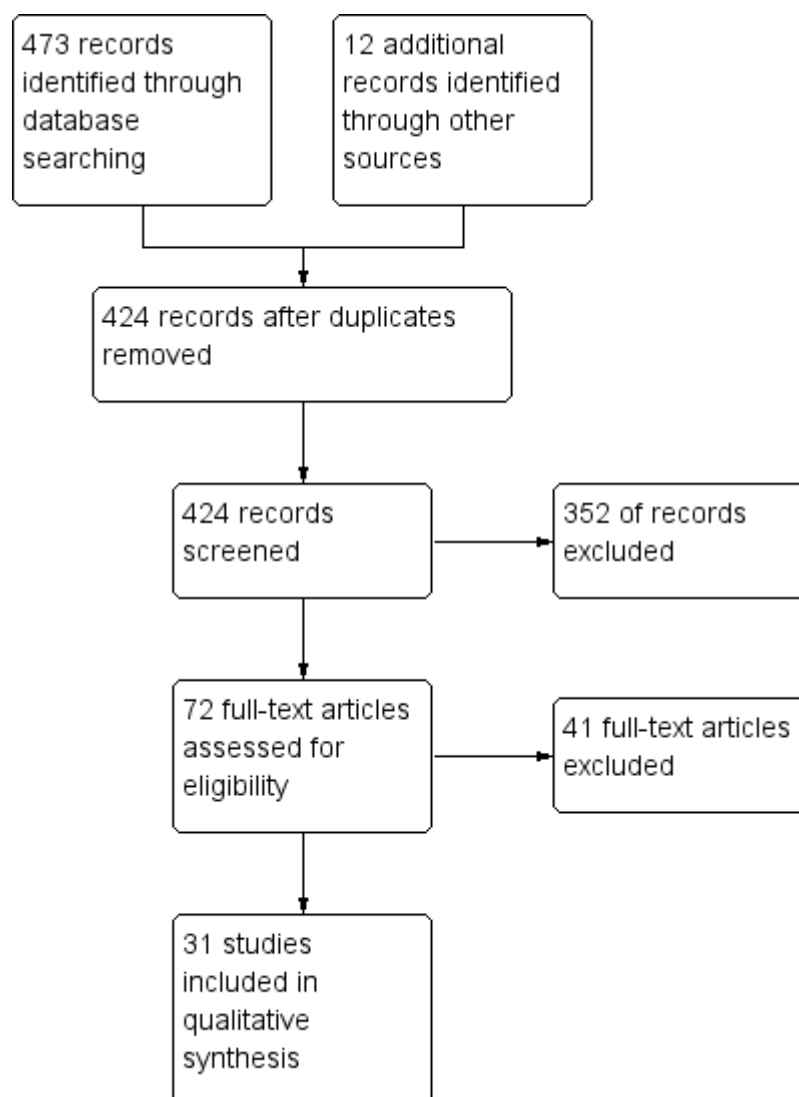
Reference	Study Design	Participants	Diagnosis	Intervention	Outcomes	Reason for exclusion
(Torabinejad et al. 1994a)	Prospective double blind placebo-controlled clinical trial conducted in private practice and university dental hospitals in the USA.	588 adults (282 M, 306 F) age range < 21 to > 79.	<p>Pulpal diagnosis:</p> <p>Normal (6%), irreversible pulpitis (50%), necrotic pulp (34%), pulpless (11%).</p> <p>Periapical diagnosis:</p> <p>Normal (36%), symptomatic apical periodontitis (30%), asymptomatic apical periodontitis (29%), acute apical abscess (AAA) (6%).</p>	<p>All participants received total pulpectomy.</p> <p>Active 1 (n=57) - pen 500mg QDS 3/7 Active 2 (46) - erythromycin 500mg QDS 3/7.</p> <p>Control (n=53) – placebo QDS 3/7.</p> <p>Other Active Groups included salicylic acid, acetaminophen, ibuprofen, ketoprofen, acetaminophen + codeine, penicillin + ibuprofen and prednisolone + penicillin.</p>	<p>1° - patient-reported pain for 3/7.</p> <p>2° - frequency and incidence of side effects.</p>	Participants did not meet inclusion criteria
(Torabinejad et al. 1994b)	Prospective double blind placebo-controlled clinical trial conducted in private practice and university dental hospitals in the USA.	411 adults.	All patients underwent total pulpectomy 1-2 weeks previously. Prior to this their diagnoses had ranged between normal pulpal health and AAA.	<p>Active 1 (n=46) – penicillin 500mg QDS 3/7.</p> <p>Active 2 (n=33) – erythromycin 500mg QDS 3/7.</p> <p>Control (n=41) – placebo QDS 3/7.</p> <p>Other Active Groups - salicylic acid, acetaminophen, ibuprofen, ketoprofen, acetaminophen + codeine, penicillin + ibuprofen and prednisolone + penicillin.</p>	<p>1° - patient-reported pain for 3/7.</p> <p>2° - frequency and incidence of side effects.</p>	Participants did not meet inclusion criteria

Reference	Study Design	Participants	Diagnosis	Intervention	Outcomes	Reason for exclusion
(Walton and Chiappinelli 1993)	Randomised double-blind clinical trial in a university dental hospital in the USA.	80 adult patients (M 48, F 32). Age range 17-78 years.	<i>Asymptomatic apical periodontitis.</i>	All patients underwent total pulpectomy. Active (n=26) – 2g of penicillin at beginning of appointment and 1g 6hrs after. Control (n=24) – inert placebo by same regime. Other (n=30) – no medication.	1° - patient-reported measures of pain at intervals up to 48 hrs. 2° - patient- reported swelling and reports of side effects.	Participants did not meet inclusion criteria

Appendix V – Search strategy 2, chapter 1

1. exp Antibiotics /
2. exp Penicillins/
3. (antibiotic\$ or anti-biotic\$).tw.
4. anti-bacterial-agent\$.tw.
5. antibacterial agent\$.tw.
6. (antibacterial\$ or anti-bacterial\$).tw.
7. (penicillin\$ or amox?cillin\$ or erythromycin\$ or metronidazole\$ or clindamycin\$).tw.
8. exp Dental Care/
9. exp Dentistry, Operative/
10. exp Oral Surgical Procedures/
11. exp Endodontics/
12. exp Pathology, Oral/
13. exp Toothache/
14. exp Periapical Abscess/
15. exp Periodontal Abscess/
16. exp Tooth Injuries/
17. exp Periapical Diseases/
18. exp Focal Infection, Dental/
19. dent\$.tw.
20. (tooth or teeth).tw.
21. (apical or periapical).tw.
22. exp General Practice, Dental/
23. exp Community Dentistry/
24. exp Occupational Dentistry/
25. exp School Dentistry/
26. (emerg\$ adj5 dent\$).tw.
27. general dent\$.tw.
28. exp Primary health care/
29. exp Family practice/
30. exp General practitioners/
31. general practice.tw.
32. primary care.tw.
33. GP practice.tw.
34. family physician.tw.
35. exp Great Britain/
36. Great Britain.tw.
37. (Britain or British).tw.
38. United Kingdom.tw.
39. (England or English).tw.
40. (Wales or Welsh).tw.
41. (Scotland or Scottish).tw.
42. (Northern Ireland or Northern Irish).tw.
43. exp Inappropriate prescribing/
44. exp Physician's Practice Patterns/
45. exp Decision Making/
46. prescribing decision\$.tw.
47. exp Dentist's Practice Patterns/
48. or/1-7
49. or/8-21
50. or/22-34
51. or/35-47
52. and/48-51

Appendix VI – Study flow diagram 2, chapter 1



Included studies

- 1 randomised controlled trial of academic detailing and its effect on antibiotic prescribing amongst GPs in South Wales (Seager et al. 2006)
- 17 observational studies: (Lewis et al. 1989, Thomas et al. 1996, Palmer and Martin 1998, Anderson et al. 2000, Jaunay et al. 2000, Palmer et al. 2000a, 2000b, Roy and Bagg 2000, Dailey and Martin 2001, Palmer et al. 2001b, Salako et al. 2004, Al-Haruni and Skaug 2006, Murti and Morse 2007, Tulip and Palmer 2008, Skucaite et al. 2010, Kudiyirickal and Hollinshead 2011, Al-Huwayrini et al. 2013)
- 4 clinical audits (Muthukrishnan et al. 1996, Steed and Gibson 1997, Palmer et al. 2001a, Palmer and Batchelor 2004, Chate et al. 2006)
- 7 government-funded reports (Health and Social Care Information Centre 2008, 2009, 2010, 2011, 2012, 2013, 2014, Holyfield and Karki 2009)

Appendix VII – Observational study invitation letter, chapter 2



ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

[Date]

Dear Dr [insert practitioner name]

I am practicing GDP currently completing a PhD at Cardiff University and would like to invite you to take part in a research study. Participation requires a small amount of your clinical time for which you will be financially compensated.

The study seeks to understand the different ways dentists working in general practice in Wales manage patients with pulpal and periapical pathologies. I hope to gather information about:

- the signs and symptoms patients with these conditions present with
- the types of treatment they receive, both surgical and pharmacological

If you agree to participate in the study you will be asked to record brief information about the clinical presentation and management of the next 15 patients you see with pulpal or periapical pathologies. We will send you specially-designed forms to fill this information in on. This information may be no more comprehensive than you may write in your clinical notes and should not take you more than 5 minutes per patient. After you have recorded the information you will return the data collection booklets and brief questionnaire in the prepaid envelopes which will be provided. **You will be paid £10 for every record form you complete, £150 for all 15.** All information/data will be anonymised and unidentifiable.

After we have received back the data collection booklets we will be conducting some short telephone interviews to understand the influences on certain aspects of patient management. Participation in an interview is entirely voluntary and you will not be penalised should you not wish to take part in this aspect of the study. You will receive £60 if you choose to take part.

If you are interested in finding out more information about either part of the proposed study, please complete the contact details on the next page and return in the prepaid envelope provided.

Thank you for your time,

Miss Anwen Cope, BDS
Institute of Primary Care and Public Health
Tel: (029) 20687157
Email: copea1@cardiff.ac.uk

Phase One GDP Information
Sponsor Ref: SPON-1109/12

Appendix VIII - Observational study participant information sheet, chapter 2



Phase One Information for GDFs

Sponsor Ref: SPON1109-12

ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

PhD Student and Contact Researcher: Miss Anwen Cope, BDS
Institute of Primary Care and Public Health, Cardiff University

We would like to invite you to take part in a research study. The information on this sheet is designed to help you decide if you would like to take part. Please take your time to consider whether or not you would like to take part. Please ask us if anything is unclear or you would like more information.

What is the purpose of the study?

This study aims to comprehensively describe the management of adult patients with pulpitis, periapical periodontitis and dental abscesses by practitioners providing general dental care. We hope to gather information about the signs and symptoms patients with these conditions present to their dentist with and the types of treatment these patients receive, both surgical and pharmacological.

Why have I been invited to take part?

We are approaching general dental practitioners working in Wales. We are inviting clinicians working in both urban and rural settings. You have been selected because we believe that you are a fully qualified general dental practitioner working in a practice in Wales.

Do I have to take part?

No. Participation is entirely voluntary.

What happens if I decided not to take part?

You are completely free to decline participation. You will not be penalised in any way.

What will happen if I decide to take part?

We will send you further information about the study, forms to collect the patient information on and a brief demographic questionnaire.

We will then ask you to record basic anonymous clinical information about patients that present to you with either pulpitis, apical periodontitis or a dental abscess. We will ask you to record the brief information about the clinical presentation and management of the next 15 patients you see with pulpitis, apical periodontitis or a dental abscess. This information will be no more comprehensive than you may write in your clinical notes and should take you no more than 5 minutes per patient.

After you have recorded the information for 15 patients you will return the data collection booklet and demographic questionnaire in the prepaid envelope provided.

What happens next?

If you are interested in taking part please complete the enclosed 'Contact Details' form and return it in the pre-paid envelope provided. A member of the study team will then send you all the documents you require to begin collecting your data. If you have any questions prior

to participation please contact a member of the study team using the telephone and or email contacts provided below.

What are the disadvantages of taking part?

The only real disadvantage is that we are asking you to give up five minutes of your time to record the clinical information for each patient. For 15 patients this will amount to a maximum of 1 hour 15 minutes although you should be aware that this will be spread over a few weeks.

What are the possible benefits of taking part?

It is intended that this study will inform daily dental practice and benefit both dental patients and the wider public. **In compensation for your time we will pay each dentist £10 per patient record they complete, £150 for all 15 patients.**

What if there is a problem?

We do not anticipate any problems. However, if you are unhappy with any element of this research study please tell a member of the research team and we will try to remedy any problems. If you are still unhappy you can make a formal complaint to the chief investigator (details at the end of this information sheet).

Will the information I provide be kept confidential?

Yes. All information about you, your patients and your clinical practice will be kept confidential. Any data that identifies you (your name and contact details for example) will be kept on a secure server and / or in a locked cupboard. All study data will be kept for a period of 15 years.

What will happen to the results of the research study?

Results of the study be submitted to scientific journals for publication, may be presented at scientific meetings or conferences, and will form the basis of a report to the funders of the study.

Who is organising and funding the study?

The study has been funded by Cardiff University under its Presidential PhD Studentship scheme and by the Wales School of Primary Care Research. It is being led by researchers at the Cochrane Institute of Primary Care and Public Health. This study forms part of the PhD thesis of Anwen Cope, a dentist undertaking postgraduate research in Cardiff University.

Who has reviewed the study?

The study has been reviewed and given a favourable ethical opinion by the London Central Proportionate Review Committee.

Contact for further information

If you would like any further information about the study or have any questions, please contact the following:

Miss Anwen Cope <i>PhD Student</i>	Dr Nick Francis (Chief Investigator) <i>Senior Clinical Research Fellow</i>
Institute of Primary Care and Public Health Neuadd Meirionnydd Heath Park CF14 4XN	Institute of Primary Care and Public Health Neuadd Meirionnydd Heath Park CF14 4XN
Copea1@cardiff.ac.uk +44 (0)29 20687157	Francisna@cardiff.ac.uk +44 (0)29 20687133

Appendix IX - Observational study participant consent form, chapter 2

Phase One Consent Form for GDMs

CONFIDENTIAL

Sponsor Ref: SPON1109-12



PARTICIPANT ID NUMBER:

ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

PhD Student and Contact Researcher: Miss Anwen Cope, BDS
Cochrane Institute of Primary Care and Public Health, Cardiff University

If you are interested in taking part in this study and are willing to be contacted after you have had time to read the study information please complete this form and return to the researcher in the envelope provided.

Please provide your contact details below:

Full Name _____

Practice Address _____

Practice Postcode _____

Practice tel. no _____

*Please
Initial*

I confirm that I have received the 'Information for GDMs' sheet (version 0.1 dated 12/04/2012) for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

I agree to participate in the above study

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.

I agree that information about my clinical practice will be recorded. I understand that the information will be treated as confidential. I give permission for the anonymised data to be used in any research publications that result from the study.

Print Name
(Clinician)

Date

Signature

Print Name
(Researcher)

Date

Signature

If you require any further information, please contact:

Miss Anwen Cope
Cochrane Institute of Primary Care & Public Health
Tel: +44 (0)29 20687157

Appendix X - Observational study case report form, chapter 2

Practitioner ID



ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

Thank you for agreeing to take part in the APICAL study.

On the following forms we would like you to complete details about the **next 15 patients** that present to you any of the following pulpal, periapical or periodontal conditions:

- Reversible pulpitis
- Irreversible pulpitis
- Acute apical periodontitis
- Chronic apical periodontitis (aka apical granuloma)
- Acute apical abscess (with or without systemic involvement)
- Chronic apical abscess
- Cystic lesion (such as a radicular cyst, periodontal cyst etc)
- Periodontal abscess
- Combined perio-endo lesion
- Pericoronitis

Please complete one form per patient. It does not matter if you have seen this patient previously with the same problem—just complete the form describing the symptoms present and what treatment you provided **today**.

Number boxes should be completed as shown below.

Eg.

Duration of Symptoms in Days (including today)	<input type="text" value="0"/> <input type="text" value="0"/> <input type="text" value="8"/>
---	--

Check boxes should be completed with a cross, as shown.

Eg.

Frequency (number of times per day)	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input checked="" type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/>
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If you have any queries or require further study materials please contact:

Miss Anwen Cope

Telephone **029 2068 7157**
e-mail **copea1@cardiff.ac.uk**

Version 0.4 Sponsor Ref: SPON1109-12 12.04.2012

INCLUSION CRITERIA

Patient Number of 15

Both answers must be **YES** for patient to be eligible.

1. Is the patient 18 years or older today? Y N
2. Does the patient have at least one tooth with one of the pulpal, periapical or periodontal conditions listed previously? Y N

SECTION 1 — CLINICAL HISTORY

Age in years

Gender (m=male; f=female) M F

Duration of symptoms (in days)

Symptomatic tooth (e.g. LL7, UL4)

How did the patient pay for their treatment? (N=NHS; P=private (inc. Denplan, DPAS etc)) N P

SECTION 2 — SIGNS AND SYMPTOMS

Please mark all signs and symptoms the patient has **today** with an 'X'. **Mark all that apply**

- | | | | |
|--------------------------|--------------------------|-----------------------|--------------------------|
| Pain | <input type="checkbox"/> | Limited mouth opening | <input type="checkbox"/> |
| Localised swelling | <input type="checkbox"/> | Raised floor of mouth | <input type="checkbox"/> |
| Diffuse swelling | <input type="checkbox"/> | Difficulty swallowing | <input type="checkbox"/> |
| Cellulitis | <input type="checkbox"/> | Mucosal ulceration | <input type="checkbox"/> |
| Lymphadenopathy | <input type="checkbox"/> | Elevated temperature | <input type="checkbox"/> |
| Purulent discharge (pus) | <input type="checkbox"/> | Draining sinus tract | <input type="checkbox"/> |

SECTION 3 — DIAGNOSIS

Please mark the most likely diagnosis with an 'X'. **Pick only one**

- Reversible pulpitis
- Irreversible pulpitis
- Acute apical periodontitis
- Chronic apical periodontitis
- Acute apical abscess with no systemic involvement
- Acute apical abscess with systemic involvement
- Chronic apical abscess
- Cystic lesion
- Periodontal abscess
- Combined perio-endo lesion
- Pericoronitis

SECTION 4—TREATMENT

Please mark any treatment provided **today**. Place an 'X' in all that apply

Advice	<input type="checkbox"/>
Antibiotic prescription	<input type="checkbox"/>
Analgesic prescription	<input type="checkbox"/>
Incision and drainage	<input type="checkbox"/>
Subgingival debridement	<input type="checkbox"/>
Extraction	<input type="checkbox"/>
Temporary/permanent restoration with pulp treatment	<input type="checkbox"/>
Temporary/permanent restoration without pulp treatment	<input type="checkbox"/>
Pulp treatment without restoration	<input type="checkbox"/>

SECTION 5—ANTIBIOTIC PRESCRIPTION

Please only complete this section if a systemic antibiotic was prescribed.

Antibiotic	Amoxicillin	<input type="checkbox"/>	Clindamycin	<input type="checkbox"/>	Co-amoxiclav	<input type="checkbox"/>	Other	<input type="checkbox"/>
	Erythromycin	<input type="checkbox"/>	Metronidazole	<input type="checkbox"/>	Penicillin V	<input type="checkbox"/>		

Dose mg

Frequency (number of times per day) 1 2 3 4

Duration of Course (in days)

How did you advise the patient to take the antibiotics? Please place an 'X' in one box

For immediate use	<input type="checkbox"/>
Delayed use—to take if symptoms worsen	<input type="checkbox"/>
Delayed use—to take if treatment does not relieve symptoms	<input type="checkbox"/>
Prophylactically, against infective endocarditis	<input type="checkbox"/>

As far as you know, has the patient taken systemic antibiotics (for any reason) within the 4 weeks? Y N

SECTION 6—NON-CLINICAL FACTORS INFLUENCING TREATMENT

Please mark any factors that influenced your treatment **today**. Place an 'X' in all that apply.

Patient declined operative treatment	<input type="checkbox"/>
Patient unable to tolerate operative treatment	<input type="checkbox"/>
Previous operative treatment failed	<input type="checkbox"/>
Insufficient time to perform operative treatment	<input type="checkbox"/>
Unable to achieve adequate local anaesthesia	<input type="checkbox"/>
Patient requested antibiotics	<input type="checkbox"/>

Thank you for co-operation

Appendix XI - Observational study practitioner demographic questionnaire, chapter 2

Practitioner Demographic Survey

Practitioner ID

A LITTLE ABOUT YOU...

1. What is your gender?

Male

Female

2. What year did you first qualify as a dentist?

3. Where did you first qualify as a dentist?

(EEA— European Economic Area)

UK

EEA (non UK)

Non-EEA

3. Do you have any dental postgraduate qualifications?

(e.g. MFDS, MJDF, MFS, MFGDP, MSc, MClinDent, Postgraduate Diploma)

Yes

No

4. How many sessions of general dental care (either NHS or private) do you provide in the average week? (1 session = 1 morning OR afternoon)

5. Approximately what percentage of your clinical time is currently spent completing NHS and private work?

NHS %

Private %

6. Are you taking part in the 1000 Lives Plus Antibiotic Prescribing Audit?

Yes, already completed

Yes, currently completing

No

And finally...

Would you be interested in receiving a summary of the results of the APICAL study in the future?

Yes

No

If you have any queries, require further materials or prepaid envelopes please contact

Miss Anwen Cope

Telephone 029 2068 7157
e-mail copea1@cardiff.ac.uk

Version 0.1 Sponsor Ref: SPON1109-12 12.04.2012

Appendix XII - Proportionate Review Committee letter, chapter 2



Health Research Authority

NRES Committee London - Central

Skipton House
80 London Road
London
SE1 6LH

Telephone: 020 7972 2555

Facsimile:

25 July 2012

Dr Nick Francis
Senior Clinical Research Fellow
Cochrane Institute of Primary Care and Public Health, Cardiff University
5th Floor, Neuadd Meirionnydd
Heath Park, Cardiff
CF14 4YS

Dear Dr Francis

Study title: Antibiotic and Primary Care Dental Problems (APICAL) -
A description of the management of pulpal and apical
pathologies in primary care, use of antibiotics and the
influences on antibiotic prescribing in relation to these
conditions.
REC reference: 12/LO/1213
Protocol number: SPON1109-12

The Proportionate Review Sub-committee of the NRES Committee London - Central reviewed the above application on 11 July 2012.

Ethical opinion

On behalf of the Committee, the sub-committee gave a favourable ethical opinion of the above research on the basis described in the application form, protocol and supporting documentation, subject to the conditions specified below.

Ethical review of research sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at <http://www.rforum.nhs.uk>.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations.

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

You should notify the REC in writing once all conditions have been met (except for site approvals from host organisations) and provide copies of any revised documentation with updated version numbers. Confirmation should also be provided to host organisations together with relevant documentation.

Approved documents

The documents reviewed and approved were:

Document	Version	Date
Covering Letter		04 July 2012
Evidence of insurance or indemnity		06 July 2012
GP/Consultant Information Sheets	2	21 June 2012
Investigator CV		04 July 2012
Letter from Sponsor		04 May 2012
Other: Phase 1 GDP invitation	2	21 June 2012
Other: Phase 1 case report form	4	12 April 2012
Other: Phase 1 practitioner demographic survey	1	12 April 2012
Other: WSPCR Funding		20 March 2012
Other: Phase 2 & 3 interview topic guides	1	20 June 2012
Other: Phase 3 GMP participant invitation	2	21 June 2012
Other: CV for Ivor Chestnutt		
Other: CV for Dr Fiona Wood		
Other: CV for Miss A Cope		20 June 2012
Participant Consent Form: Phase 3	1	12 April 2012
Participant Consent Form: Phase 1	1	12 April 2012
Participant Information Sheet: Phase 1 - participant information	1	12 April 2012
Participant Information Sheet: Phase 3 participant information	1	12 April 2012
Participant Information Sheet: Phase 2 participant information	1	12 April 2012
Participant Information Sheet: Phase 2 consent form	1	12 April 2012
Protocol	5	20 June 2012
REC application		04 July 2012

Membership of the Proportionate Review Sub-Committee

The members of the Sub-Committee who took part in the review are listed on the attached sheet.

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

Further information is available at National Research Ethics Service website > After Review

12/LO/1213	Please quote this number on all correspondence
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With the Committee's best wishes for the success of this project

Yours sincerely

PP

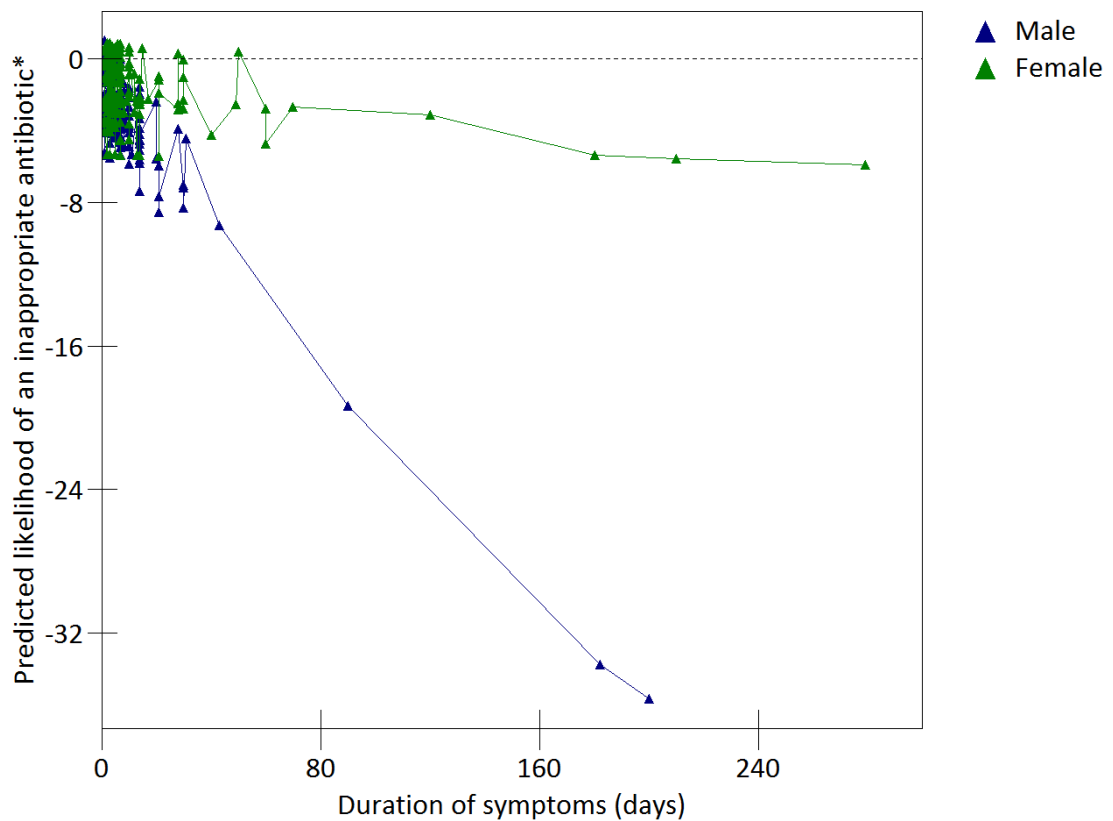


**Dr John Keen
Chair**

Email: Juliekidd@nhs.net

Enclosures: List of names and professions of members who took part in the review

Appendix XIII - Graph showing effect of reported duration of symptoms on the predicted likelihood of a patient receiving an inappropriate antibiotic and the differences in this effect by gender, chapter 4



Graph showing effect of reported duration of symptoms on the predicted likelihood of a patient receiving an inappropriate antibiotic and the differences in this effect by gender. *as determined by guidelines published by the Scottish Dental Clinical Effectiveness Programme and the Faculty of General Dental Practice(UK).

Appendix XIV - Dental Read Codes for cohort (CPRD) study, chapter 4

Code	Definition
191..00	Tooth symptoms
191..11	Dental symptoms
191..12	Teeth symptoms
1912.00	Toothache
1913.00	Bad teeth / caries
1913.11	Caries – symptom
1914.00	Dental swelling
191Z.00	Tooth symptoms NOS
1923.00	Sore gums
1923.11	Sore gums - symptom
1928.00	Bleeding gums
J00..00	Tooth development and eruption disorders
J00..12	Teeth development and eruption disorders
J00..13	Tooth eruption disorders
J006.00	Tooth eruption disturbances
J006000	Late tooth eruption
J006100	Obstructed tooth eruption
J006200	Premature tooth eruption
J006300	Persistent primary tooth eruption
J006400	Persistent deciduous teeth
J006z00	Tooth eruption disturbances NOS
J007.00	Teething syndrome
J00y.00	Other tooth development and eruption disturbances
J00yz00	Other tooth development and eruption disturbances NOS
J00z.00	Tooth development and eruption disorders NOS
J01..00	Teeth hard tissue diseases
J010.00	Dental caries
J010000	Arrested dental caries
J010100	Cementum dental caries
J010200	Acute dentine dental caries
J010300	Chronic dentine dental caries
J010400	Dentine dental caries unspecified
J010500	Acute enamel dental caries
J010600	Chronic enamel dental caries
J010700	Incipient enamel dental caries
J010800	Enamel dental caries unspecified
J010900	Infantile melanodontia
J010A00	Odontoclasia
J010B00	White spot lesions of teeth
J010z00	Dental caries NOS
J011.00	Excessive attrition of teeth
J011000	Approximal tooth wear
J011100	Occlusal tooth wear
J011z00	Excessive tooth attrition NOS
J012.00	Abrasion of teeth
J012000	Dentifrice abrasion of teeth
J012100	Habitual abrasion of teeth
J012200	Occupational abrasion of teeth
J012300	Ritual abrasion of teeth
J012400	Traditional abrasion of teeth
J012500	Wedge defect of teeth NOS
J012z00	Abrasion of teeth NOS
J013.00	Erosion of teeth
J013200	Idiopathic teeth erosion
J013300	Occupational teeth erosion
J013z00	Erosion of teeth NOS
J014.00	Pathological tooth resorption

Code	Definition
J014000	External resorption of teeth
J014100	Internal resorption of teeth
J014111	Internal granuloma of pulp
J014z00	Pathological tooth resorption NOS
J015.00	Hypercementosis
J015.11	Cementation hyperplasia
J016.00	Ankylosis of teeth
J01y.00	Other teeth hard tissue disease
J01y100	Sensitive teeth dentine
J01yz00	Other teeth hard tissue disease NOS
J01z.00	Hard tissue teeth disease NOS
J02..00	Pulp and periapical tissue disease
J02..11	Periapical tissue disease
J020.00	Pulpitis
J020000	Pulpal abscess
J020100	Pulpal polyp
J020200	Acute pulpitis
J020300	Chronic hyperplastic pulpitis
J020400	Chronic ulcerative pulpitis
J020500	Chronic pulpitis unspecified
J020600	Suppurative pulpitis
J020z00	Pulpitis NOS
J021.00	Necrosis of the pulp
J021000	Pulp gangrene
J021100	Mummified pulp
J021z00	Necrosis of the pulp NOS
J022.00	Pulp degeneration
J022z00	Pulp degeneration NOS
J023.00	Abnormal pulp hard tissue
J023z00	Abnormal pulp hard tissue NOS
J024.00	Acute apical periodontitis
J024.11	Dental infection
J025.00	Periapical abscess without a sinus
J025000	Dental abscess
J025100	Dentoalveolar abscess
J025z00	Periapical abscess without a sinus NOS
J026.00	Chronic apical periodontitis
J026000	Apical granuloma
J026100	Periapical granuloma
J026z00	Chronic apical periodontitis NOS
J027.00	Periapical abscess with a sinus
J027.11	Gumboil
J027000	Alveolar process fistula
J027100	Dental fistula
J027z00	Periapical abscess with a fistula NOS
J028.00	Radicular cyst
J028000	Periodontal cyst
J028011	Apical cyst
J028100	Periapical cyst
J028200	Radiculodental cyst
J028300	Residual radicular cyst
J028z00	Radicular cyst NOS
J02z.00	Pulp and periapical tissue disease NOS
J03..00	Gingival and periodontal disease
J03..11	Gingivitis/gingival disease
J03..12	Periodontal disease
J030.00	Acute gingivitis
J031.00	Chronic gingivitis
J031.11	Gingivitis
J031000	Simple marginal gingivitis

Code	Definition
J031100	Ulcerative gingivitis
J031200	Desquamative gingivitis
J031400	Gingivostomatitis
J031z00	Chronic gingivitis NOS
J032.00	Gingival recession
J032000	Generalised gingival recession
J032100	Localised gingival recession
J032200	Postinfective gingival recession
J032300	Postoperative gingival recession
J032z00	Gingival recession NOS
J033.00	Acute periodontitis
J033000	Acute pericementitis
J033100	Acute pericoronitis
J033200	Paradontal abscess
J033300	Periodontal abscess
J033z00	Acute periodontitis NOS
J034.00	Chronic periodontitis
J034000	Chronic pericoronitis
J034100	Chronic pericementitis
J034200	Chronic periodontitis simplex
J034300	Chronic periodontitis complex
J034400	Alveolar pyorrhoea
J034z00	Chronic periodontitis NOS
J035.00	Periodontosis
J03X.00	Disorder of gingiva & edentulous alveolar ridge, unspec
J03y.00	Other specified periodontal disease
J03y000	Giant cell epulis
J03y100	Giant cell peripheral granuloma
J03y200	Gingival cysts
J03y400	Gingival fibromatosis
J03y500	Gingival polyp
J03y600	Periodontal lesions due to traumatic occlusion

Code	Definition
J03y700	Gingival & edentulous alveolar ridge les associated with trauma
J03yz00	Other specified periodontal disease NOS
J03z.00	Gingival and periodontal disease NOS
J05..00	Other dental disease/condition of teeth/supporting structure
J054.00	Orofacial sinus
J05y.00	Other specified dental disorder
J05y.11	Toothache
J05y000	Alveolar ridge enlargement NOS
J05y100	Irregular alveolar process
J05yz00	Other specified dental disorder NOS
J05z.00	Dental diseases and conditions NOS
J083.00	Oral cellulitis and abscess
J083000	Cellulitis of floor of mouth
J083100	Oral soft tissue cellulitis unspecified
J083200	Abscess of oral soft tissue unspecified
J083z00	Oral cellulitis and abscess NOS
J083z11	Infection mouth
Jyu0000	[X]Other disorders of tooth development
Jyu0100	[X]Other dental caries
Jyu0200	[X]Other specified diseases of hard tissues of teeth
Jyu0300	[X]Other+unspecified diseases of pulp+periapical tissues
Jyu0400	[X]Other periodontal diseases
Jyu0700	[X]Other specified disorders of teeth+supporting structures
S836300	Broken tooth injury
S836311	Broken teeth injury without complication
S836700	Dislocation of tooth
S837300	Broken tooth injury with complication
S837311	Broken teeth injury with complication

Appendix XV - GDP qualitative study participant information sheet, chapter 6



Phase Two Information for GDPs

Sponsor Ref: SPON1109-12

ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

PhD Student and Contact Researcher: Miss Anwen Cope, BDS
Cochrane Institute of Primary Care and Public Health, Cardiff University

We would like to invite you to take part in a 30 minute telephone interview as part of a research study. The information on this sheet is designed to help you decide if you would like to take part. Please take your time to consider whether or not you would like to take part. Please ask us if anything is unclear or you would like more information.

What is the purpose of the study?

This study aims to understand the influences on the management of pulpitis, apical periodontitis and dental abscesses by general dental practitioners, specifically regarding the use of the systemic antibiotics.

Why have I been invited to take part?

We are approaching general dental practitioners working in Wales, who treat adult patients experiencing pulpitis, apical periodontitis or dental abscesses. We are inviting clinicians working in both urban and rural settings. You have been selected because we believe that you are a fully qualified general dental practitioner working in a practice in Wales.

Do I have to take part?

No. Participation is entirely voluntary.

What happens if I decided not to take part?

You are completely free to decline participation. You will not be penalised in any way.

What will happen if I decide to take part?

We will contact you about arranging a date and time for the telephone interview. Interviews will be scheduled at a time convenient to you, which can be outside standard office hours. The interview will last up to 30 minutes. At the start of the interview the aims of the project will be briefly reviewed and you will have the opportunity to ask any unresolved questions. You will then be asked to verbally confirm your consent.

The interview will begin with some open-ended questions about the treatment of patients with pulpitis, apical periodontitis and dental abscesses and the use of antibiotics to treat these conditions. There are no right or wrong answers; we are interested in finding out about your experiences as a dental practitioner. As the interview progresses, the researcher may ask you to elaborate more about a particular topic. You are free to decline to answer any question at any time without giving a reason.

The interview will be audio-recorded and this recording will be transcribed. The transcript will then be anonymised. This will involve removing the names of all individuals and other potential identifiers (such as the name of the place they work).

Researchers will then read the anonymised transcripts and identify the main messages, or 'themes', that are common across several participants, and the main differences.

What happens next?

If you are interested in taking part please complete and return the enclosed 'Contact Details and Consent Form'. If you have any questions please contact a member of the study team using the telephone and or email contacts provided below. We will then contact you to organise the date and time for the telephone interview.

What are the disadvantages of taking part?

The only real disadvantage is that we are asking you to give up 30 minutes of your time for the telephone interview.

What are the possible benefits of taking part?

It is intended that this study will inform daily dental practice and benefit both dental patients and the wider public. **In compensation for your time we will pay each participant £60**

What if there is a problem?

We do not anticipate any problems. However, if you are unhappy with any element of this research study please tell a member of the research team and we will try to remedy any problems. If you are still unhappy you can make a formal complaint to the chief investigator (details at the end of this information sheet).

Will the information I provide be kept confidential?

Yes. All information about you, including background information about you and everything that you say during the interview, will be kept confidential. Written transcripts of what you say in the interview will be anonymised so that it is not possible to identify who the data is about. Any data that identifies you (your name and contact details for example) will be kept on a secure server and / or in a locked cupboard. Audio-recordings of the interviews will be stored in a locked cupboard within Cardiff University and transferred onto a secure server on the Cardiff University network. Only members of the Cardiff research team will have access to the audio-recordings. All study data will be kept for a period of 15 years.

What will happen to the results of the research study?

Results of the study (including anonymised direct quotations from the interviews) will be submitted to scientific journals for publication, may be presented at scientific meetings or conferences, and will form the basis of a report to the funders of the study.

Who is organising and funding the study?

The study has been funded by Cardiff University under its Presidential PhD Studentship scheme and by the Wales School of Primary Care Research. It is being led by researchers at the Cochrane Institute of Primary Care and Public Health. This study forms part of the PhD thesis of Anwen Cope, a dentist undertaking postgraduate research in Cardiff University.

Who has reviewed the study?

The study has been reviewed and given a favourable ethical opinion by the London Central Proportionate Review Committee.

Contact for further information

If you would like any further information about the study or have any questions, please contact the following:

Miss Anwen Cope <i>PhD Student</i> Cochrane Institute of Primary Care and Public Health Neuadd Meirionnydd Heath Park CF14 4XN Copea1@cardiff.ac.uk +44 (0)29 20687157	Dr Nick Francis (Chief Investigator) <i>Senior Clinical Research Fellow</i> Cochrane Institute of Primary Care and Public Health Neuadd Meirionnydd Heath Park CF14 4XN Francisna@cardiff.ac.uk +44 (0)29 20687133
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Appendix XVI - GDP qualitative study participant consent form, chapter 6

Phase Two Consent Form for GDPs

CONFIDENTIAL

Sponsor Ref: SPON1109-12



PARTICIPANT ID NUMBER:

ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

PhD Student and Contact Researcher: Miss Anwen Cope, BDS
Cochrane Institute of Primary Care and Public Health, Cardiff University

If you are interested in taking part in this study and are willing to be contacted after you have had time to read the study information please complete this form and return to the researcher in the envelope provided.

Please provide your contact details below:

Full Name _____

Practice Postcode _____

Contact tel. no _____

Please indicate preferred method of contact.

Email _____

Please Initial

I confirm that I have received the 'Information for GDPs' sheet (*version 0.1 dated 12/04/2012*) for the above study

I agree to participate in a 30 minute interview and understand that the researcher will contact me to confirm the interview time and date

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, my legal rights being affected

I agree that the interview may be electronically recorded. I understand that the recording will be treated with the strictest confidentiality and may be listened to by the research team but by no-one else. The recording will not be labelled with my name and any written record or report derived from it will be fully anonymised. I give permission for the anonymised data to be used in any research publications that result from the study.

Print Name
(Clinician)

Date

Signature

Print Name
(Researcher)

Date

Signature

If you require any further information, please contact:

Miss Anwen Cope
Cochrane Institute of Primary Care & Public Health
Tel: +44 (0)29 20687157

Appendix XVII - GDP qualitative study topic guide version 1, chapter 6

Question	Prompts
Can you start by telling me a little bit about the practice you work in? If you work in two practices, just describe the one you work in the most.	<ul style="list-style-type: none"> • Number of dentists? • Type of patients? • NHS/private split?
Can you talk me through what happens when a patient comes in with dental pain?	<ul style="list-style-type: none"> • What questions would you ask? • What would you do in your examination? • What kind of treatments do patients with acute dental conditions need?
Can you think of any factors that might influence your management of patients with dental pain?	<ul style="list-style-type: none"> • What's like when you have a short amount of time to treat a patient? • Do patients always have the treatment you recommend?
Can you tell me about when you might use antibiotics to treat a patient with dental pain?	<ul style="list-style-type: none"> • Can you give me an example? • Are you able to expand any more on that? • Are there any patients you might be more likely to prescribe antibiotics for?
How would you say you use antibiotics most frequently – by themselves, as a stop-gap until you can provide more comprehensive treatment or as in combination with operative treatment?	
Are there any situations you can imagine when you may be more likely to prescribe antibiotics to a patient?	<ul style="list-style-type: none"> • What would make you more likely to prescribe in this situation?
Can you think of anything that has resulted in you changing how you prescribe antibiotics?	<ul style="list-style-type: none"> • In what way and why?
How would you think other dentists working in general practice use antibiotics? Do you think all dentists use antibiotics in the same way?	<ul style="list-style-type: none"> • How does this make you feel?
Do you think there are patients expect antibiotics when they have dental pain?	<ul style="list-style-type: none"> • Do you think you'd be more likely to prescribe antibiotics if you felt a patient expected them? • Do patients ever explicitly ask you for antibiotics?

Question	Prompts
How often do you prescribe painkillers for patients with dental pain?	<ul style="list-style-type: none"> • In your experience do you prescribe more antibiotics or pain killers? • Do you think antibiotics are more effective than painkillers for patients with dental pain? • How confident would you feel prescribing non-over the counter painkillers to patients?
Have you been on any courses about antibiotic prescribing?	<ul style="list-style-type: none"> • Can you think of anything that might have changed the way you think about prescribing antibiotics? • Is there anything you can think of that would make you change the way you prescribe antibiotics?
How effective, in your experience are antibiotics in relieving dental pain?	<ul style="list-style-type: none"> • Can you give me any examples?
Have you come across cases where antibiotics have not been effective at resolving dental pain?	<ul style="list-style-type: none"> • Why do you think that was?
Sometimes in the news there are things about antibiotic resistance. What is your understanding of antibiotic resistance?	<ul style="list-style-type: none"> • Do you think resistance is a problem / a problem in dentistry? • Do you think about resistance if you were to give a patient antibiotics?
There's evidence that suggests some people with dental pain go and see their GP about it. What do you think would be the pros and cons of this?	<ul style="list-style-type: none"> • What do you feel about patients seeing their GP with dental problems? • Do you think GPs treat dental problems effectively?

Appendix XVIII - GDP qualitative study topic guide version 7, chapter 6

Opening Questions – Typical Management

Can you start by telling me a little bit about the practice you work in? If you work in two practices, just describe the one where you work the most.

- The number of dentists?
- The type of patients who are treated?
- The NHS/private split?

Can you talk me through what happens when a patient comes in or rings up with dental pain – do you have specific emergency appointments or are they booked into empty spaces in your appointment book?

- Why does your practice do it this way?
- Has this always been the case?
- How long do you have to treat the average patient with pain?

In your experience do you think that patients with dental pain attend expecting a certain type of treatment or do you think they're willing to listen to your recommendations about what you think would be best?

- Why do you think this is?
- How does this make you feel?

I'd like now to discuss some of the factors that might influence the management of patients with dental pain.

How does the amount of time you have to treat a patient impact on you might go about managing their pain?

- Can you give me an example?
- What would you do if you only had a short appointment to treat a patient with dental pain?

Do you ever encounter patients who don't want to have operative treatment (an extraction or pulp treatment) when they come in?

- Why do you think this is?
- How does this make you feel?

What is it like managing anxious or nervous patients who have toothache?

I'd like now to talk a little bit about antibiotics for the treatment of dental pain and how you might use antibiotics for patients with dental problems.

Can you think of an example of a situation when you might prescribe antibiotics to a patient with an acute dental condition?

- Can you give me an example?
- Are you able to expand any more on that?
- Are there any patients you might be more likely to prescribe antibiotics for?

Are there ever situations where you give a patient antibiotics to take 'just in case'?

Do you think patients expect antibiotics when they have dental pain?

- Do patients ever explicitly ask you for antibiotics?
- How do you feel when you think patients want antibiotics for a dental problem?
- If you felt a patient expected antibiotics would you be more likely to prescribe them?

Can you think of any examples when a patient wanted antibiotics but you felt they weren't necessary?

- How would you explain this to a patient?

How do you view your own prescribing levels and patterns in relation to other dentists working at your practice/in the local area?

- How would you think other dentists working in general practice use antibiotics?
- Do you think all dentists use antibiotics in the same way?
Do you think there are dentists who use too many antibiotics? What would improve the prescribing practices of these other dentists?
- How does this make you feel?

Do you think your prescribing practices have changed over time?

- Can you think of anything that has resulted in you changing how you prescribe antibiotics?
- In what way and why?

How do you keep up-to-date with new information about antibiotics?

- Have you been on any courses where antibiotic prescribing has been discussed?
- Do you remember reading anything recently about antibiotics in dentistry?

Do you think more needs to be done to tell patients that antibiotics aren't always effective for dental problems?

Do you refer to any written guidelines when you prescribe?

- How useful do you find these?

Are there ever occasions when you prescribe antibiotics that aren't in the clinical guidelines?

- Can you give me an example?
- How does this make you feel?

How often do you prescribe painkillers for patients with dental pain?

- In your experience do you prescribe more antibiotics or pain killers?
- Do you think antibiotics are more effective than painkillers for patients with dental pain?
- How confident would you feel prescribing non-over the counter painkillers to patients?

If we could just talk a bit about antimicrobial resistance

What do you understand about the term antimicrobial resistance?

What do you think causes resistance?

Do you think resistance is a problem / a problem in dentistry?

- In your opinion, is antibiotic resistance a problem?
- Do you think about resistance if you were to give a patient antibiotics?

Have you ever come across cases where antibiotics have not been effective?

What do you think your patients understand about antibiotic resistance?

- Do you discuss it with them?

What do you think can/should be done about resistance?

- Can anything be done in dentistry to reduce resistance?

I'd like to think now about people who go see their GP with dental problems.

There's evidence that suggests some people with dental pain go and see their GP about it.

What do you think would be the pros and cons of this?

- What do you feel about patients seeing their GP with dental problems?
- Do you think GPs treat dental problems effectively?

Lastly I'd just like to ask you about your involvement in the APICAL study and maybe the Antibiotic Prescribing Audit that's happening at the moment?

- How do you feel about your involvement in these projects?
- What could be done to optimise prescribing in general dental practice?

Appendix XIX - GMP qualitative study invitation letter, chapter 6



[Date]

Dear Dr [insert practitioner name]

I am a practicing dentist currently completing a PhD at Cardiff University and would like to invite you to take part in a research study. Participation requires a small amount of your time for which you will be financially compensated.

The study seeks to understand the different ways GPs working in general practice in Wales manage patients with dental problems. Through telephone interviews I hope to gather information about:

- attitudes of GPs towards the management of dental problems in general practice
- factors that may influence the antibiotic prescribing habits for dental conditions

If you agree to participate in the study we will contact you to arrange a date and time for the telephone interview. Interviews will be scheduled at a time convenient to you, which can be outside standard office hours. The interview will last up to 30 minutes. **You will be paid £60 for your participation.**

All information about you, including background information about you and everything that you say during the interview, will be kept anonymous.

If you are interested in finding out more information about participating in the proposed study, please complete the contact details on the next page and return in the prepaid envelope provided. If you have any questions, please contact me using the details below.

Thank you for your time,

Miss Anwen Cope, BDS
Institute of Primary Care and Public Health
Tel: (029) 20687157
Email: copea1@cardiff.ac.uk

Phase Three GMF Information
Sponsor Ref: SPON-1109/12

Appendix XX - GMP qualitative study participant information sheet, chapter 6

Phase Three Information for GPs

Sponsor Ref: SPON1109-12



ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

PhD Student and Contact Researcher: Miss Anwen Cope, BDS
Cochrane Institute of Primary Care and Public Health, Cardiff University

We would like to invite you to take part in a 30 minute telephone interview as part of a research study. The information on this sheet is designed to help you decide if you would like to take part. Please take your time to consider whether or not you would like to take part. Please ask us if anything is unclear or you would like more information.

What is the purpose of the study?

This study aims to understand the attitudes of GPs towards the management of dental problems in general practice and influences on their antibiotic prescribing habits for these conditions.

Why have I been invited to take part?

We are approaching GPs working in Wales. We are inviting clinicians working in both urban and rural settings. You have been selected because we believe that you are a fully qualified GP working in a practice in Wales.

Do I have to take part?

No. Participation is entirely voluntary.

What happens if I decided not to take part?

You are completely free to decline participation. You will not be penalised in any way.

What will happen if I decide to take part?

We will contact you about arranging a date and time for the telephone interview. Interviews will be scheduled at a time convenient to you, which can be outside standard office hours. The interview will last up to 30 minutes. At the start of the interview the aims of the project will be briefly reviewed and you will have the opportunity to ask any unresolved questions. You will then be asked to verbally confirm your consent.

The interview will begin with some open-ended questions about your experiences of the treatment of patients' dental problems. There are no right or wrong answers; we are interested in finding out about your experiences as a GP. As the interview progresses, the researcher may ask you to elaborate more about a particular topic. You are free to decline to answer any question at any time without giving a reason.

The interview will be audio-recorded and this recording will be transcribed. The transcript will then be anonymised. This will involve removing the names of all individuals and other potential identifiers (such as the name of the place you work).

Researchers will then read the anonymised transcripts and identify the main messages, or 'themes', that are common across several participants, and the main differences.

What happens next?

If you are interested in taking part please complete and return the enclosed 'Contact Details and Consent Form'. If you have any questions please contact a member of the study team using the telephone and or email contacts provided below. We will then contact you to organise the date and time for the telephone interview.

What are the disadvantages of taking part?

The only real disadvantage is that we are asking you to give up 30 minutes of your time for the telephone interview.

What are the possible benefits of taking part?

It is intended that this study will inform daily general practice and benefit both patients and the wider public. **In compensation for your time we will pay each participant £60**

What if there is a problem?

We do not anticipate any problems. However, if you are unhappy with any element of this research study please tell a member of the research team and we will try to remedy any problems. If you are still unhappy you can make a formal complaint to the chief investigator (details at the end of this information sheet).

Will the information I provide be kept confidential?

Yes. All information about you, including background information about you and everything that you say during the interview, will be kept confidential. Written transcripts of what you say in the interview will be anonymised so that it is not possible to identify who the data is about. Any data that identifies you (your name and contact details for example) will be kept on a secure server and / or in a locked cupboard. Audio-recordings of the interviews will be stored in a locked cupboard within Cardiff University and transferred onto a secure server on the Cardiff University network. Only members of the Cardiff research team will have access to the audio-recordings. All study data will be kept for a period of 15 years.

What will happen to the results of the research study?

Results of the study (including anonymised direct quotations from the interviews) will be submitted to scientific journals for publication, may be presented at scientific meetings or conferences, and will form the basis of a report to the funders of the study.

Who is organising and funding the study?

The study has been funded by Cardiff University under its Presidential PhD Studentship scheme and by the Wales School of Primary Care Research. It is being led by researchers at the Cochrane Institute of Primary Care and Public Health. This study forms part of the PhD thesis of Anwen Cope, a dentist undertaking postgraduate research in Cardiff University.

Who has reviewed the study?

The study has been reviewed and given a favourable ethical opinion by the London Central Proportionate Review Committee.

Contact for further information

If you would like any further information about the study or have any questions, please contact the following:

Miss Anwen Cope <i>PhD Student</i>	Dr Nick Francis (Chief Investigator) <i>Senior Clinical Research Fellow</i>
Cochrane Institute of Primary Care and Public Health Neuadd Meirionnydd Heath Park CF14 4XN	Cochrane Institute of Primary Care and Public Health Neuadd Meirionnydd Heath Park CF14 4XN
Copea1@cardiff.ac.uk +44 (0)29 20687157	Francisna@cardiff.ac.uk +44 (0)29 20687133

Appendix XXI - GMP qualitative study participant consent form, chapter 6

Phase Three Consent Form for GMPs

CONFIDENTIAL

Sponsor Ref: SPON1109-12



PARTICIPANT ID NUMBER:

ANTIBIOTICS AND PRIMARY CARE DENTAL PROBLEMS

PhD Student and Contact Researcher: Miss Anwen Cope, BDS
Cochrane Institute of Primary Care and Public Health, Cardiff University

If you are interested in taking part in this study and are willing to be contacted after you have had time to read the study information please complete this form and return to the researcher in the envelope provided.

Please provide your contact details below:

Full Name _____

Practice Postcode _____

Daytime tel. no _____

Email _____

Please indicate preferred method of contact.

Please Initial

I confirm that I have received the 'Information for GMPs' sheet (version 0.1 dated 12/04/2012) for the above study

I agree to participate in a 30 minute interview and understand that the researcher will contact me to confirm the interview time and date

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, my legal rights being affected

I agree that the interview may be electronically recorded. I understand that the recording will be treated with the strictest confidentiality and may be listened to by the research team but by no-one else. The recording will not be labelled with my name and any written record or report derived from it will be fully anonymised. I give permission for the anonymised data to be used in any research publications that result from the study.

Print Name
(Clinician)

Date

Signature

Print Name
(Researcher)

Date

Signature

If you require any further information, please contact:

Miss Anwen Cope
Cochrane Institute of Primary Care & Public Health
Tel: +44 (0)29 20687157

Appendix XXII - GMP qualitative study topic guide version 1, chapter 6

Question	Prompts
I'd like to start things off very generally by asking you about the practice you work in?	<ul style="list-style-type: none"> • The number of doctors, branch surgeries, rural/urban location. • Can you describe your patient demographic?
<p><i>The next questions relate to seeing patients with dental problems...</i></p> <p>How often would you say that see patients with dental problems in your day-to-day working life?</p>	<ul style="list-style-type: none"> • Are you seeing patients with dental problems on a daily or weekly basis?
In your experience do you think that the number of patients consulting you for dental problems has increased, decreased or stayed about the same?	<ul style="list-style-type: none"> • Can you think of any reasons for this?
And in your experience do patients attending with dental pain – do they come in just because of the dental problem or do they come in with a collection of different concerns?	<ul style="list-style-type: none"> • How does this make you feel?
What do you think are the reasons why people go to the doctors with dental problems?	<ul style="list-style-type: none"> • Why do you think that patients don't go and see the dentist? Is it because they can't or because they don't want to?
What do you think patients consulting their GP due to dental problems expect?	<ul style="list-style-type: none"> • Advice? • Antibiotics? • Painkillers?
If an adult patient, came in complaining of on and off, really severe pain from one of their back teeth, what would you do?	<ul style="list-style-type: none"> • Would you look in their mouth? • What kind of things would you look for? • How do you feel looking in patients' mouths? • Would you do anything else? • What kind of diagnosis would you be thinking of?
What kind of treatment/advice do you provide to patients with dental problems?	<ul style="list-style-type: none"> • Would you prescribe antibiotics? If so, which antibiotics would you prescribe most commonly? • Do you ever refuse to treat patients with dental problems?

Question	Prompts
What would you say is your attitude towards seeing patients who attend due to dental problems?	<ul style="list-style-type: none"> • Do you view think treating dental problems is part of your responsibilities as a GP?
How confident do you feel when diagnosing and prescribing for dental problems?	<ul style="list-style-type: none"> • Why do you feel this way?
What are your sources of information about managing dental problems?	
Have you ever received teaching or guidance about managing dental problems?	<ul style="list-style-type: none"> • How did you find this?
Would you say that patients in your local area can access dental services easily?	<ul style="list-style-type: none"> • Would you recommend a specific dentist or out of hours dental centre to patients with dental problems?

Appendix XXIII - GMP qualitative study topic guide version 5, chapter 6

I'd like to start things off very generally by asking you about the practice you work in?

- The number of doctors, branch surgeries, rural/urban location.
- Can you describe your patient demographic?

The next questions relate to seeing patients with dental problems.

What would happen if a patient was to call the practice or present at the reception with a dental pain?

- Do you have a specific practice policy regarding patients with dental problems?
- Has this always been the case?

How often would you say that see patients with dental problems in your day-to-day working life?

- Are you seeing patients with dental problems on a daily or weekly basis?

In your experience over the years do you think that the number of patients consulting you for dental problems has increased, decreased or stayed about the same?

- Can you think of any reasons for this?

In your experience do patients attending with dental pain – do they come in just because of the dental problem or do they come in with a collection of different concerns?

- How does this make you feel?

Do you find that patient consulting for dental problems reconsult for the same problem in the future?

- How long it is before they reconsult?

What do you think are the reasons why people go to the doctors with dental problems?

- Why do you think that patients don't go and see the dentist?
- Is it because they can't or because they don't want to?

What do you think patients consulting their GP with to dental problems expect?

- Do you think they expect advice / antibiotics / painkillers?

Patients who see an NHS dentist may have to pay a contribution to the cost of their care. Were you aware of this?

- In your opinion do you think this influences patients to seek help from their GP?

- If so, how big an influencing factor do you think it is?

The next questions relate to how you might manage a patient consulting with dental problems.

If an adult patient, came in complaining of on and off, severe pain from one of their back teeth which is keeping them awake at night - what would you do?

- Would you look in their mouth?
- What kind of things would you look for?
- How do you feel looking in patients' mouths?
- Would you do anything else?
- What kind of diagnosis would you be thinking of?

How long does the average dental consultation take in comparison to other appointments?

What kind of treatment or advice do you provide to patients with dental problems?

- Would you prescribe antibiotics? If so, which antibiotics would you prescribe most commonly?
- Would you prescribe analgesics? If so, which analgesics would you prescribe most commonly?

What kind of advice do you provide to patients with dental problems?

- Would you advise they see a dentist?
- Do you think patients do end up seeing a dentist?

In what situation might you decide to give a patient with dental problems antibiotics?

- Why would you prescribe an antibiotic in this situation?
- Is there anything that might alter this?

In what situation might you decide not to give a patient with dental problems antibiotics?

- Why would you not prescribe an antibiotic in this situation?
- Is there anything that might alter this?

In your experience are antibiotics effective in the treatment of the majority of dental problems?

If we could just talk now about your attitude towards dental consultations.

What would you say is your opinions towards seeing patients who attend with a dental problems?

- Do you view think treating dental problems is part of your responsibilities as a GP?

- Do you think your attitude towards seeing patients with dental problems has changed during your time in general practice?
- Do you ever refuse to treat patients with dental problems?

How do your colleagues in feel about seeing patients with dental pain?

How confident do you feel when diagnosing and prescribing for dental problems?

How do you feel about treating patients with other mouth-related problems? Things like temporomandibular joint problems or dry mouth?

- Do you feel differently about treating these problems than specifically tooth-related problems?

Have you ever received teaching or guidance about managing dental problems?

- How did you find this?
- Would you like teaching or guidance about managing dental problems?

Local Dental Services

Would you say that patients in your local area can access dental services easily?

- Would you recommend a specific dentist or out of hours dental centre to patients with dental problems?

What kind of interaction do you have with any local dental practices?

- Would you or have you referred patients to a dentist?
- Would you like more links between the two professions?

Appendix XXIV – Qualitative study code books, chapter 6

Qualitative interviews with GDPs

<i>Practice Organisation</i>	
Practice structure and local demographics	Descriptions about practice - staff, patients, local area
NHS/private split	Descriptions of practice/practitioner NHS/private split
Taking on new patients	Whether practice/practitioner is accepting new patients and attitudes towards this
Appointment book structure	How patients with acute conditions are seen: length of time for acute conditions, changes in appointment book structure and appointment structures at previous practices
How long a patient has to wait to see a dentist	Descriptions of how quickly a patient will be seen (both before getting an appointment and sitting in the waiting room) and also practice policies about seeing patients or regular vs irregular attenders
Reception staff booking appointments	Descriptions how reception staff manage patients presenting with acute conditions and reflections on this
Patient continuity	Do dentists see their own patients when they have acute conditions? What are their reflections on this? What happens when a colleague sees their patients (or vice versa)?
Reflections on working a practice OR being a dentist	Practitioner's feelings about working at practice, including comparisons with previous practices and reflections on particular aspects of practice organisation (staff shortages, working as a single handed dentist) or feelings about being a dentist
Local access to dental services	Perception about how easy/difficult is to access dental care locally

<i>Management of Acute Conditions</i>	
Acute conditions - presentation and causes	Descriptions of the types of acute conditions presenting in general dental practice and their causes
Acute conditions - history and examination	Descriptions of clinical history taking and examination
Dentist's current practice and attitude towards managing acute conditions	Descriptions of what the dentist wants to achieve when managing patients with acute conditions, what treatments they provide and feelings and attitudes towards patients or managing patients with acute conditions but not if reference made to antibiotics
Changes in practice when managing acute conditions	Descriptions of how a dentist perceives their practicing style/relationship with patients has evolved NOT if talking about changing antibiotic prescribing behaviours (code as changes in personal prescribing behaviours)

<i>Management of Acute Conditions continued...</i>	
Providing definitive treatment	References to providing definitive treatment or delaying treatment and getting patients back for definitive treatment later (definitive treatment - filling, root canal treatment or extraction)
Patient beliefs, expectations and accepting recommendations	Perceived attitudes towards and expectations of dental care for acute conditions including factors that modify patient expectation and attitudes towards patient's expectations. Including accepting recommendations. NOT codes about antibiotics
Communicating diagnosis, prognosis or treatment plan	How dentists explain to their patients what is wrong and available options for treatment

<i>Factors that Influence Management of Patients with Acute Conditions</i>	
Time pressures	Whenever a dentist refers to having/not having enough time, including the effects of acute conditions on the rest of their day (working through lunch etc.)
Irregular attenders/new patients	When dentist mentions treating either new patients or irregular attenders and how this impacts on the management of the patient
Anxious patients	Descriptions of treating nervous patients and any consequences/impact on management.
Treating a colleague's patients	Descriptions of treating a colleague's patient and any consequences/impact on management.
Complex cases	Descriptions of treating complex cases and any consequences/impact on management.
Specialist treatment required	Managing patients who require specialist treatment (wisdom teeth, general anaesthetic) and any consequences/impact on management, references to secondary/tertiary care providers, attitudes towards referring patients to specialists.
Patient's attitude towards operative treatment	Situations where patients refuse operative treatment and impacts on their management OR where patients are happy to have/prefer operative treatment
Unclear diagnosis	Descriptions of treating patients when diagnosis is unclear and any consequences/impact on management.
Severe Infections	Treating patients with severe infections (swollen faces, limited mouth opening, airway compromise)
Colleagues	When the management of a patient is influenced by boss/colleagues/nurses/reception staff (including prescribing antibiotics)
Financial aspects of managing patients with acute conditions	Descriptions of remuneration for acute conditions, any reference to NHS UDA style, LHBs or commissioning bodies for dental services
Differences between NHS and private practice/patients	When a dentist mentions differences between NHS and private patients

<i>Antibiotic Prescribing</i>	
Situations they would prescribe antibiotics	Any descriptions of times they would or have given antibiotics, conditions antibiotics are effective for, how antibiotics work for
Situations they wouldn't prescribe antibiotics	Any descriptions of times they wouldn't or didn't given antibiotics, conditions antibiotics don't work for
Type/dose/frequency/duration of antibiotics	Any references to antibiotic names, doses, length of courses etc.
Repeated courses of antibiotics	Any cases when patients have received more than one course of antibiotics for the same problem
Expectations/requests for antibiotics	When patients implicitly or explicitly request antibiotics or dentist perceives patient wants antibiotics, attitudes towards this and how this affects treatment
Patient attitudes towards antibiotics - positive	Whenever dentist refers to patient's viewing antibiotics as effective/as a preferred treatment
Patient attitudes towards antibiotics - negative	Whenever dentist refers to patients not wanting to take antibiotics
Prescribing due to medical conditions	Referring to times when antibiotics are given to prevent conditions such as bacterial endocarditis, due to complicated medical histories or in cases when patients take bisphosphonates
Prescribing antibiotics "Just in case"	Descriptions of prescribing antibiotic to prevent patient experiencing problems in the future, for example, to take on holiday
Perceived compliance with antibiotics	Whether patients complete their course of antibiotics/take as advised

<i>Reflections on Prescribing</i>	
Attitudes towards prescribing analgesics	Practices and attitudes towards recommending/prescribing analgesics
Reflection on own antibiotic prescribing practices	Any reflections on their own level of prescribing or practice-level prescribing levels, including feelings about when they prescribe antibiotics in situations when they may not be appropriate
Changes in personal prescribing behaviours	Also description of how their use of antibiotics changed/stayed the same during their career
Changes in prescribing behaviours of dentists as a profession	Descriptions of how antibiotic use has changed across the dental profession
Prescribing behaviours of other dentists – within practice	Descriptions of how other dentists within the same practice (current) use antibiotics and reflections on their behaviour
Prescribing behaviours of other dentists – as a profession	Descriptions of how other dentists as a profession overall use antibiotics. Code also includes feelings of professional isolation/not knowing what is happening in other practices

<i>Reflections on Prescribing continued...</i>	
Prescribing behaviours of other dentists - predecessors at practice	Descriptions of how dentists who previously worked at the practice prescribed antibiotics and how this affects the dentist.
Sources of information about prescribing	Undergraduate teaching, courses, journals, clinical guidelines, talking with colleagues
Difficulties accessing continuing professional development (CPD)	Any reference to difficulties accessing CPD
Changes after 1000 Lives Audit or APICAL	Any changes that have arisen out of recent study/audit or references to prescribing habits not changing following study/audit
Relative importance of antibiotic prescribing	Either as part of public health in general or in terms of CPD requirements
Their involvement in APICAL	What dentists thought about being involved in APICAL
Prescribing other formulary items	Descriptions of prescribing other medicines (e.g. fluoride) NOT antibiotics or analgesics.

<i>Antibiotic Resistance</i>	
Knowledge about antibiotic resistance	Description of the mechanisms of antibiotic resistance, knowledge of the effects of antibiotic resistance, or specific examples where practitioners have encountered resistance
Causes of antibiotic resistance	Reasons a dentist gives for development of antibiotic resistance
Attitude of patients towards antibiotic resistance	Descriptions of how they feel their patients or the general public perceive antibiotic resistance
Attitudes towards antibiotic resistance	Dentists' reflections on seriousness of condition, including personal concerns about taking antibiotics
Solutions for improving prescribing and reducing antibiotic resistance	Suggestions about measures that may slow or eliminate antibiotic resistance, or things that might improve prescribing behaviours

<i>GMPs and Dental Problems</i>	
Experience of patients seeing GMPs with dental problems	Descriptions of whether practitioner has observed this and what management the patients received (or hypothetically receive)
Reasons patients see GMPs with dental problems	Reasons a dentist identifies as to why a patient may see a GMP with a dental problem
Attitudes towards patients seeing a GMP with a dental problem	Reflections on patients seeing GMPs, "it makes me angry", "I find it frustrating"
Relationships with local GMPs	Any description of relationships with local GMPs

Qualitative interviews with GMPs

<i>Practice organisation and frequency of dental consultations</i>	
Practice structure	Descriptions of the practice and patient population
Patient demographics	Demographic details of either the local area or specifically patients attending with dental problems
Practice/practitioner policy about managing dental problems	Descriptions of where there may be or not be a practice policy about seeing patients with dental problems. Also descriptions of GMPs refusing to see patients with dental problems.
Receptionist triage	Descriptions of questions receptionists might ask patients presenting with dental problems
Appointment structure - triage system	When GMPs talk about patients being asked questions about their problems prior to being seen, either by nurse/GMP
Appointment structure - open surgery	When GMPs talk about having an open surgery
Appointment structure – prearranged appointments	When GMPs have pre-assigned appointment times for patients
Frequency of dental consultations	Frequency of consultations dental problems
Increase/decrease in consultations for dental problems	How frequency of consultations for dental problems has increased/decreased/stayed the same and reasons for this
Comparisons with previous practices	When GMP makes comparisons with other places they have worked with regard to frequency of dental consultations/practice policy
Length/complexity of appointments for dental problems	Descriptions of how long and/or complex GMPs find consultations for dental problems
Sole complaint or multiple problems	Whether patients consulting for dental problems have one or multiple concerns (shopping list).
Reconsultation	Whether patients consulting for dental problems reconsult with same/other dental problems

<i>Why patients see GMPs with dental problems</i>	
Convenience/ease of getting appointment	When a patient might book to see the GMP because it's easier/more convenient than seeking dental attention
Access to dental services	When a patient might attend because access to local dental services is poor or when they might attend despite good local access
Poor local infrastructure	When transport/length of time to see dentist might influence a patient to see GMP
Dissatisfaction with dentist	When dissatisfaction with dental care causes patients to seek help from GMP
Financial	How much financial concerns affect a patient's decision to seek help from their GMP
Anxious about seeing dentist	If patients are anxious about seeing a dentist and how this may bring them to consult a GMP
Dentist can't fit them in	If patients can't or believe they won't be able to book an appointment with their dentist
Perceived need for antibiotics	When a patient cites need for antibiotics as reason for consulting GMP, "My dentist would give me antibiotics"
Not aware problem is dental in origin	When a patient is not sure what the source of their problem is and decide to consult GMP
Not sure who to see	Descriptions of when a patient isn't sure who to consult about their dental problem

<i>Examining, diagnosing and managing patients with dental problems</i>	
Examining patient	Descriptions of any examination, signs and symptoms a GMP looks for
Perception of severity of dental problems	How serious or painful GMPs judge dental problems to be
Diagnoses/causes of dental conditions	Any diagnoses/causes of dental problems
Applying medical knowledge to dental problems	Examples of how GMPs apply medical knowledge to dental problems.
Confidence when managing dental problems	Certainty/uncertainty when managing dental problems
Patient expectations of care	What GMPs perceive patients expect from the consultation
Treatment - analgesics	Descriptions of prescribing/recommending or not prescribing/recommending painkillers
Treatment - operative	Descriptions of operative interventions or why GMPs would not attempt operative intervention
Treatment - antibiotics	Descriptions of prescribing/recommending or not prescribing/recommending antibiotics and the effectiveness of antibiotics for dental problems
Treatment - other medicines	Descriptions of prescribing other medicine NOT antibiotics or analgesics
Treatment – no treatment	Descriptions of providing advice alone.
Requests for antibiotics	When a patient may request/expect antibiotics, reasons for this
Requests for analgesics	When a patient may request/expect analgesics, reasons for this
Types of antibiotics	Types/doses antibiotics prescribed/reasons
Advice to see dentist	Whenever a GMP advises a patient to see a dentist
Advising patients about how to get a dentist	Specific advice about how they recommend a patient gets a dentist - e.g. LHB number/NHS direct
Direct referrals to dentist	When a GMP directly refers a patient (phone/letter) to a dentist or the reasons they wouldn't do this
Referral to secondary care	When a GMP talks about referring patients to secondary care - oral and maxillofacial surgery
Factors that affect management	Factors that affect how a GMP manages a patient with dental problems e.g. time of day/week etc.
Severe dental infections	Descriptions of what GMPs do when they encounter a severe dental infection
Influence of medical organisations	Any advice, direction or guidance GMPs have received from the BMA, GMC, LHB etc.

<i>Attitudes towards managing patients with dental problems</i>	
"Not dentally qualified"	Whenever GMP refers to not having dental training
Duty of care	When a GMP describes wanting/feeling responsibility to help a patient
Attitude towards seeing patients with dental problems - positive	Examples of positive attitudes with relation to seeing patients with dental problems
Attitude towards seeing patients with dental problems - neutral	Examples of neutral attitudes with relation to seeing patients with dental problems
Attitude towards seeing patients with dental problems - negative	Examples of negative attitudes with relation to seeing patients with dental problems
Attitudes of colleagues towards seeing patients with dental problems	Plus descriptions of how colleagues handle patients with dental problems
Financial aspects of seeing patients with dental problems	Such as reimbursement from LHB or not getting paid for seeing dental problems
Raising concerns about the number of dental consultations	Whether a GMP would raise concerns about dental consultations and to who
Sources of information about dental problems	Courses, colleagues, undergraduate teaching etc. about dental problems
Reception to teaching about managing dental problems	Do GMPs want instruction on managing dental problems?
Managing non-dental orofacial problems	How GMPs feel about managing patients with non-dental orofacial issues
Attitudes to antibiotics in general	Antibiotic prescribing profile of practice, reasons for changing antibiotic use, patient attitudes towards antibiotics.

<i>Local dental services</i>	
Description of local dental services	References to what dental services are available in local area
Attitudes of patients to dental care	For example, descriptions of patients not wanting regular dental care, only emergency
Local difficulties with dental services	Descriptions of problems with local dental services - dentist went private/recruitment problems
Attitudes towards dental profession	Any feelings GMPs express about dentists
Relationships with local dentists	Any professional/personal relationships with local dentists
Dentists requesting help from GMPs	Instances when a dentist requests assistance from GMP

General dental practitioners' perceptions of antimicrobial use and resistance: a qualitative interview study

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IN BRIEF

- Provides insights into beliefs and attitudes held by general dental practitioners (GDPs) with regard to antibiotic use and resistance.
- Reports that perceptions of resistance may vary between GDPs.
- Suggests that antibiotic prescribing practices of GDPs may be influenced by both immediate clinical pressures and longer term public health concerns.

RESEARCH

Background Dentists are responsible for 9–10% of all antibiotics dispensed in primary care in the UK, many of which may be provided contrary to clinical guidelines. Since antibiotic consumption has been identified as a major cause of antibiotic resistance, dental prescribing may be a significant contributor to this important public health problem. **Objective** This study aims to explore general dental practitioners' (GDPs) perceptions and attitudes towards antibiotic use and resistance. **Method** Qualitative interview study with 19 purposively sampled GDPs working in Wales. A set of open-ended questions were developed and amended during semi-structured telephone interviews. Interviews were recorded, transcribed verbatim and codes were developed using thematic analysis. **Results** Perceptions of antibiotic use and resistance varied widely between practitioners, particularly with respect to the prevalence and impact of resistant strains on the management of dentoalveolar infection, and the impact of dental prescribing on the emergence of resistance. GDPs reported that their antibiotic prescribing decisions were driven by both clinical pressures and wider public health considerations. **Conclusions** Interventions to enhance the quality of antibiotic prescribing in primary care dentistry should address issues associated with inappropriate prescribing as well as providing education about the causes, prevalence and impact of antibiotic resistance.

INTRODUCTION

Since their introduction in the 1930s and 1940s, antibiotics have saved countless lives. However, soon after their earliest trials it became evident that some bacteria possessed, or could acquire, resistance to these agents. During the intervening 80 years there has been a gradual and sustained emergence of antimicrobial resistant bacterial strains, while the number of new antibiotics has decreased, leading to widespread concern about the impact antibiotic resistance could have on the management of infectious diseases.^{1–3}

Antibiotic resistance is considered a pressing international public health problem,^{1,2} and is associated with increased morbidity, mortality and healthcare costs.⁴ Antibiotic consumption is recognised as a major cause of emerging resistance and some of the

increase in resistance is directly attributed to the indiscriminate or poor use of antibiotics.^{5,6} In response, initiatives at local, national, and international levels have attempted to promote antibiotic stewardship among healthcare professionals.^{1,6} Many interventions to improve prescribing occur within primary care, as approximately 80% of all antibiotics are prescribed within this setting.⁷ Despite this, qualitative research has suggested that many general practitioners (GPs) working in primary care do not perceive antibiotic resistance as a problem in their practice, but rather regard it as a secondary care or hospital problem.^{8,9}

Dentists currently prescribe approximately 9–10% of all antibiotics dispensed in primary care in the United Kingdom,^{10,11} and therefore the possible contribution of dental prescribing to the development of antibiotic resistance should not be underestimated. There is concern that antibiotics are frequently prescribed inappropriately in the management of acute dental conditions where they may be of little clinical benefit, such as in the treatment of irreversible pulpitis, or as a substitute to providing local, operative measures or adequate analgesia.^{12,13} In addition, antibiotic therapy prescribed by dentists is typically empirical, employing broad-spectrum agents that can predispose to the selection of resistant

strains.¹⁴ Antibiotic resistant bacteria are increasingly isolated from odontogenic infections.^{15–18} Furthermore, studies have identified a correlation between the emergence of antibiotic resistant bacteria such as *Prevotella sp.* and previous administration of antibiotics for dental infections.¹⁸

While a previous study has examined the antibiotic prescribing knowledge among dental professionals,¹⁹ to date there has been no research undertaken into GDPs' perceptions of antibiotic resistance. Therefore the aim of the study reported here was to explore clinicians' beliefs and attitudes towards antibiotic use and resistance.

METHODS

Qualitative methods were selected as being the most appropriate for exploring practitioners' perceptions of antibiotic resistance. Such methods do not seek to generate statistically representative data, instead they endeavour to interpret, or obtain a 'deeper understanding' of certain aspects of human beliefs, attitudes or behaviour.²⁰ Since little is currently known about attitudes of members of the dental profession towards antibiotic resistance, a qualitative approach allowed researchers to have greater freedom to explore issues and, if necessary, to enquire about tangential topics that had not previously been considered. This contrasts

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with quantitative approaches with structured questionnaires that may be driven by researcher's preconceptions.

Subjects and sampling

This analysis was completed as part of a larger study examining influences on antibiotic prescribing behaviours of GPs. We interviewed a 'purposive sample' of clinicians who had taken part in a cross-sectional study investigating the surgical and pharmacological management of adults with acute dental conditions within the General Dental Service (the Antibiotics and Primary Care Dental Problems [APICAL] study). The 42 GPs participating in APICAL had been randomly selected from publicly available databases of GPs providing state-subsidised National Health Service (NHS) or private dental treatment to adult patients in Wales.

From those GPs who expressed a willingness to take part in an interview, participants were selected on the basis of their location and length of time since qualification. This was done to obtain maximum variation within the sample. Non-probabilistic sampling techniques were employed as the objectives of the interviews were not to obtain a representative sample but to explore a wide range of perspectives and experience among GPs.

The study was reviewed and given a favourable ethical opinion by the London Central Proportionate Review Committee (12/L0/1213). All GPs provided their written consent before interview.

Data collection

Semi-structured telephone interviews were conducted with participating clinicians by a researcher trained in qualitative interviewing techniques (AC). AC is a qualified dentist undertaking postgraduate research and at the time when the interviews were conducted (July – October 2013) was a practicing GP. All participants were made aware of her professional identity before the interview.

An interview guide was prepared before data collection. This was informed by the scientific literature, topic guides from other studies and clinical experiences of the research team. In the early stages of interviewing, the topic guide went through several iterations during which questions were added and revised.

Before the interview it was stressed to participants that the goal of the interviews were not to test knowledge but to understand the practitioner's experiences and point of view.

All interviews were audio recorded and transcribed verbatim, apart from one interview in which the recording device failed. No notes were recorded during the interview

other than memos of additional questions and probes to ask each participant, to encourage active listening on the part of the interviewer. Instead, field notes were recorded in the form of a 'qualitative diary' following each interview. Interviews were anonymised on transcription and checked against the original recording to ensure fidelity, this also ensured the researcher (AC) was immersed in the dataset.

Analysis

Thematic analysis techniques as described by Braun and Clarke were employed.²¹ Transcripts were first coded to identify different features of the dataset with codes representing 'the most basic segment, or element, of the raw data or information'.²² A second qualitative researcher (FW) then second coded 20% of the transcripts to examine the coding system. Codes were then collated, defined and grouped into themes. Themes were then reviewed, defined and named, before all data coded as 'antibiotic resistance' were extracted for further analysis for the purposes of this paper. Analysis was facilitated by the qualitative data analysis software package NVivo (QSR International).²³

Data collection, transcription and analysis was undertaken concurrently to examine the emergence of themes and at which point 'saturation' had been reached. Saturation is defined as 'data adequacy' and in practice is the process of collecting data until no new information is obtained.²⁴ Since there are no published guidelines regarding how to assess data saturation in qualitative research, within this study saturation was judged to be when the richness of data within a theme no longer appeared to be increasing with subsequent interviews. Therefore the interview process ceased when the researcher felt that there was sufficient data to build a comprehensive and convincing insight into GP behaviour. This point was judged to have been following coding of the nineteenth interview.

RESULTS

Out of the 27 GPs who expressed an interest in participating in an interview, 19 were interviewed. Out of the 19 participating clinicians, 10 were male and the median number of years since graduation was 17. All but one qualified from dental schools in the UK and five had postgraduate qualifications such as MJDF/MFDS or MSc. Just over half (10/19) worked in practices in urban locations with the remainder based in town and fringe locations. Practitioners were based throughout all seven Welsh Local Health Boards (LHBs). While most practitioners undertook both NHS and private work, 15 reported that they spent the majority of

their time treating patients under the NHS. Thirteen practitioners worked in locations that had Wales Index of Multiple Deprivation (WIMD) 2011⁸ ranks, the official measure of relative deprivation for small areas in Wales,²⁵ indicating they served the 50% most deprived populations, while six were from practices that had WIMD scores suggesting they served the 50% least deprived areas. Interviews lasted on average 25.6 minutes (SD 4.93 minutes).

Awareness of resistance

All clinicians were aware of antibiotic resistance, with many citing the example of methicillin-resistant *Staphylococcus aureus* (MRSA). There was an appreciation that prevalence of resistance was increasing and that this may present therapeutic problems for secondary care practitioners should individuals harbouring resistance contract a 'major' infection. Practitioners' knowledge of antibiotic resistance was informed by both 'formal' sources such as undergraduate teaching, postgraduate courses and journal articles, as well as media reports.

There were conflicting opinions as to whether antibiotic resistance occurred within dentoalveolar infections. Most of the clinicians interviewed had experienced antibiotic treatment failure, and some attributed this to the presence of resistant bacteria, particularly in relation to amoxicillin. However, other practitioners attributed antibiotic failure to achieve adequate pus drainage and emphasised the need to perform local measures in addition to prescribing antibiotics in situations of dentoalveolar infections.

'I would say 20 years ago amoxicillin seemed to clear most swollen faces quite quickly erm, now I'm finding amoxicillin, it might work, but I'm using metronidazole and amoxicillin more often, in combination... I definitely worry more about a severe infection and a lot aren't responding to amoxicillin and that's the first choice.' (GDP23, >30 years since qualification)

Causes of resistance

All dentists identified the link between antimicrobial prescribing and increasing prevalence of resistance. While many practitioners described how overprescribing could contribute to antibiotic resistance, there were varying levels of understanding about how antibiotic prescribing could lead to the emergence of resistant strains.

'...some of them [bacteria] will occasionally mutate, so what that means is that their, sort of their DNA, their genetic makeup like we have, changes a bit. Sometimes these changes mean that the antibiotics that we can give you won't work. And sometimes

when antibiotics are given for the wrong reasons you can end up leaving some of these bacteria around, which then mutate, which then change, which means that the next time we maybe give antibiotics the bacteria that mutated, that changed, are still with us.' (GDP5, <10 years since qualification)

'(Laughing) I don't know too much about it to be honest.' (GDP24, <10 years since qualification)

Clinicians' perceptions of the extent to which prescribing by the dental profession contributed to antibiotic resistance varied between individuals. However, the majority of practitioners believed that while all antibiotic prescribing could theoretically lead to the emergence of resistance, the contribution of dental prescribing to antibiotic resistance was likely to be far less than medical colleagues. Clinicians who reported that dental prescribing was likely to have little to no impact on the prevalence of antibiotic resistance generally justified this due to the fewer number, shorter courses and narrower range of antibiotics dentists are able to prescribe in comparison with other medical professionals.

Several practitioners specifically cited overprescribing by general medical practitioners (GMPs) as the most significant cause of antibiotic resistance. Other explanations offered for antibiotic resistance included antibiotic use in agriculture and farming, prescribing by hospital doctors and the availability of over the counter antibiotics in developing countries.

'The dental team, compared to our medical cousins, we actually prescribe very, very little, compared to them... we can't bear the brunt, as it is, of antibiotic resistance developing in the world.' (GDP8, >30 years since qualification)

'I know some people who've got a [medical] problem and their GP will end up giving them 7 days of something and then another 7 days and then another 7 days. I think that's probably going to cause more problems than a 4 day course from the dentist.' (GDP6, <10 years since qualification)

Responding to resistance

Some practitioners, particularly those who had been qualified in excess of 20 years, discussed changing their prescribing patterns either directly or indirectly because of antibiotic resistance.

'...though I will try not to prescribe. I am, I am, I think we're all very aware, I mean 25 years ago we were probably prescribing, maybe over prescribing, but today I think we're all very aware of all these resistant strains of bacteria and we do try not to prescribe. Well I do anyway' (GDP26, 20-30 years since qualification)

Several practitioners who had changed their prescribing behaviours had been partly influenced to do so because of the publication of clinical guidelines.

'I would say under current guidelines we really are trying to avoid giving antibiotics. There has been a big change, I mean in the timespan that we've worked in general practice there's been a huge change in that.' (GDP3, 20-30 years since qualification)

However, clinicians also acknowledged the difficulties balancing between clinical pressures and public health considerations.

'I'm becoming, obviously like a lot of practitioners, far more aware of the use of antibiotics now, and the misuse of antibiotics, so I am trying to prescribe less than I used to. They're the only option sometimes when you've got patients sitting on the shelves in the waiting room and you want to get home, and the nurse wants to go home, the easiest option is to put a prescription and bring them back a day or so later, but I would certainly never do that anymore.' (GDP37, >30 years since qualification)

'It really depends whether that patient presented at a time when I had a fair bit of time on my hands. Now if I was under pressure, I will be honest and tell you that I will write them a prescription for some antibiotics, if I've got six people sitting waiting for treatment, you know.' (GDP26, 20-30 years since qualification)

When asked what should be done to optimise prescribing among the dental profession, practitioners who primarily provided NHS services were more likely to suggest that feedback about current prescribing patterns and greater incentives to provide operative treatment for the management of acute dental conditions may encourage practitioners to prescribe fewer antibiotics. However, some GDPs, particularly those primarily providing private dentistry, described how raising awareness of resistance and appropriate management of acute dental conditions (for example, operative treatment) among the public would reduce patients' expectation of antibiotics and increase willingness to receive operative treatment.

DISCUSSION

This is the first qualitative study to explore GDPs' observation and understanding of antimicrobial resistance. We found that perceptions of resistance varied widely between practitioners, particularly with respect to the prevalence and impact of resistant strains on the management of dentoalveolar infections and the contribution of dental prescribing to emergence of resistance. Some practitioners felt strongly that they had experienced treatment failure directly related to antibiotic

resistance, while others related poor clinical outcomes to inadequate surgical intervention. Many practitioners felt that prescribing practices of the dentists had improved during the last two decades, with several relating this change to the publication of clinical guidelines regarding antibiotic prescribing. Some GDPs felt that antibiotic prescribing of the dental profession could be improved if operative treatment for acute dental conditions was incentivised under the NHS contract while others described how increasing public awareness of resistance would reduce patient expectation of antibiotics and increase acceptance of operative treatment.

The GDPs interviewed were drawn from a wide range of geographical areas, served local communities with a range of deprivation and were a mix of private and NHS providers and performers. This allowed investigators to obtain a wide range of views and beliefs. However, clinicians who agreed to take part in APICAL may have had a special interest in antibiotic prescribing or postgraduate education. It is possible that we missed important data obtainable only from GDPs who did not wish to participate. While we attempted to interview practitioners from a broad purposive sample of GDPs, our aim was to identify important themes regarding antibiotic resistance, not to generate statements generalisable to other dental practitioners.

Interviewing GDPs about prescribing and antibiotic resistance was potentially professionally sensitive. Practitioners may be aware that their prescribing behaviour deviates from an 'ideal' that exists within clinical guidelines and therefore practitioners' responses may be biased to attempt to provide 'correct', rather than honest responses. However, all GDPs were reassured at the start of the interview that they were not going to be judged on their prescribing decisions and that no consequences would result from anything revealed during the study. In fact, investigators found that GDPs were typically candid about their usual practice and the pressures they experienced. This could be in part, attributable to the shared professional identity between the interviewer and participants, although similar openness has been described in studies where interviewers did not share the profession of the participants being interviewed.⁸

Similar to the current findings, a grounded theory study of GMPs' perceptions of antimicrobial resistance reported that clinicians' antibiotic prescribing decisions were a balancing act between immediate duty to their patient, patient pressure and wider responsibilities to public health.⁸ Dentists participating in the current study particularly highlighted the impact clinical

time pressures could have on their decision to prescribe antibiotics for a patient with an acute dental condition. While the possible association between clinical time pressures and antibiotic prescribing habits of GDPs have been described previously,²⁶ it still remains unclear the exact degree to which time pressures influence prescribing behaviours.

There was a belief among many of the GDPs interviewed that antibiotic prescribing behaviours of the dental profession as a whole had improved over the last few decades. However, recent studies have revealed that antibiotics are still widely used by dentists in the management of acute dental conditions, often without conjunctive local measures (such as dental extraction, endodontic treatment or incision and drainage of a swelling).¹² This suggests that further efforts are needed to continue to impress upon dental professionals the importance of optimising antibiotic usage. Previous interventions that have successfully improved prescribing behaviour among GDPs have included clinical audit,^{27,28} and pharmacist delivered academic detailing.²⁹ However, it is unclear whether these interventions result in long-term changes in antibiotic use and therefore further studies are required to identify the interventions that produce sustained improvements in prescribing behaviour. The current study also highlighted that some GDPs have deficiencies in their knowledge regarding the aetiology of antibiotic resistance, and are unsure about the impact dental prescribing could have on the emergence of resistance. Raising awareness of such matters within the dental community may positively influence some practitioners to improve their prescribing practice. Interventions will also need to take into account the influence clinical pressures have on antibiotic prescribing decisions in primary dental care.

CONCLUSIONS

This is the first study to provide insights into GDPs' perceptions of antibiotic resistance. Dental practitioners are aware of resistance but vary in their assessment of the impact of dental prescribing on the

emergence of resistance. Antibiotic prescribing decisions taken by GDPs are complex and may be influenced by clinical pressures. Interventions to enhance the quality of antibiotic prescribing in primary care dentistry should address these issues while educating GDPs about the aetiology, prevalence and impact of antibiotic resistance.

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- Davies S C. *Annual report of the chief medical officer, volume two, 2011. Infections and the rise of antimicrobial resistance*. London: Department of Health, 2013.
- World Health Organization. *World Health Organization report on infectious diseases 2000: overcoming antimicrobial resistance*. Geneva: WHO, 2000.
- Lewis M A. Why we must reduce dental prescription of antibiotics: European Union Antibiotic Awareness Day. *Br Dent J* 2008; **205**: 537–538.
- Cosgrove S E. The relationship between antimicrobial resistance and patient outcomes: mortality, length of hospital stay, and health care costs. *Clin Infect Dis* 2006; **42**: S82–S9.
- Goossens H, Ferech M, Vander Stichele R, Elseviers M. Outpatient antibiotic use in Europe and association with resistance: a cross-national database study. *Lancet* 2005; **365**: 579–587.
- Costelloe C, Metcalfe C, Lovering A, Mant D, Hay A. Effect of antibiotic prescribing in primary care on antimicrobial resistance in individual patients: systematic review and meta-analysis. *BMJ* 2010; **340**: c2096.
- European Centre for Disease Prevention and Control (ECDC), European Medicines Agency (EMA). *The bacterial challenge: time to react*. Stockholm: ECDC, 2009. Online article available at http://www.ecdc.europa.eu/en/publications/Publications/0909_TER_The_Bacterial_Challenge_Time_to_React.pdf (accessed June 2014).
- Simpson S A, Wood F, Butler C C. General practitioners' perceptions of antimicrobial resistance: a qualitative study. *J Antimicrob Chemother* 2007; **59**: 292–296.
- Wood F, Phillips C, Brookes-Howell L et al. Primary care clinicians' perceptions of antibiotic resistance: a multi-country qualitative interview study. *J Antimicrob Chemother* 2013; **68**: 237–243.
- Karki A J, Holyfield G, Thomas D. Dental prescribing in Wales and associated public health issues. *Br Dent J* 2011; **210**: E21.
- Prescribing and Primary Care Services. *Prescribing by dentists: England 2012*. London: Health and Social Care Information Centre, 2013.
- Tulip D E, Palmer N O. A retrospective investigation of the clinical management of patients attending an out of hours dental clinic in Merseyside under the new NHS dental contract. *Br Dent J* 2008; **205**: 659–664.
- Dailey Y M, Martin M V. Are antibiotics being used appropriately for emergency dental treatment? *Br Dent J* 2001; **191**: 391–393.
- Sweeney L C, Dave J, Chambers P A, Heritage J. Antibiotic resistance in general dental practice—a cause for concern? *J Antimicrob Chemother* 2004; **53**: 567–576.
- Kuriyama T, Karasawa T, Nakagawa K, Nakamura S, Yamamoto E. Antimicrobial susceptibility of major pathogens of orofacial odontogenic infections to 11 β -lactam antibiotics. *Oral Microbiol Immunol* 2002; **17**: 285–289.
- Eick S, Pfister W, Straube E. Antimicrobial susceptibility of anaerobic and capnophilic bacteria isolated from odontogenic abscesses and rapidly progressive periodontitis. *Int J Antimicrob Ag* 1999; **12**: 41–46.
- Teng L J, Hsueh P R, Chen Y C, Ho S W, Luh K T. Antimicrobial susceptibility of viridans group streptococci in Taiwan with an emphasis on the high rates of resistance to penicillin and macrolides in *Streptococcus oralis*. *J Antimicrob Chemother* 1998; **41**: 621–627.
- Kuriyama T, Nakagawa K, Karasawa T, Saiki Y, Yamamoto E, Nakamura S. Past administration of beta-lactam antibiotics and increase in the emergence of beta-lactamase-producing bacteria in patients with orofacial odontogenic infections. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000; **89**: 186–192.
- Mainjot A, D'Hoore W, Vanheusden A, Van Nieuwenhuysen J P. Antibiotic prescribing in dental practice in Belgium. *Int Endod J* 2009; **42**: 1112–1117.
- Patton M Q. *Qualitative research and evaluation methods*. 3rd ed. Thousand Oaks, California: Sage Publishing, Inc, 2002.
- Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006; **3**: 77–101.
- Boyatzis R E. *Transforming qualitative information: thematic analysis and code development*. Thousand Oaks, California: Sage Publishing, Inc, 1998.
- NVivo qualitative data analysis software. 8th ed. OSR International Pty Ltd, 2008.
- Morse J M. The significance of saturation. *Qual Health Res* 1995; **5**: 147–149.
- Statistics for Wales. *Welsh Index of Multiple Deprivation (WIMD)*. Cardiff: Welsh Government, 2011. Online information available at <http://wales.gov.uk/statistics-and-research/welsh-index-multiple-deprivation/?lang=en#/statistics-and-research/welsh-index-multiple-deprivation/?lang=en> (accessed March 2014).
- Palmer N A, Pealing R, Ireland R S, Martin M V. A study of therapeutic antibiotic prescribing in National Health Service general dental practice in England. *Br Dent J* 2000; **188**: 554–558.
- Chate R A, White S, Hale L R et al. The impact of clinical audit on antibiotic prescribing in general dental practice. *Br Dent J* 2006; **201**: 635–641.
- Palmer N A, Dailey Y M, Martin M V. Can audit improve antibiotic prescribing in general dental practice? *Br Dent J* 2001; **191**: 253–255.
- Seager J M, Howell-Jones R S, Dunstan F D, Lewis M A, Richmond S, Thomas D W. A randomised controlled trial of clinical outreach education to rationalise antibiotic prescribing for acute dental pain in the primary care setting. *Br Dent J* 2006; **201**: 217–222.