AN INVESTIGATION OF ANTIBIOTIC PRESCRIBING IN NATIONAL HEALTH SERVICE GENERAL DENTAL PRACTICE IN ENGLAND

Thesis submitted in accordance with the requirements

of the University of Liverpool for the degree of

Doctor of Philosophy by

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This thesis is dedicated to my mother and late father, who have always supported and encouraged me and been proud of my achievements.

The knowledge of man is as the waters, some descending from above, and some springing from beneath; the one informed by the light of nature, the other inspired by divine revelation.

Francis Bacon

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ABSTRACT

AN INVESTIGATION OF ANTIBIOTIC PRESCRIBING IN NHS GENERAL DENTAL PRACTICE IN ENGLAND

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There is a worldwide problem of antimicrobial resistance caused by the overuse of antibiotics. Part of the work described in this thesis investigated the prescribing of antibiotics by dental practitioners in NHS general dental practice to determine whether they prescribe appropriately. The knowledge of general dental practitioners on antibiotic use was also investigated. In the absence of guidelines on the use of antibiotics one of the aims of this thesis was to devise guidelines based on the evidence available, disseminate the guidelines and test their effectiveness through audit.

It was clear from the results that the therapeutic prescribing of antibiotics in general dental practice varies widely with evidence of gross overuse. A significant number of general dental practitioners also prescribed prophylactic antibiotics inappropriately, both for surgical procedures and for patients at risk from bacterial endocarditis. Some dental practitioners prescribed prophylactic antibiotics for clinical procedures and medical conditions for which there was no benefit to the patient. From the

results of the prescription investigation it was clear that there was a wide variation in the doses, frequencies and duration of the antibiotics prescribed by general dental practitioners, with a significant number being outside the recommendations of the Dental Practitioners Formulary.

General dental practitioners' knowledge of the use of antibiotics in clinical practice was generally good, but there were some areas of prescribing which showed deficiencies in knowledge. A critical review of the literature resulted in the production of nationally agreed guidelines on the use of antibiotics in general dental practice. The effectiveness of these guidelines was tested in an audit. A significant improvement in the appropriateness of general dental practitioner prescribing of antibiotics was found, along with a large decrease in the number of prescriptions issued following the use of the guidelines.

The methods described within this thesis have been used to investigate dental practitioner prescribing in a number of countries. The guidelines and results in this thesis have been used to start to investigate and improve undergraduate and postgraduate education of dentists, in the belief that this will give rise to more rational prescribing and thereby minimise the further development of antimicrobial resistance.

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PREFACE AND ABBREVIATIONS

The terms "antibiotic" and "antimicrobial" have been used throughout this thesis for substances which inhibit or kill micro-organisms.

Throughout this thesis exclusive use of the rINN has been used in preference to the UK name of antibiotics. It is now accepted practice (Directive 92/27/EEC) to use the Recommended International Non-proprietary Name (rINN) for all medicinal substances.

The conventions used for referencing within the text of this thesis follow the Havard method and are as follows:

Textual references in the text are quoted by the author's name and the year of publication. Where there is more than one author only the first author is stated plus *et al.*

Off text referencing, where the citation is not part of the text, is given as (Name (s) Date). Where there are more than three authors only the first author is used plus *et al.* Where several references are shown, these are separated by semicolons and placed chronologically.

The bibliography is in the Vancouver style with the references placed in alphabetical order of the first named author showing their surname and initials, followed by the other authors of the citation.

Bacterial nomenclature and taxonomy used in this thesis is that adopted by the Journal of Antimicrobial Chemotherapy.

PREFACE AND ABBREVIATIONS cont.

Units of measurement are expressed in SI units.

Latin abbreviations.

bd- *bis die* (twice daily)

tds- *ter die sumendus* (three times daily)

qds- *quarter die sumendus* (four times daily)

Other abbreviations used are as follows:

ADA- American Dental Association

AHA- American Heart Association

AIDs- Autoimmunodeficiency Disease

BNF- British National Formulary

BSAC- British Society for Antimicrobial Chemotherapy

CDS- Community Dental Services

DNA- Deoxyribonucleic acid

DPF- Dental Practitioners' Formulary

FGDP (UK)- Faculty of General Dental Practitioners (UK)

GDP- General Dental Practitioner

GDS- General Dental Services

GMP- General Medical Practitioner

MREC- Multi-centre Research Ethical Committee

NHS- National Health Service

PPA- Prescription Pricing Authority

SMAC- Standing Medical Advisory Committee

SPSS- Statistical Package for Social Science

Tab- tablet

1. INTRODUCTION

Since their discovery antibiotics have played an essential role in decreasing morbidity and mortality caused by infectious diseases. Approximately 50 million prescriptions for antibiotics are dispensed in England every year. This equates to one prescription for each person every year. Most human prescribing in the UK (80%) is of oral antibiotics in the community, the majority by general medical practitioners. General dental practitioners account for approximately 7% of antibiotics dispensed in the community (Standing Medical Advisory Committee, 1998). There is growing concern that the overuse of antibiotics in man may contribute to the problem of antimicrobial resistance.

1.1 Antimicrobial resistance

Nearly half a century ago scientists noticed the emergence of β-lactamase penicillin-resistant bacteria. One of the first resistant bacteria to be isolated was *Staphylococcus aureus,* a common bacterium in the human body's normal bacterial flora. In recent years infections caused by resistant strains have increased worldwide with as many as 60% of hospital-acquired infections caused by drug-resistant microbes. The most recent of these infections – multidrug-resistant tuberculosis (MDR-TB), vancomycin-resistant *Enterococci* (VRE) and methicillin-resistant *Staphylococcus aureus* (MRSA) – are no longer confined to hospitals but are present in the community at large. This has lead to serious concern by the World Health Organisation concerning the widespread overuse of antibiotics. The World Health Organisation (1997) stressed the importance of the monitoring and management of bacterial resistance to antimicrobial agents and developing a global strategy for the containment of antimicrobial resistance. In the House of Lords Select Committee on Science and Technology, Seventh Report (1998) on resistance to antibiotics and other antimicrobial agents, Lord Soulsby, Chairman of the Select Committee, stated:

"This enquiry has been an alarming experience, which leaves us convinced that resistance to antibiotic agents and other anti-infective agents constitutes a major threat to public health and ought to be recognised as such more widely than it is at the present time."

In 1997 the Chief Medical Officer asked the Standing Medical Advisory Committee (SMAC) to examine the effect of medical prescribing on antimicrobial resistance. The SMAC responded by setting up an interdisciplinary group including representation from the Standing Dental Advisory Committee. Their report (Standing Medical Advisory Committee, 1998) made recommendations directed towards:

"Ensuring that best practice in antimicrobial prescribing becomes routine practice. This will require a willingness, on the part of the health care professionals and the public alike, to treat antimicrobials as a valuable and non-renewable resource, to be treasured and conserved in everyone's interest."

There is therefore an ethical responsibility for every clinician to use antimicrobials in a way that minimises the emergence of antimicrobial resistant micro-organisms.

1.1.1 Antimicrobial resistance and the oral cavity

Odontogenic infections typically are polymicrobial, containing a mixture of Gram-positive and Gram-negative organisms such as anaerobic streptococci and *Prevotella* species (Smith and Bagg, 1998a). One study (Lewis *et al.*, 1995) found that 23% of bacterial isolates from acute suppurative oral infections contained β-lactamase producing bacteria which were resistant to penicillin and 5% were also resistant to a combination of amoxicillin and clavulanic acid (Augmentin). The problem of β-lactamase production and penicillin resistance amongst *Bacteroides* species and *Prevotella* species has been noted and is thought to be increasing (Heimdahl, von Konow and Nord, 1981; Tuner and Nord, 1993; Kononen *et al.*, 1995; Matto *et al.*, 1999). Failures have also been reported of antimicrobial therapy in odontogenic infections with penicillin due to β-lactamase producing bacteria (Heimdahl, von Konow and Nord, 1980).

Kilian (1995) reported the presence of metronidazole-resistant *Helicobacter pylori* and suggested that dentally prescribed metronidazole could have contributed to this resistance. In a study of patients receiving prophylaxis it was found that 22% had erythromycin-resistant oral streptococci (Longman *et al.*, 1991). It was reported in a study of patients with periodontitis that 23% of the flora (oral streptococci, staphylococci, enterobacteriaceae and *Actinomyces* species) was resistant to tetracyclines (Olsvik *et al.*, 1995). A study of pus aspirates showed that 54% of strains of *Streptococcus mitis* isolated from dentoalveolar infections were shown to be penicillin- and erythromycin-resistant (Smith *et al.*, 1999).

There is therefore ample evidence that the overuse of antibiotics is contributing to the emergence of resistant strains within the oral cavity. The importance of best practice in antimicrobial prescribing in general dental practice is therefore essential in order to reduce the threat to public health of antimicrobial resistance. This takes on greater significance because it has been suggested that foreign DNA obtained from *Streptococcus oralis* may have a role to play in penicillin resistance in *Streptococcus pneumoniae* (Coffey *et al.*, 1993). This was thought to be particularly significant because the high levels of prescribing for upper respiratory infections favour the emergence of resistant oral streptococci. These resistant streptococci transmit their genes to pneumococci in the upper respiratory tract. The mechanism of this transmission and other mechanisms of antimicrobial resistance will be dealt with in detail in the next section.

1.1.2 Mechanisms of antimicrobial resistance

The basic principle for the emergence of antimicrobial resistance is based on Darwinian selection. Antimicrobials kill susceptible bacteria but the resistant ones survive to multiply and potentially infect other patients. Although bacteria are often referred to as being resistant to antibiotics, even the most resistant bacterium can be inhibited or killed, *in vitro*, by a sufficiently high antibiotic concentration. Patients would not, however, be able to tolerate the high toxic concentrations of antibiotic required in most cases. The susceptibility of bacterial species to an antibiotic varies considerably, for example, *Streptococcus pneumoniae* have a minimum inhibitory concentration of 0.01 mgl^{-1} to benzylpenicillin whereas *Escherichia coli* requires 32-64mgl^{-1} to inhibit growth, which cannot be achieved in the body without toxicity (Hawkey, 1998). This susceptibility of bacterial species to an antibiotic gives rise to the concept of clinical resistance, which is dependent on outcome. The outcome for the patient is a result of the interaction of the type of infecting bacterium, its location in the body, the tissue distribution of the prescribed antibiotic, its concentration at the site of the infection and the immune status of the patient.

Bacteria exhibit many mechanisms to protect themselves from antibiotics. Hayward and Griffin (1994) and Smith and Bagg (1998b) give detailed accounts of these mechanisms. They can be classified into five basic types, as shown in Figure 1.1, and are described in the following sections.

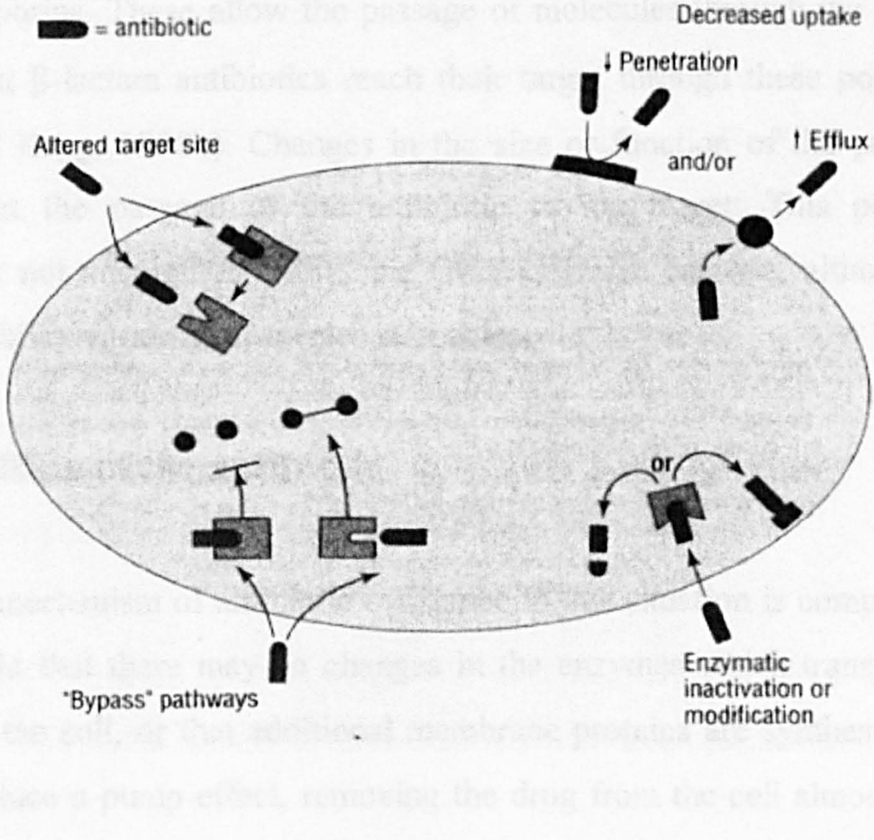
1.1.2.1 Antibiotic modification

This is the most common mechanism of resistance to the most often used antibiotics - the penicillins. The resistant strains of bacteria still retain the same sensitive target as sensitive strains but the antibiotic is prevented from reaching it. The four membered β-lactam ring of the penicillin is broken down by bacterial enzymes called β-lactamases, rendering the antibiotic inactive. There are over 200 types of β-lactamases, which are widespread amongst many Gram-positive and Gram-negative bacterial species (Bush, Jacoby and Medeiros, 1995). Beta-lactamases exist naturally in all bacteria but are only produced in small amounts to deal with the breakdown of by-products involved with cell wall metabolism. Resistant strains, however, produce large amounts of 2-lactamases which are released extracellularly.

Figure 1.1

Mechanisms of antibiotic resistance.

(Reproduced from Hawkey, (1998) with permission of the BMJ Publishing Group)



Most β-lactamases inactivate, to some degree, both penicillins and cephalosporins (Livermore, 1995).

1.1.2.2 Altered cell wall permeability

Some resistant bacteria protect the target from antibiotic action by preventing penetration of the cell wall. The walls of Gram-negative bacteria consist of an outer membrane that protects the cell. This is a bi-layered lipid structure with hollows consisting of protein molecules known as porins. These allow the passage of molecules through the cell wall. Most β-lactam antibiotics reach their target through these porins (Smith and Bagg, 1998b). Changes in the size or function of the porin can prevent the passage of the antibiotic to the target. This porin variation is not uncommon with some Gram-negative bacteria, although the permeability varies from species to species.

1.1.2.3 Efflux of the antibiotic

The exact mechanism of antibiotic resistance in this situation is complex. It is thought that there may be changes in the enzymes which transport drugs into the cell, or that additional membrane proteins are synthesized which produce a pump effect, removing the drug from the cell almost as soon as it enters. The antibiotic therefore never reaches an inhibitory level. This is a recognised mechanism for tetracycline resistance (Chopra, Hawkey and Hinton, 1992).

1.1.2.4 Modification of the target

The antibiotic can penetrate the cell membrane and reach the target but is unable to inhibit the activity of the target because of structural changes in the molecule. Enterococci are inherently resistant to cephalosporins because the enzymes responsible for cell wall synthesis (by the production of the polymer peptidoglycan) have a low affinity for cephalosporins and are therefore not inhibited. Most strains of *Streptococcus pneumoniae,* although susceptible to penicillins and cephalosporins, acquire DNA from other bacteria. The acquisition of the DNA changes the enzyme for cell wall synthesis. The altered enzyme still synthesizes peptidoglycan but its structure is altered (Garcia-Bustos and Tomasz, 1990) so that it deveops a low affinity to penicillins. The antibiotic is unable to prevent cross-linking of the peptidoglycan in the bacterial cell wall and therefore the organism becomes resistant to inhibition by penicillins (Tomasz and Munoz, 1995).

1.1.2.5 Production of alternative target

The other mechanism by which bacteria can protect themselves from antibiotics is by the production of an alternative target, usually an enzyme, which is resistant to inhibition by the antibiotic whilst continuing to produce the original sensitive target. The alternative enzyme therefore "bypasses" the effect of the antibiotic. Methicillin-resistant *Staphylococcus aureus* (MRSA) produce an alternative penicillin binding protein (PBP2a) in addition to the normal proteins. As PBP2a is not inhibited by antibiotics, such as flucloxacillin, the cell continues to produce peptidoglycans to maintain a sound cell wall and the organism remains viable (Michel and Gutmann, 1997).

1.1.3 Genetics of resistance

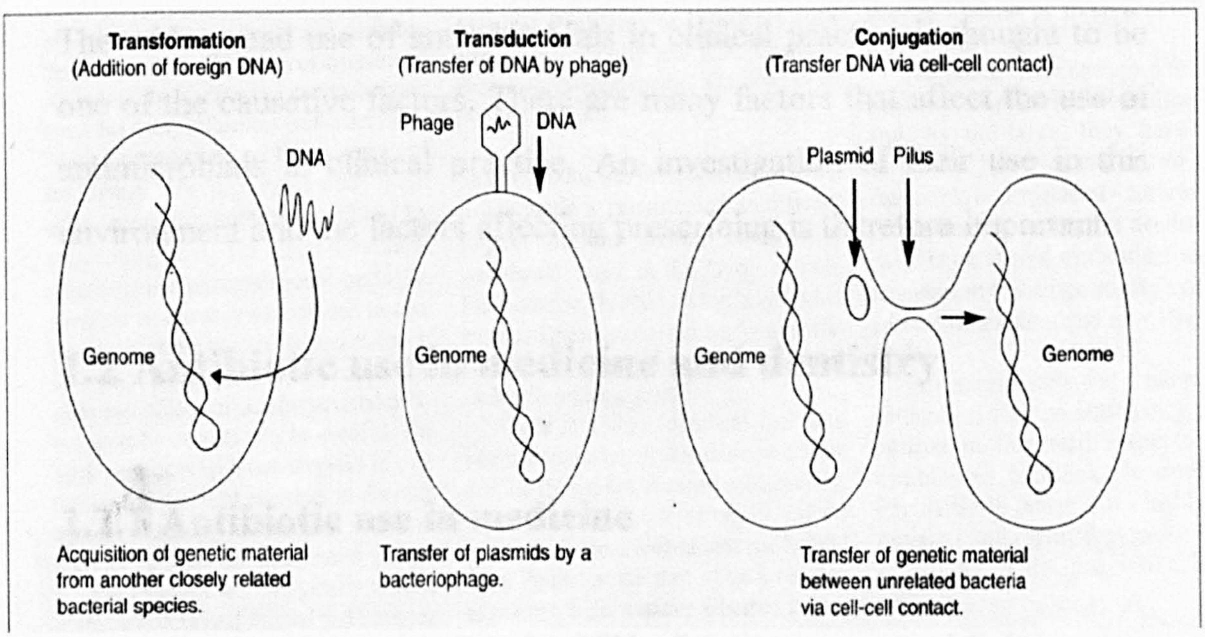
Resistance in bacteria can be intrinsic or acquired. Intrinsic resistance occurs naturally and is present in the genome of a bacterium, for example vancomycin-resistant *Escherichia coli.* Acquired resistance develops when an antibiotic-sensitive bacterium becomes resistant. This may occur by mutation or acquisition of new DNA. The mechanisms are described by Smith and Bagg (1998b) and are shown in Figure 1.2.

Bacteria have only one chromosome and the potential to divide from one cell to 16 million cells in a six-hour period. This allows for a multiplicity of opportunities for mutation and transfer of genetic material. Resistance as a result of mutation can be passed vertically within the species (transformation) or resistance can result from acquisition of genetic material from unrelated bacteria (conjugation). Bacteriophages can also transfer resistance (transduction) and this is seen in staphylococci. The genetic material is most often transferred by plasmids, which are self-replicating loops of DNA, or transposons, which are discrete segments of DNA. The range of bacteria to which plasmids can spread is often limited. Transposons therefore play a role in passing resistance between species, including from commensals to pathogens and *vice versa.*

Figure 1.2

Mechanisms by which bacteria acquire antimicrobial resistant genes.

(Reproduced from Smith and Bagg, (1998b) with kind permission of George Warman Publications (UK) Ltd)



The evidence linking antimicrobial use in man and resistance is overwhelming. Acquired resistance is absent from bacteria before the antimicrobial era with only inherent resistance to specific species being present. Resistance has repeatedly emerged following the introduction of new drugs and then clinical use and tends to occur where their use is the heaviest. It often develops in the normal bacterial flora of patients receiving antimicrobial therapy, such that if a further infection arises from this flora it is more likely to be resistant. This is more likely to occur in patients treated with antibiotics than in those who have not received therapy.

The widespread use of antimicrobials in clinical practice is thought to be one of the causative factors. There are many factors that affect the use of antimicrobials in clinical practice. An investigation of their use in this environment and the factors affecting prescribing is therefore important.

1.2 Antibiotic use in medicine and dentistry

1.2.1 Antibiotic use in medicine

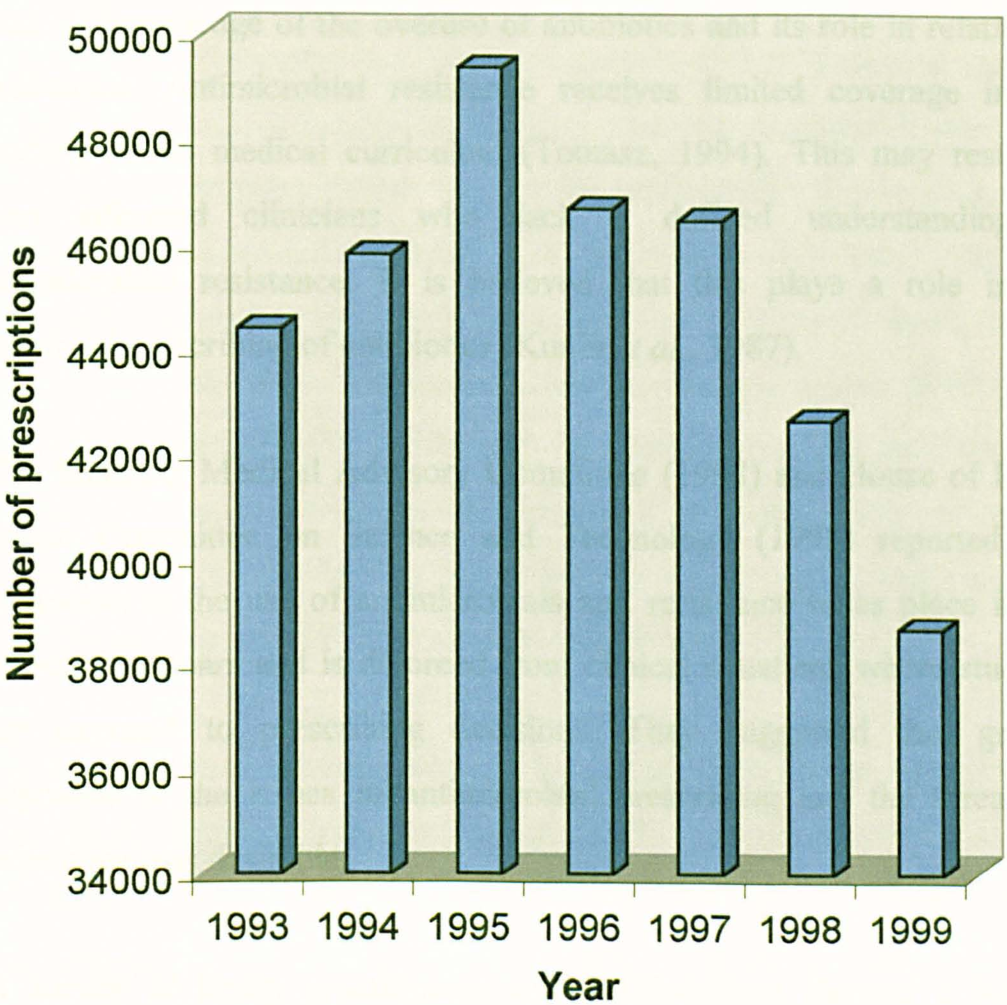
Hospital prescribing accounts for 20% of human usage and is important, mainly because the prescribing is in a confined environment and is concentrated on a small number of patients who tend to be medically compromised. The majority of antibiotic prescribing in the hospital environment is for respiratory tract infections. In a national survey of infection in 43 hospitals in the UK it was noted that 25% of patients received antibiotics (Emmerson, 2000). Of these patients, however, less than 50% showed any evidence of infection. Emmerson also stated that in another study that most hospital patients receiving antibiotics were treated without bacteriological evidence of the infecting pathogen. In Emmerson's review only 7% of antibiotics prescribed for surgical prophylaxis fulfilled the criteria for the suitability of drug and timing of administration. This irrational use of antibiotics in the hospital environment, known to be a fertile environment for opportunistic infections due to the compromised nature of the patient, contributes to the problem of resistant bacteria in man.

The Department of Health (1999) statistics for the number of antibiotic prescriptions dispensed in the UK by primary care medical practitioners is shown in Figure 2.1. It is believed that between 20%-50% of antibiotic use in primary care medicine is inappropriate (Harrison and Lederberg, 1998). Over 50% of community use in medicine of antibiotics is for respiratory tract infections, where the vast majority of infections are due to viral pathogens. A further 15% of antibiotics are used for urinary tract infections where there is evidence of protracted use of antibiotics (Standing Medical Advisory Committee, 1998).

Most respiratory tract infections are for tonsillopharyngitis (sore throat) and it has been shown in a double-blind trial of penicillin and placebo, that antibiotics have a minor impact on the duration of symptoms (Whitfield and Hughes, 1981). In a nationwide study in the Netherlands it was found that 70% of practitioners would prescribe antibiotics for sore throat (Kuyvenhoven, de Melker and van der Velden, 1993).

Figure 1.3

General medical practitioner antibiotic prescription items dispensed in thousands for the years 1993-1999



1.2.1.1 Factors contributing to the inappropriate use of antibiotics in medical practice

There are many factors that can lead to the inappropriate use of antibiotics in medical practice, thereby contributing to the problem of antimicrobial resistance. One of these factors may be the prescribers' lack of knowledge of the overuse of antibiotics and its role in relation to resistance. Antimicrobial resistance receives limited coverage in the undergraduate medical curriculum (Tomasz, 1994). This may result in less informed clinicians who lack a defined understanding of antimicrobial resistance. It is believed that this plays a role in the irrational prescribing of antibiotics (Kunin *et al.*, 1987).

The Standing Medical Advisory Committee (1998) and House of Lords Select Committee on Science and Technology (1998) reported that education in the use of antimicrobials and resistance takes place in the pre-clinical years and is divorced from clinical situations where students are exposed to prescribing decisions. They suggested that greater exposure to the issues of antimicrobial prescribing and the threats of resistance was desirable.

A survey of family practitioners and paediatricians showed a lack of knowledge among respondents about the use of antibiotics in the treatment of acute purulent rhinitis (Schwartz *et al.*, 1997). In this survey over 70% of family practitioners and 53% of paediatricians prescribed antibiotics for acute purulent rhinitis of short duration where there is no indication for antibiotics. Prior experience of antibiotic prescribing is thought to be another factor in inappropriate prescribing (Belongia and

Schwartz, 1998). Belongia and Schwartz (1998) also suggested that prescribers maintained the diagnostic and prescribing habits from the pre-antibiotic resistance era. A further study (Kuyvenhoven, de Melker and van der Velden, 1993) showed that practitioners who had qualified since 1975 prescribed more appropriately for sore throat.

Inappropriate or inadequate diagnosis of a medical condition may also cause overuse of antibiotics. McIsaac and Goel (1997) showed that the majority of family practitioners failed to make an adequate diagnosis by using throat cultures before prescribing antibiotics. Where diagnostic facilities are unavailable, making a differential diagnosis, organism identification, and antimicrobial susceptibility patterns difficult, it has been shown that greater amounts of antimicrobials are prescribed (Bosu and Ofori-Adjei, 1997). It has also been suggested that as resistance becomes more prevalent, prescribers may be more likely to utilize broader spectrum antibiotics for empirical therapy and prophylaxis of infections (Yu *et al.*, 1991; Goldmann and Huskins, 1997).

The use of the incorrect antibiotic for bacterial infections may lead to overuse and proliferation of resistance. In China it was reported that 63% of antimicrobials used to treat proven bacterial infections were inappropriate (Hui *et al.*, 1997). In another study in Bangladesh 50% of prescriptions for antimicrobials in a hospital unit were inappropriate (Hossain, Glass and Khan, 1982).

Inappropriate dose, frequency and duration are also believed to give rise to antimicrobial resistance. A correlation exists between long treatment duration, sub-therapeutic or sub-optimal doses and increases in selective resistance (Rice *et al.*, 1990; Guillemot *et al.*, 1998). Many scientists and clinicians (Martin *et al.*, 1997b; Pichichero and Cohen, 1997) believe that shorter courses decrease the selective resistance pressures of antimicrobials on micro-organisms.

One of the most important reasons for over prescribing in general medical practice is patient expectation. Bosu and Ofori-Adjei (1997) and Macfarlane *et al.* (1997a) have shown patient demand for antimicrobials increases unnecessary prescriptions. In the study by Macfarlane *et al.* (1997a) patient pressure was the most common influence in the decision to prescribe, even when the clinician felt antibiotics were not indicated. In a survey of 3610 patients conducted by Branthwaite and Pechere (1996) 50% of patients believed that antibiotics should be prescribed for respiratory tract infections, with the exception of the common cold. A total of 81% expected to feel better after three days and 87% would then cease therapy and reuse them again at a later time. Many patients received antibiotics for viral respiratory illness and these treatments were perceived as effective, even though the infections were self-limiting. It was felt that this enhances patient beliefs that antibiotics are necessary and they continue to request them (Macfarlane, Holmes and Macfarlane, 1997b; Little *et al.*, 1997). This type of demand prescribing leads to a 'perpetual cycle' where patients receive antibiotics when they are not indicated.

Within medical practice fear of litigation is thought to be one reason why clinicians over prescribe antimicrobials (Fidler, 1998). It has also been suggested that financial considerations within medical practice may be a factor in over prescribing. It may be quicker for clinicians to prescribe an antibiotic, rather than treat the patient or assess the patient's understanding of a condition. Avorn (1987) expressed the view that the positive economic benefit to the clinician is seen where patient expectation of a prescription, if not fulfilled, could lead to a loss of patients as a result of consistently opposing such requests.

It can be concluded from this brief review of antibiotic prescribing in medical practice that inappropriate prescribing is common. It has also been shown that a number of non-clinical factors can affect prescribing in medical practice. A number of strategies for promoting the judicious use of antibiotics by doctors and patients have been suggested in order to reduce the problem of antimicrobial resistance.

1.2.1.2 Strategies for reducing the inappropriate use of antibiotics in medical practice

In order to reduce inappropriate use of antimicrobials it is important to understand the prescribing patterns of practitioners. This enables identification of the areas where strategies may be developed to improve the use of antibiotics; this has been investigated.

A number of strategies have been used to reduce inappropriate prescribing in medical practice. A study in Finland showed that the introduction of nationwide recommendations to reduce the use of macrolides in respiratory and skin infections reduced prescriptions by 50%. As a result the proportion of group A streptococci infections resistant to macrolides was nearly halved over a four-year period (Seppala *et al.*, 1997). An intervention study by Stephenson (1996) reduced the prescribing of antibiotics and as a result decreased the proportion of pnuemococcal infections caused by penicillin-resistant strains.

Educational initiatives have been shown to be effective in changing medical practitioners' prescribing habits. In a randomised controlled trial educational material, together with pharmacist visits to practitioners, improved appropriate prescribing for sore throats (De Santis *et al.*, 1994). D'Angio *et al.* (1990) in a further study also showed the benefit of an educational programme, including mailing, in reducing antibiotic prescribing. The use of pharmacists in educating clinicians can also have a positive impact on the correct utilization of antibiotics (Thornton *et al.*, 1991). A controlled trial of three educational interventions showed that direct mailing and a drug educator had little effect in comparison to a visit from a physician to discuss changes in prescribing practice (Schaffner *et al.*, 1983). In a prospective study of the use of a computer-assisted management program for antibiotics and other anti-infective agents more appropriate prescribing of antibiotics at the correct dose and duration was evident (Evans *et al.*, 1998).

The Standing Medical Advisory Committee (1998) has suggested that evidence-based guidelines are urgently needed for antimicrobial use, particularly for the treatment of common clinical conditions in the community. The use of guidelines in the past has been shown to improve prescribing in medical practice. In three surveys, one before the production of guidelines, a second eight months after the production of guidelines and a third four years later, an increase in the proportion of appropriate prescribing of antibiotics was demonstrated (Harvey *et al.*, 1983). Harvey concluded that guidelines facilitate the audit of antibiotic usage and aid rational prescribing.

Patient leaflets have been used to improve patient knowledge in the use of antibiotics for lower respiratory tract infections (Macfarlane, Holmes and Macfarlane, 1997b). This strategy was shown to reduce antibiotic prescriptions and the future consultation habits of patients. Belongia and Schwartz (1998) have suggested a multifaceted approach to increase public understanding of antibiotic resistance and to change expectations about the use of antibiotics. They suggested not only a public relations campaign, but clinic-based education and community outreach activities. Some of these strategies have been put in place causing a decrease of prescribing of antibiotics by GMPs (see Figure 1.3).

The Standing Medical Advisory Committee (1998) stressed the need to improve medical education at undergraduate level. It has been suggested that increasing the problem-based pharmacotherapy training for medical and paramedical students can have a positive effect on long-term good prescribing habits. In an international randomised controlled study, utilising a manual designed to support problem-based learning, a positive impact on the prescribing skills of 219 students in seven medical schools was demonstrated (de Vries *et al.*, 1995). Students from the study group performed significantly better than controls in prescribing in all the patient problems presented.

1.2.2 Antibiotic use in dental practice

Antibiotics are used in dental practice therapeutically as an adjunct to the management of dental infections and prophylactically to prevent metastatic infection, such as infective endocarditis. Department of Health (1999) statistics of the use of antibiotics by GDPs are shown in

Figure 1.4. The trends of GDP prescribing can be compared with antibiotic use of medical practitioners from 1993-1999 in Figure 1.3. It can be seen that medical practitioner prescribing of antibiotics is reducing, whereas dental practitioner antibiotic prescribing is steadily increasing.

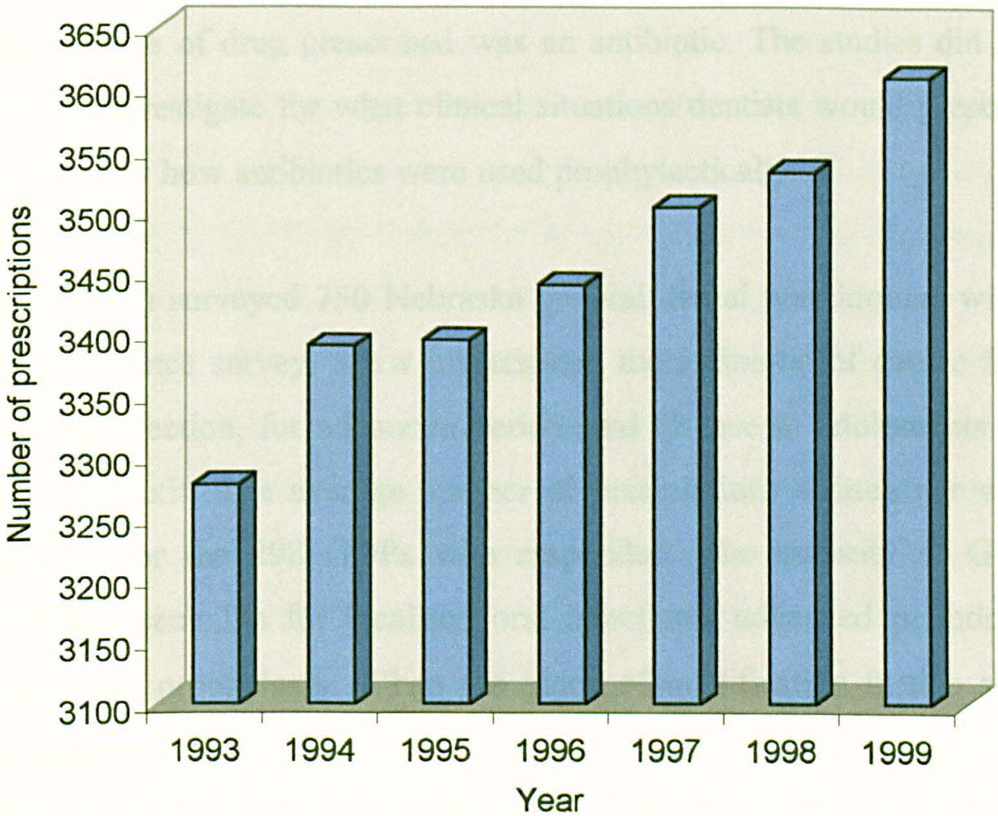
The number of prescriptions issued by general dental practitioners is approximately 7% of all antibiotics prescribed in the community. This small number may play a part in the emergence of resistant strains, particularly if there was evidence of inappropriate use. There is however, little information available on the antibiotic prescribing practices of general dental practitioners, particularly in England. This will be investigated in this thesis.

Most of the early studies of prescribing by dental practitioners were undertaken in the United States of America and looked at the range of drugs prescribed. In a survey of 357 volunteer dentists in the New York area information on all drugs prescribed over a four-week period was collected (Ciancio *et al.*, 1989). Over 4500 prescriptions were issued with 157 different medications. It was found that the majority of prescriptions (2458) were written for antibiotics by general dental practitioners. Within this study penicillin was the most frequently prescribed antibiotic (1783) followed by erythromycin (808).

Picozzi and Ross (1989) used a 14-item questionnaire to investigate dentists drug prescribing habits. Volunteer dentists (402), of whom 92% were general practitioners, representing 47 states in the USA responded. Part of this survey investigated which antibiotics would be used for treating infections.

Figure 1.4

The number of antibiotic prescription items prescribed by general dental practitioners in thousands for 1993-1999



Virtually all dentists listed penicillin as their first choice for the treatment of dental infections. These studies involved non-random samples and provided very limited information on antibiotic prescribing practices of GDPs. McFarland (1976) investigated the drug prescribing practices of 57 Kentucky general dental practices for a four-week period. Of a total of 14,697 patients treated, 678 (4.6%) received medication for home use. The most frequently prescribed drugs in this study were penicillin antibiotics (33.2%). These studies showed that the most common type of drug prescribed was an antibiotic. The studies did not, however, investigate for what clinical situations dentists would prescribe antibiotics or how antibiotics were used prophylactically.

Shaw (1983) surveyed 750 Nebraska general dental practitioners with a drug preference survey. Shaw investigated the antibiotic of choice for a localised infection, for advanced periodontal disease in adolescents and for prophylaxis. The average number of prescriptions written per week was nine for the 298 GDPs who responded. The majority of GDPs prescribed penicillin for localised oral infections, advanced periodontal disease and prophylaxis. When the place of qualification in this study was compared to drug prescribing preferences there was no significant difference. The year of qualification, however, showed a highly significant difference in drug prescribing preferences, with younger dentists prescribing more appropriately. The results of this survey suggested that drug selection is profoundly affected by dental school education and remains resistant to postgraduate influence. Shaw and Krejci (1993) conducted a further survey of 500 randomly selected general dental practitioners in Nebraska. In this survey practitioners were asked to identify the drug they would use for prevention of bacterial endocarditis. Most of the respondents (343) would have prescribed a penicillin (97%) in this situation. There was, however, a significant difference in older dentists who would prescribe erythromycin or tetracycline for prophylaxis. The studies of Shaw (1983) and Shaw and Krejci (1993) looked at two specific areas of antibiotic prescribing and did not investigate the clinical conditions or factors that might affect prescribing. One of the aims of this thesis is to investigate prescribing for a wide range of commonly presenting clinical conditions in general dental practice.

Schuman *et al.* (1983) were concerned about the wide range of opinion on the use of antibiotics in paediatric practice so undertook a questionnaire survey to determine the specific use of antibiotics amongst members of the American Academy of Paedodontics. In this study 80% of respondents routinely gave prophylaxis for heart conditions, 35% for patients with trauma and swelling, 62% for patients with an infection and swelling and 86% for cellulitis. There were however, wide geographical variations in responses demonstrating a lack of consensus as to the indications for antibiotic use.

Durack (1975) and Brooks (1980) investigated the current practice and compliance of GDPs with guidelines for prevention of bacterial endocarditis by way of questionnaires. In both these studies the majority of dentists failed to use the correct regimen. A questionnaire survey of GDPs and community dentists in the Lothian area investigated the provision of prophylaxis for endocarditis (Holbrook, Willey and Shaw, 1983). This survey showed that there was inadequate identification of patients at risk, there was doubt as to what procedures needed antibiotic cover, that antibiotics when administered fell outside the guidelines and that preventive dental treatment for "at risk" patients had not been fully implemented. Gould (1984) in a further questionnaire survey, which included 320 GDPs and 400 GMPs in East London, investigated the medical conditions and the dental procedures that predispose to infective endocarditis and reported similar findings.

Preus *et al.* (1992) undertook a questionnaire study of antibiotic prescribing practices of 10% of all Norwegian dentists. Preus and colleagues found that during a typical week 32% did not prescribe antibiotics and 5% wrote more than five prescriptions. The mean number of prescriptions for each dentist was 2.04. Specialist practitioners (e.g. periodontists and oral surgeons) prescribed significantly more than general dental practitioners. Dentists with research, or teaching experience, prescribed significantly more than those without. It was also concluded from this study that 22% might prescribe when the patient is in pain, 73% and 38% in cases of abscesses with or without malaise, 2.5% for endodontic therapy, 60% to prevent complications and 68% for prophylaxis if the patient revealed a history of endocarditis. In this study the penicillins were the antibiotics of choice in most cases. This limited study involving all grades of dentist confirmed some inappropriate prescribing of antibiotics, particularly for patients in pain and for infections where there was no indication of a systemic involvement. It was also shown that there was inappropriate prescribing for patients requiring prophylaxis.

In a questionnaire study of 600 general dental practitioners in the UK (Lewis *et al.*, 1989b), GDPs were asked to estimate the approximate number of patients who presented with bacterial infections seen per month and record their choice of antibiotic. It was estimated that only 5% of all patients seen presented with acute infections and seven different antibiotics with a variety of regimens would be prescribed. This study did not show actual incidences of infection, but gave an account of the antibiotics that would be prescribed by dentists to treat dental infections. In this particular study penicillin was the antibiotic of choice for the majority of GDPs for dental infections, apart from acute ulcerative gingivitis.

Muthukrishnan *et al.* (1996), in another questionnaire study in the Torbay area, examined medical and dental practitioners' antibiotic management of an imaginary clinical situation relating to an acute dentoalveolar infection. Most of the general medical practitioners and GDPs surveyed would have used amoxicillin or penicillin, but with patients allergic to penicillin erythromycin was the antibiotic of choice. It was shown that medical practitioners tended to prescribe at higher doses than GDPs. The conclusions drawn from this study were that general medical practitioner prescribing choices differed significantly from those of dental practitioners, and that both medical and dental practitioners were unaware of the inappropriateness of the doses employed. It was evident from the results that a greater awareness of the use of antibiotics by general dental practitioners was required.

All the questionnaire studies reviewed above were limited in the areas of investigation and in sample size. One of the aims of this thesis was to investigate the broad area of antibiotic prescribing by a large population of geographically distributed GDPs.

The use of antibiotics in dental hospital practice has been investigated. In a study of antibiotic prescribing by dentists at Manchester Dental Hospital over a one-month period, 80% of prescriptions were for the treatment of dental and oral infections; the remaining 20% were for prophylaxis for infective endocarditis (Barker and Qualtrough, 1987). This study examined the case notes for 192 sequential patients who received antibiotics. The information collected was the antibiotic and dosage, the status of the prescribers, clinical findings such as pain, swelling, temperature, clinical diagnosis and treatment done. The results were compared with the taught principles for the prescribing of antibiotics. The conclusions that were drawn from this study were that in many cases too many prescriptions were issued and too few alternative clinical interventions employed. It was felt by Barker and Qualtrough (1987) that there was a need for stricter control of antibiotic prescribing in order to prevent the development of resistance, needless patient exposure and the possible development of hypersensitivity.

A prospective cross-sectional study of 500 new patients who attended the examination and emergency clinic of Cardiff Dental School in May 1994 was undertaken (Thomas *et al.*, 1996). The source and type of antibiotic prescribed and the nature of the complaint were recorded. The results showed that antibiotics were prescribed in 30% of patients and there was a wide variation in the prescriptions by both medical (33%) and dental practitioners (55%). It was concluded from the study that a large number of prescriptions for antibiotics were prescribed for inappropriate clinical conditions (e.g. pulpitis). This study also suggested that there was a need to target both medical and dental practitioners with prescribing protocols in an attempt to rationalize prescribing. Highlighted from this study was the problem of attempting to investigate prescribing patterns for dental infections from data derived from prescriptions alone. One of the aims of this thesis was to investigate

GDPs prescribing patterns both by a questionnaire and analysis of prescriptions.

Mason *et al.* (1997) investigated the early management of 155 children and adolescents presenting with pain at the Eastman Dental Institute. The investigation consisted of a questionnaire investigating symptoms and any medication taken. The results showed that 67 children had received antibiotic therapy, of whom 31% did not have any localised swelling. This study suggested that children sometimes receive inappropriate initial treatment for dental pain in the form of antibiotics from GDPs.

Palmer (1996) in an audit of an emergency "out of hours" service showed that of 50% patients who attended for consultations and received antibiotics only 25% had evidence of infection. It was shown that an antibiotic was prescribed rather than a definitive diagnosis made and appropriate treatment provided. The study also suggests that GDPs use antibiotics to manage emergency patients more quickly. These aspects of antibiotic prescribing (e.g. difficulty in making a diagnosis and pressures of workload or time) were investigated in the questionnaire part of this thesis.

More recently a study compared general medical and dental practitioners antibiotic prescribing for dental conditions (Anderson, Calder and Thomas, 2000). In this study information from the General Practice Morbidity Database of medical practices in Wales was compared with dental practitioner prescribing from three settings: a dental practice emergency rota, a dental hospital emergency clinic and a Health Authority weekend emergency clinic. More than 50% of patients attending the Health Authority emergency clinic received antibiotics.

This was similar to the results of Palmer's study (1996). Anderson *et al.* (2000) concluded that general medical practitioners were more likely to prescribe antibiotics than dentists for acute dental problems and that both prescribed broad-spectrum antibiotics, contrary to existing recommendations in the Dental Practitioners Formulary (1998). This study however, failed to determine whether the patients attending with an acute dental problem and receiving antibiotics actually had acute infections.

Roy and Bagg (2000) investigated antibiotic prescribing patterns by GDPs in Glasgow by analysis of prescription information collated by the Information and Statistics Division of the Primary Information Unit in Edinburgh. A 10% sample of prescriptions (3554) was selected at random and the information collected was the name of the antibiotic, dose and quantity of antibiotic dispensed. The frequency and duration were calculated from the strength of the antibiotic and the duration, assuming GDPs followed the standard in the British National Formulary. Based on this assumption there was a wide variation both in frequency and duration of all the antibiotics prescribed. Eight different antibiotics were used, with amoxicillin, metronidazole and penicillin accounting for the majority. A more comprehensive evaluation of prescribing habits by analysis of actual prescriptions from a larger geographically distributed sample could give more accurate information. This was investigated by the prescription study within this thesis.

The conclusions by Roy and Bagg (2000) were that lack of proper guidelines might impede the selection of the most appropriate antimicrobial therapy. In view of the increasing problems of antimicrobial resistance, it was also suggested that efforts should be made to educate both dentists and patients on the appropriate use of antibiotics. The production of nationally agreed guidelines and educational initiatives is therefore of importance.

In a small study involving seven practitioners, an audit of antibiotic prescribing in general practice was done (Steed and Gibson, 1997). In the initial data collection period the range of antibiotics used, dose prescribed and duration of treatment varied widely. Nearly 14% of prescriptions in the initial data collection period were issued to "hedge your bets" and 17% for pain. Patients involved in the audit were questioned about their understanding of antibiotic use. It was noted that their understanding was good, although over 40% expected it as part of their treatment. The practitioners set standards for the audit based on their own formulated clinical guidelines. These were based on published articles and consultation with experts in oral surgery and medicine, dental therapeutics and general practice. A minimum effective formulary of therapeutic agents was also produced giving dose, frequency and duration. This was done because no national or local guidelines existed. In the second data collection period there was a 50% reduction in the number of prescriptions with a reduction in prescribing for inappropriate reasons. Although this study consisted of a very small sample it demonstrated that practitioners do prescribe inappropriately and that audit, even with locally agreed guidelines, can improve antibiotic prescribing. It was the intention within this thesis to devise nationally agreed guidelines based on the current evidence available and recognised best practice. Another aim of this thesis was to disseminate the guidelines produced and to audit the effectiveness of them in reducing inappropriate antibiotic prescribing.

All the studies reviewed above support some degree of inappropriate use of antibiotics in dentistry. But how widespread is the problem within dentistry, particularly within general dental practice? What factors affect the prescribing of antibiotics?

The published studies reviewed also demonstrated the lack of comprehensive national guidelines for GDPs, which have been agreed by the profession. A review of the current recommendations and guidelines available to GDPs on the use of antibiotics and the controversies surrounding their use is investigated in the following section.

1.3 Guidelines on prescribing antibiotics in dentistry

Dental practitioners have several sources of information on antibiotic prescribing. All this information, together with what practitioners were taught at dental school and their experiences within postgraduate environments, plays a part in influencing prescribing practices. An examination of the various sources of information and their shortcomings and controversies will be considered.

1.3.1 Dental Practitioners Formulary (DPF) incorporating the British National Formulary (BNF)

The Dental Practitioners Formulary (1998) includes details of those preparations that dental practitioners can prescribe to patients receiving National Health Service treatment in England. The Dental Formulary Subcommittee oversees the preparation of the DPF but it is published under the authority of the Joint Formulary Committee on behalf of the British Medical Association and the Royal Pharmaceutical Society of Great Britain. The stated aims of the BNF/DPF are to provide dental surgeons and other healthcare workers with sound, up to date information about the use of medicines, key information on the prescribing, dispensing and administration of medicines, and a list of all drugs that are commonly prescribed in the UK.

The information contained within the DPF is drawn from critically evaluated clinical and pharmaceutical literature, manufacturers' product literature, professional authorities, regulatory bodies and from data used for pricing the prescriptions. The Dental Formulary Subcommittee receive clinical advice from experienced academics on all therapeutic prescribing, ensuring that the recommendations are of relevance to dental practice. Comments and constructive criticism are welcomed from all healthcare workers and many dentists, doctors and pharmacists have in the past presented comments and suggestions.

The DPF part of the BNF provides information of special relevance to the dental surgeon, including recommendations for the prophylaxis of infective endocarditis, advice on medical emergencies, other medical problems that might appear in dental practice and a review of the oral side-effects of drugs. Within this section of the BNF are listed all the preparations on the Dental Practitioners' List with notes on each of the preparations. Dental surgeons can, of course, prescribe or administer any number or variety of substances privately to treat a clinical situation, provided the current legal requirements are observed.

The DPF gives background information on the use of the antibiotics listed including the type of infection, choice of antibacterial drug, dose and route. The individual preparations are then listed to show indications, cautions, contra-indications, side effects and dose.

1.3.1.1 Type of infection

The DPF recommends that antibiotics should only be used on the basis of defined need. They should be used in conjunction with, but not as an alternative to, other appropriate measures such as drainage of a tooth or extraction. Antibiotics should be also prescribed for prophylaxis for infective endocarditis (see section 1.3.1.4). The DPF lists the types of infection encountered in dental practice for which antibiotics may be required, with a cautionary note that in most cases early establishment of drainage and removal of the cause of the infection can achieve resolution. The DPF, however, states the importance of prescribing where there is a spreading infection, which can be life threatening due to airway obstruction, or cavernous sinus thrombosis.

The DPF also recognises that antibiotics may be indicated if treatment has to be delayed. It states that antibiotics are essential if the body's natural defence mechanisms are compromised (e.g. immuno-compromised patients).

1.3.1.2 Choice of antibiotic drug

The DPF is categorical in that "blind" prescribing of antibiotics for unexplained pyrexia, facial swelling and cervical lymphadenopathy can lead to difficulty in establishing a definitive diagnosis. Practitioners need to have knowledge of cause of the presenting condition, the prevalent organism in a given clinical situation, and its sensitivity. The use of bacteriological sampling is suggested in severe infections or where an infection fails to respond after a few days. Roy *et al.* (1999) suggested that most prescribing in dental practice was empirical with broad-spectrum antibiotics being used increasingly and that microbiological sampling can aid the decision making process for antibiotic therapy.

The DPF provides information on the reasons for failure of an antibiotic to resolve an infection. These may be a result of incorrect diagnosis, lack of additional measures, poor host resistance or poor patient compliance. Information is also provided on the use of combinations of antibiotics in the treatment of severe or resistant infections. It recommends a combination of phenoxymethylpenicillin (or erythromycin) with metronidazole for treatment of severe infections, or resistant infections.

1.3.1.3 Dose, route and duration

The DPF gives broad advice on the antibiotic dose to be used in dental infections stating that age, weight, renal and hepatic function and the severity of the infection are factors which must be considered. It does inform dentists that small doses are ineffective and may lead to the selection of resistant strains. In the notes accompanying each preparation it does however, list the manufacturers' recommended dose. The oral route of administration is recommended as being effective in all but very severe infections where the intramuscular route may be considered.

In the DPF no specific information is given on the duration of the course of antibiotics prescribed. A broad statement is made that courses should not be unduly prolonged because they are wasteful and may lead to side-effects.

1.3.1.4 Listed antibiotic preparations

The notes on the listed preparations contained within the DPF are shown in Table 1.1 along with indications, dose, frequency and duration. As can be seen from these tables the DPF fails to define the duration of antibiotic therapy in nearly all of the listed preparations. Very little advice is given on the specific clinical conditions that may require therapeutic antibiotics and the DPF fails to provide definitive indications for the use of antibiotics when treatment has to be delayed.

The DPF's recommendations relating to the use of prophylactic antibiotics for infective endocarditis and a number of medical problems are based on the guidelines of the Working Party of the British Society for Antimicrobial Chemotherapy. These will be dealt with in the next section.

Table 1.1

Antibiotic preparations in the DPF showing indications, dose, frequency and duration

Antibiotic	Indications	Adult dose	Child Dose	Frequency	Duration
Phenoxymethylpenicillin	1st choice for most dental infections- ineffective with β-lactamase producing bacteria	500mg increasing to 750mg for severe infections	1-5 years 125mg 6-12 years 250mg	Four times daily	Not specified
Amoxicillin	No more effective than above. Also ineffective with β-lactamase producing bacteria.	250mg. 500mg for severe infections.	0-10 years 125mg, doubled for severe infections.	Three times daily	Not specified
		For severe infections 3g	-	One dose then repeated after 8 hr	Not specified
	Used for prophylaxis	3g	0-5 years 0.75g, 5-10 years 1.5g	One dose 1 hr pre-op	-

Table 1.1 cont

Antibiotic	Indications	Adult Dose	Child Dose	Frequency	Duration
Ampicillin	As amoxicillin but not used for short course therapy	0.25-1g 30 mins before food	Under 10 years –half adult dose	Four times daily	Not specified
Cephalexin	No advantage over penicillins	250mg		Four times daily	Not specified
		or 500mg		Three times daily	Not specified
		increased to 1-1.5g for severe infections		Four times daily	Not specified
			1-5 years 125mg	Three times daily	Not specified
			6-12 years 250mg	Three times daily	Not specified
Cephradine	As for cephalexin	250-500mg 0.5-1g		6 hrly 12 hrly	Not specified
			25-50mg/kg	daily in divided dose	Not specified

Table 1.1 cont

Antibiotic	Indications	Adult Dose	Dose	Frequency	Duration
Erythromycin	Alternative to Phenoxymethylpenicillin in penicillin-allergic patients. Also used for β-lactamase producing bacterial infections. Evidence of resistance to it	250mg-500mg or 0.5-1g	2-8years 250mg All doses doubled in severe infections	Four times daily Two times daily Four times daily Four times daily	Not specified Not specified Not specified Not specified
Metronidazole	First choice for AUG and pericoronitis Best alternative to penicillin for dental infections	200mg	1-3 years 50mg 3-7 years 100mg 7-10 years 100mg	Three times daily Three times daily Twice daily Three times daily	3 -7 days although three days is sufficient

Table1.1 cont

Antibiotic	Indications	Adult Dose	Child Dose	Frequency	Duration
Clindamycin	Not indicated for routine use in dental infections because of serious side-effects	Specialist use only for infections			
	Cross-resistance with erythromycin bacteria				
	Indicated for single dose prophylaxis for patients allergic to penicillin	For adult prophylaxis 600mg	Under 5 years 150mg 5-10 years 300mg	1 hr before treatment	-

Table 1.1 cont

Antibiotic	Indications	Adult Dose	Child Dose	Frequency	Duration
Tetracycline	*Systemic* refractory periodontal disease *Local* Oral ulceration, herpes	250mg Increase to 500mg in severe infections As oral rinse 250mg in water	Not recommended for children under 12 years because of staining of teeth during development	Four times daily Four times daily	Not given Three days
Doxycycline	Refractory periodontal disease	200mg with water then 100mg	As for tetracycline	One on first day then daily	Not given
Oxytetracycline	As above	250-500mg	As for tetracycline	Four times daily	Not given

1.3.2 Recommendations of the Working Party of the British Society for Antimicrobial Chemotherapy (BSAC) on antibiotic prophylaxis

The Working Party of the British Society for Antimicrobial Chemotherapy (1982; 1986; 1992b), also known as the Endocarditis Working Party (1990; 1993; 1997) have provided recommendations over a number of years on the use of antibiotic prophylaxis for infective endocarditis and a number of cardiac and medical conditions. These recommendations will be dealt with in the following sections.

1.3.2.1 Recommendations for prophylaxis for patients at risk of infective endocarditis

Patients at risk of infective endocarditis have been defined by the Working Party of the BSAC as those with cardiac defects or who have had prosthetic replacement of damaged valves. The importance is emphasized of taking a thorough medical history to determine whether there is, or has been, a heart defect or rheumatic fever, or a history of previous infective endocarditis. The recommendations also suggest that turbulence around a heart valve has been identified as a risk factor for infective endocarditis. Murmurs in children are generally accepted by the BSAC to be of little significance but it is, however, suggested that a cardiologist is consulted in this situation. The recommendations also state that patients with a history of coronary artery by-pass surgery or an implanted pacemaker do not require antibiotic prophylaxis. The dental procedures that need antibiotic prophylaxis are given in broad terms, namely, extractions, scaling and surgery involving the gingival tissues. As dentists carry out many clinical procedures that could potentiate a bacteraemia the guidelines remain non-specific.

1.3.2.2 Recommendations for prophylaxis for patients who are medically compromised

The Working Party of the BSAC advises that patients who are immunosuppressed (including transplant patients) and patients with indwelling intraperitoneal catheters do not require antibiotic prophylaxis for dental procedures. There is very little evidence that dental treatment causes infection in immunosuppressed and immunodeficient patients and therefore prophylaxis is usually not required. The Working Party of the BSAC (1992a) also recommends that antibiotic prophylaxis is not required for patients with prosthetic joint implants as there is no evidence that infections follow dental procedures.

The need for national guidelines to aid decision making in the use of antibiotics for specific clinical conditions and prophylaxis is important. Grol *et al.* (1998), however, found that even if guidelines are of high scientific quality, clinicians may still not follow them unless they are uncontroversial, specific, evidence-based and require no change to existing routine. Grimshaw and Russell (1994) and Freemantle *et al.* (2001) suggested that the publication of guidelines alone are seldom of value but are more effective when linked with educational initiatives. Opinion leaders (100%) and audit with feedback (42%) have also been shown to be more effective than formal continuing education in persuading practitioners to accept guidelines (Davis *et al.*, 1995). It was the intention of this thesis to develop nationally agreed guidelines and to test their effectiveness in improving antibiotic prescribing.

1.3.3 Therapeutic and prophylactic use of antibiotics in dentistry

There is a plethora of information that dentists can access from the literature on the therapeutic and prophylactic use of antibiotics. In some areas of antibiotic prescribing there is controversy and conflicting advice. It is proposed to deal with this information under two headings; therapeutic use and prophylactic use.

1.3.3.1 General principles of therapeutic prescribing of antibiotics in dentistry

There is some debate and controversy in the literature about the therapeutic use of antibiotics in the treatment of acute dental infections. It is proposed to look at the general principles of therapeutic use of antibiotics in dentistry, the microbiology of dental infections and antibiotic sensitivities and the clinical conditions where antibiotics may be used.

Cawson and Spector (1989) maintain that the main indication for antibiotic treatment is that the infection must be severe enough to justify treatment and antibiotic use is more appropriate than surgical treatment. Cawson and Spector (1989) also state that most dental infections are rarely serious and that the use of antibiotics "just in case" there is an infection can cause serious harm to the patient by delaying the diagnosis.

Seward *et al.* (1987), Howe (1985) and Donoff (1997) suggest that where dental infections are present it is important to obtain adequate drainage of pus. This can be achieved by either endodontic treatment, extraction of teeth for infections of pulpal and periodontal origin, periodontal treatment, surgical treatment of impacted teeth, infected cysts and retained roots. Cawson and Spector (1989), Pogrel (1994) and Martin (1998) suggest that antibiotics are only required if drainage cannot be established, there are signs of a spreading infection (cellulitis), there is an elevated body temperature and local lymph node involvement. Pogrel (1994) and Donoff (1997) advise that in cases of severe spreading infections where there is a raised temperature, the patient is toxic and dehydrated, and regional lymphadenopathy is present, referral for surgical drainage and antibiotic therapy is advised. It has also been suggested that ideally, where antibiotics are to be prescribed, knowledge of the infecting organism and its sensitivity should be known (Donoff, 1997). This information in most cases should enable practitioners to prescribe the appropriate antibiotic.

1.3.3.2 Microbiology and antibiotic sensitivities of dental infections

Lewis *et al.* (1990) in their review of the findings of microbiological studies of acute dentoalveolar infections found that acute periapical abscesses are usually associated with overgrowth of normal commensal bacteria. In the summary Lewis *et al.* (1990) reported that from all the studies investigated, the majority of isolates from dental abscesses belonged to three bacterial groups: facultative anaerobic Gram-positive cocci, strictly anaerobic Gram-positive cocci and strictly anaerobic

Gram-negative bacilli. A number of researchers have investigated the sensitivities of bacteria found in dental abscesses (von Konow, Nord, and Nordenram 1981; Lewis, MacFarlane and McGowan 1989a; van Winkelhoff, van Steenbergen and de Graaf 1992; Goumas *et al.*, 1997). These researchers found that most bacteria were sensitive to penicillins, erythromycin, clindamycin and metronidazole. Lewis *et al.* (1989a) also found that anaerobic bacteria were more sensitive to clindamycin or metronidazole. In another investigation, however, it was shown that anaerobic bacteria were resistant to erythromycin (von Konow, Nord and Nordenram, 1981).

Lewis *et al.* (1989a; 1990) recommended that a penicillin is the first choice for most dental infections, probably amoxicillin. Amoxicillin has been shown to have excellent absorption, achieve high concentrations at the sites of acute infection and has a broad spectrum of activity (Boon *et al.*, 1982). Lewis *et al.* (1986b) also showed that a short-course high-dose regimen of 3g of amoxicillin taken immediately, followed by a further dose eight hours later was efficacious in severe infections. In a double-blind study of the effect of amoxicillin versus penicillin in acutely abscessed primary teeth it was shown that there was less swelling and associated symptoms with the short-course, high-dose of amoxicillin (Paterson and Curzon, 1993).

The use of metronidazole with amoxicillin has been suggested if improvement does not occur with a single antibiotic (Dimitroulis, 1997). In patients allergic to penicillin, erythromycin or clindamycin has been suggested, although Goumas *et al.* (1997) felt that clindamycin was the preferred choice because of anaerobic sensitivity to this antibiotic.

Roy *et al.* (1999) suggested, however, that culturing of a pus sample and sensitivity testing should be carried out more often, particularly if an infection fails to respond to antibiotics.

Duration of therapy for a dentoalveolar abscess varies from 3-7 days, with Lewis *et al.* (1989b) showing in their survey that a five day regimen is the most popular with GDPs. It has been suggested that most dental infections respond to appropriate antibiotic therapy with 1-2 days, as long as supportive therapy has been instituted (Barclay, 1990). It has been recommended that therapy should be continued for two days after resolution of the infection in order to prevent the emergence of resistant bacteria (Wynn and Bergman, 1994). Lacey (1984) however, suggested that the use of antibiotics beyond the time of clinical improvement encourages the emergence of resistance rather than reducing it. Martin *et al.* (1997b) in their prospective study investigated the effects of antibiotics on 759 patients attending a dental hospital with acute dentoalveolar abscesses, localised swelling and a raised temperature. The patients in this study were given either amoxicillin 250mg three times daily, clindamycin 150mg four times daily or erythromycin four times daily along with appropriate treatment (incision of abscess or extraction). The patients were reviewed after two, three and 10 days and 96% of the patients had marked resolution of the infection at two days. None of these patients required further antibiotics and showed complete resolution at 10 days. The results of this study showed that in most cases 2-3 days of antibiotics are sufficient to control infection.

1.3.3.3 The use of antibiotics for clinical conditions that give rise to dental infections

An evaluation of the clinical conditions that give rise to acute dental infections and the literature relating to the use of antibiotics in those conditions are shown in Table 1.2. As can be seen from Table 1.2 there is a consensus of opinion for most clinical conditions. Controversy exists for the therapeutic prescribing of antibiotics for dry socket, pericoronitis, the root canal treatment of acute periapical abscesses, sinusitis and chronic periodontitis. Grol *et al.* (1998) suggested that if guidelines are to be accepted they must be uncontroversial. The aim of this thesis was to produce guidelines for GDPs, which had the support of experts in the field of antimicrobial prescribing and specialist societies.

Table 1.2
Clinical conditions and recommendations for antibiotic prescribing from the literature

Clinical condition	Recommendation	References
Acute pulpitis	Yes No	Samaranayake and Johnson (1999) Abbott *et al.* (1990), Cawson and Spector (1989) Olson *et al.* (1995)
Pericoronitis	Yes– sometimes if evidence of spread	Gill and Scully (1991), Seward *et al.*(1987), Blakey *et al.* (1996), Samsudin and Mason (1994)
Acute ulcerative gingivitis	Yes	Shinn (1962), Johnson and Engel (1986), Duckworth *et al.* (1966)
Dry socket	Yes No	Rood and Murgatroyd (1979), Krekmanov and Hallander (1980) Rud (1970) Curran *et al.* (1974) Happonen *et al.* (1990), Monaco *et al.* (1999)
Cellulitis	Yes	Pogrel (1994), Emmerson (2000), Martin (1998), Holbrook (1991), Baker and Fotos (1994)
Chronic marginal gingivitis	No	Pogrel (1994), Emmerson (2000) Cawson and Spector (1989)
Chronic periodontitis	Controversy– only as adjunct to debridement, juvenile periodontitis	Asikainen *et al.* (1990), Kunihira *et al.* (1985), Lindhe and Liljenberg (1984), Mariotti and Monroe (1998), Ng and Bissada (1998), Novak *et al.* (1988), Palmer *et al.* (1996), Seymour and Heasman (1995), Loesche *et al.* (1991), Van Palenstein Helderman (1986)
Periodontal abscess	Yes No–unless severe	Herrera *et al.* (2000) Seymour and Heasman (1995), Cawson and Spector (1989), Pogrel (1994), Martin (1998)
Re-implantation of teeth	Yes– based on opinion	Abbott *et al.* (1990), Trope (1995), Gregg and Boyd (1998), Hammarstrom *et al.* (1986)
Acute periapical infection-before drainage	Yes–where drainage impossible or diffuse spreading infection No	Longman *et al.* (2000), Lewis *et al.* (1986b), Abbott *et al.* (1990) Pallasch (1979), Lewis *et al.* (1986b), Abbott *et al.* (1990), Fouad *et al.* (1996)

Table 1.2 cont

Clinical condition	Recommendation	References
Acute periapical infection with drainage	No Yes	As above
Acute periapical infection after drainage	Yes–only with spreading infection	Longman *et al.* (2000) Lewis *et al.* (1986b), Abbott *et al.* (1990)
Post obturation	Controversial	Morse *et al.* (1987), Oliet (1983), Selden (1993), Sjogren *et al.* (1997), Mata *et al.* (1985), Abbott *et al.* (1988), Walton and Fouad (1992), Walton and Chiappinelli 1993)
Sinusitis	Yes–if radiographic evidence No	Williams *et al.* (2000), de Ferranti *et al.* (1998), Low *et al.* (1997), Hansen *et al.* (2000) Stalman *et al.* (1997a), Low *et al.* (1997), Stalman *et al.* (1997b), van Buchem *et al.* (1997)
Chronic infection	No–unless acute flare up or medically compromised	Pogrel (1994)

1.3.3.4 Prophylactic use of antibiotics in dental practice

Antibiotic prophylaxis is used in the prevention of post-operative infection in healthy patients and to prevent bacterial endocarditis in susceptible patients. There is an abundance of literature on the use of prophylactic antibiotics, but a paucity of evidence from both animal and randomised control trials that prophylactic antibiotics in dentistry are effective or necessary. This is due to the ethical difficulties in completing this type of research on volunteers or patients.

The prophylactic use of antibiotics in healthy patients is controversial. Longman and Martin (1991) reappraised the evidence for the use of antibiotics to prevent post-operative infection. They concluded that prophylaxis is unnecessary in the majority of minor oral surgery cases, for the removal of mandibular third molars, and endodontic therapy (see Table 1.2). It has been suggested that there was no evidence that antibiotic prophylaxis, given to healthy patients undergoing surgical endodontics was of benefit (Pallasch, 1989; Carr and Bentkover, 1998). Carr and Bentkover (1998), however, state that prophylactic antibiotics should be prescribed when the maxillary antrum or the floor of the nose has been breached. Pallasch and Slots (2000) in a review of the literature concluded that prophylaxis for surgical procedures should only be used where there was evidence of a high infection rate. The routine prophylactic use in patients with dry sockets is not supported by scientific evidence, but remains controversial. In patients with a history of repeated dry sockets following extractions, however, metronidazole has been shown to be effective (Rood and Murgatroyd, 1979).

The parameters for the use of prophylactic antibiotics in medically compromised patients are not well established. The medically compromised patient can fall into one of the following groups: patients who have prosthetic implants, patients who are immunocompromised, patients who have had radiotherapy to the jaws and patients at risk of infective endocarditis.

Dental procedures leading to a bacteraemia have been implicated in late infections of prosthetic hip and knee arthroplasties (Bartzokas *et al.*, 1994; Waldman, Mont and Hungerford, 1997; Little, 1997). The number of these is small and as a result prophylaxis in these patients remains controversial (Sandhu *et al.,* 1997). LaPorte *et al.* (1999) found from a recent study of 2973 total hip arthroplasties that only three of the patients had late joint infections that could be associated with dental procedures. Of these two patients had a systemic disease predisposing to infection. A retrospective review of 3490 patients with total knee arthroplasties found that only 62 of these had late infections of the joints, of which only seven could be associated with dental treatment (Waldman, Mont and Hungerford, 1997). The conclusion from these studies was that only patients with predisposing systemic disease should receive antibiotic prophylaxis for relevant dental procedures. Field and Martin (1991) reviewed the evidence for the use of prophylactic antibiotics for patients with artificial joints undergoing oral and dental surgery. The authors concluded that for the majority of patients with artificial joints prophylaxis was not justified. Field and Martin (1991) also felt that certain medically compromised patients with artificial joints have an increased risk of infection and therefore prophylaxis may be justifiable. The American Dental Association and American Academy of

Orthopaedic Surgeons (1997) issued an advisory statement recommending antibiotic cover only for patients with systemic factors predisposing to infection undergoing extensive dental procedures. Pallasch and Slots (2000) in a review of the literature, however, stated that this contention could not be substantiated by clinical evidence. This confirms the advice of the Working Party of the BSAC discussed in section 1.3.2.2.

Other prostheses (e.g. penile implants, prosthetic valvular grafts, intra-ocular lenses and breast implants) are not considered to be susceptible to infection from dental bacteraemias (Little and Falance, 1993).

It has been suggested that antibiotic prophylaxis might be required in immunocompromised patients (Longman and Martin, 1991). Walters (1997) set out the arguments for and against prophylactic antibiotics stating categorically that prophylaxis was always required in the immunocompromised patient. This advice is at variance with the advice of the Working Party of the BSAC, discussed in section 1.3.2.2, which maintains there is little evidence that dental treatment is followed by infection in the immunocompromised or immunosuppressed patient. In a review of the literature it was concluded that there was no scientific evidence for prophylaxis for controlled or moderately controlled diabetics (Alexander, 1999). Maintenance of dental care for uncontrolled diabetics should be delayed until the diabetes is stabilized (Hall *et al.*, 1994).

There is controversy regarding the use of prophylactic antibiotics for intravenous drug users (Tong and Rothwell, 2000). For patients with human immunodeficiency virus or AIDS, in the absence of a bacterial infection, antibiotic prophylaxis is not required (Pallasch, 1997). Patients who have undergone a splenectomy show no evidence of having a greater risk of developing a dental infection from dental procedures (Pallasch and Slots, 2000), but some physicians (Westerman, 1991) recommend prophylaxis for invasive dental procedures. It has been recommended that dental patients with a suppressed granulocyte count should have antibiotic prophylaxis because of the increased risk of bacteraemia-induced infections (Anon, 1981). No controlled clinical studies have shown the efficacy of this practice (Pallasch and Slots, 2000). Bottomley *et al.* (1972) suggested that patients on haemodialysis with in-dwelling catheters require prophylaxis to prevent post-dental treatment complications. There is no scientific evidence to support this contention from the literature and this is at variance with BSAC recommendations discussed in section 1.3.2.2. Patients who have been exposed to therapeutic radiation to the mandible or maxilla may be susceptible to infection due to *endarteritis obliterans*. This continues with time and there is a risk of extractions inducing osteoradionecrosis. It is therefore a common practice to prescribe prophylactic antibiotics before extractions for these patients.

The rationale behind antibiotic prophylaxis in cardiac patients is that micro-organisms may settle on damaged endocardium as a result of acquired or congenital heart disease. This may give rise to infective endocarditis and therefore antibiotic prophylaxis should be given to all susceptible patients exposed to a bacteraemia. According to Cawson (1981) and the American Heart Association (1997) there is no clear evidence in humans for the protective effect of prophylaxis for dental procedures. Most of the recommendations provided are a result of analyses of the literature from procedure related endocarditis. These include *in vitro* susceptibility data of pathogens implicated in endocarditis, results of prophylactic studies in experimental animal models, and retrospective analyses of human endocarditis cases in terms of antibiotic prophylaxis usage patterns and apparent prophylaxis failures. A review of the incidence of infective endocarditis related to dental treatment in the preceding three months found that fewer than 15% of cases of infective endocarditis had a history of previous dental treatment (Cherubin and Neu, 1971). A retrospective investigation of 544 cases of infective endocarditis found that only 13.7% had received dental treatment in the preceding three months (Bayliss *et al.*, 1983). The conclusion from this study was that the level of dental hygiene was more important than the dental procedure. A review of 53 cases of infective endocarditis concluded that the portal of entry was dental in 43% of cases (Hollanders *et al.*, 1988). Sekido *et al.* (1999), however, reviewed 38 patients with a history of infective endocarditis and concluded that the portal of entry was dental in only 18.4% of the cases.

Durack (1998) reviewed the recent evidence on antibiotic prophylaxis. A number of the papers (Guntheroth, 1984; Clemens and Ransohoff, 1984; Bor and Himmelstein, 1984; Van der Meer *et al.*, 1992a, 1992b; Strom *et al.*, 1998; Roberts, 1999) called into question the need for prophylaxis when carrying out dental procedures. An example of one of the papers reviewed by Durack was that of Guntheroth (1984) who looked at failure of prophylaxis in 18 patients and found that none were associated with dental treatment. Guntheroth, in his discussion, reviewed the literature dating back to 1909 and found that of 1322 patients with infective endocarditis only 3.6% had received prior dental treatment.

Seymour *et al.* (2000) provided a more recent critical review of the evidence that links dental treatment to infective endocarditis and the inherent risks of antibiotic prophylaxis. The authors concluded that there was increasing evidence that spontaneous bacteraemia were the most likely cause of infective endocarditis in "at risk" patients rather than specific dental treatment episodes. Seymour *et al.* (2000) felt that without the evidence of a randomised controlled trial to confirm that dental treatment causes infective endocarditis and the published study of 53 cases of endocarditis involving litigation (Martin, Butterworth and Longman, 1997a), it would be difficult to abandon prophylaxis. In view of this circumstantial evidence of dentally induced infective endocarditis the Working Party of the BSAC and the American Dental Association recommend antibiotic prophylaxis for patients at risk. As controversy exists at present, there is a need for up-to-date guidelines to define patients at risk of infective endocarditis and the dental procedures that require prophylaxis.

The American Heart Association (1997) gives comprehensive guidelines for practitioners on the cardiac conditions requiring prophylactic antibiotics. The summary of their guidelines is shown in Table 1.3. The AHA divides the conditions into high and moderate risk and also gives those conditions not requiring prophylaxis. The American Dental Association (1997) in a special report has rationalised its recommendations for clinical procedures requiring prophylaxis based on the available evidence. This is shown in Table 1.4.

Table 1.3

Guidelines for medical conditions requiring antibiotic prophylaxis (modified from American Heart Association, 1997)

Medical conditions requiring prophylaxis
Previous bacterial endocarditis
Prosthetic heart valves
Ventricular septal defect
Patent ductus arteriosus
Coarctation of the aorta
Surgically constructed systemic pulmonary shunts
Rheumatic and other acquired valvular dysfunction (e.g. aortic stenosis)
Hypertrophic cardiomyopathy
Atrial septal defect repaired with patch
Persistent heart murmur
Mitral valve prolapse with valvular regurgitation
Radiotherapy to head and neck*
Cerebrospinal shunts
Medical conditions not requiring prophylaxis
Coronary by- pass surgery
Rheumatic fever– no valvular dysfunction**
Coronary heart disease
Pacemakers
Physiological/ functional/ innocent heart murmurs
Haemodialysis patients
Hodgkin's disease
AIDS
Patients on immunosuppressives
Patients with autoimmune disease
Renal transplant patients
Patients with prosthetic joints
Prosthetic implants (penile, breast)
* for extractions particularly in the mandible ** check with GMP

Table 1.4

Guidelines for the clinical dental procedures requiring antibiotic prophylaxis in medically compromised patients (American Dental Association, 1997)

Prophylaxis recommended
Dental extractions including minor oral surgery
Periodontal procedures including probing, scaling, root planing, surgery
Dental implant placement
Endodontic instrumentation or surgery only beyond the apex
Initial placement of orthodontic bands but not brackets
Subgingival placement of antibiotic fibres
Prophylaxis not recommended
Restorative dentistry (operative or prosthodontic) with or without retraction cord *
Local anaesthetic injections (apart from intraligamentary)
Placement of rubber dams
Intracanal endodontic treatment, post placement
Removal of sutures
Taking of impressions
Placement of removable prosthetic or orthodontic appliances
Taking of radiographs
* Clinical judgement in circumstances where there is significant bleeding may indicate prophylaxis

Recommendations for the choice of antibiotic, route and dose are dependant on the pathogenicity of the bacteria, and any history of drug allergy. Many organisms cause infective endocarditis but from the dental perspective oral streptococci have been implicated. For this reason penicillins are used mainly for prophylaxis. Amoxicillin is preferable to penicillin V because of its better absorption rate and ability to maintain high blood levels for the required period (Shanson, Cannon and Wilks, 1978). The Working Party of the BSAC (1982) recommends 3g orally, one hour before treatment. Children under 10 years were to be prescribed half the adult dose and children less than five years of age a quarter the dose. For patients allergic to penicillin erythromycin stearate had been previously suggested but clindamycin 600mg, one hour pre-operatively has been shown to be more efficacious (Aitken *et al.*, 1995; American Heart Association, 1997).

Longman and Martin (1991) suggest that these antibiotics and doses are appropriate for surgical prophylaxis in the healthy patient. They also suggest metronidazole 200mg, one hour pre-operatively for surgical prophylaxis.

The American Heart Association (1997) differs slightly to the Working Party of the BSAC in its recommendations suggesting that 2g of amoxicillin is adequate in producing the required serum levels. Dajani *et al.* (1994) suggested this dose causes less gastrointestinal upset. For children it is recommended that the dose should be 50mg kg^{-1} one hour before treatment. For patients allergic to penicillin clindamycin is the recommended antibiotic for prophylaxis.

1.4 Aims of the study

There is widespread concern about the increasing problem of antimicrobial resistance due to the inappropriate use of antibiotics in clinical practice. It has been shown that there are many factors that influence medical and dental practitioner prescribing of antibiotics. There is evidence that antibiotic prescribing is increasing in general dental practice. There is therefore a need to investigate when, how and what practitioners prescribe in order to reduce inappropriate antibiotic prescribing.

Most of the journals and textbooks are limited in providing evidence of when general dental practitioners prescribe antibiotics. There is very little evidence of how and what they prescribe and what the knowledge status of general dental practitioners on the use of antimicrobials is at the present time.

Present recommendations fail to provide specific clinical indications for therapeutic prescribing with little or no indication of the duration of therapy. Existing guidelines for general dental practitioners also fail to be specific on the clinical procedures requiring prophylaxis and which patients are at risk. There is also limited information on strategies that have been used in general dental practice to reduce inappropriate prescribing.

The aims of this study then are to:

1) To investigate when GDPs prescribe antibiotics.
2) To investigate how and what GDPs prescribe.
3) To assess the present knowledge of GDPs on antibiotic prescribing.
4) Devise guidelines based on the evidence available and recognised best practice.
5) Disseminate the guidelines and test the effectiveness of the guidelines through audit.

2. MATERIALS AND METHODS

2.1 Introduction

The first part of the study consisted of a questionnaire survey of GDPs to investigate when they prescribed antibiotics. The questionnaire was also used to assess practitioners' current knowledge on the use of antibiotics. The second part of the study involved examination of prescriptions for antibiotics issued by practitioners. This was to provide evidence of how and what practitioners prescribe. The final part of the study consisted of the production of guidelines on antimicrobial prescribing and testing the efficacy of the guidelines by way of an audit by GDPs.

2.2 Ethical approval

The Local Research Ethics Committee at the Liverpool Dental Hospital, Pembroke Place, Liverpool approved the protocol for the pilot study. The protocol for the definitive study was submitted to the North West Multi-Centre Research Ethics Committee, MREC North West, Gateway House, Piccadilly South, Manchester because the study involved more than five LREC geographical boundaries. It was agreed by the MREC that ethical approval was not required.

2.3 Questionnaire study

The questionnaire study was done in two parts, a pilot study and a definitive study. The pilot study was used to evaluate the design of the questionnaire. The definitive study followed modifications to the pilot study design.

2.3.1 Pilot questionnaire

The aim of the pilot questionnaire study was to gather information on general dental practitioners' knowledge of antibiotic prescribing and patterns of prescribing. The pilot questionnaire was also designed to investigate any relationships that might exist between knowledge and patterns of prescribing and the year of qualification. The place of qualification and recent postgraduate education in the area of antibiotic prescribing was also investigated. The pilot questionnaire examined various aspects of therapeutic and prophylactic prescribing by general dental practitioners. The subject areas chosen for scrutiny and the pilot questionnaire are shown in Table 2.1 and Figure 2.1.

The pilot questionnaire, which had no personal identifier, was distributed in November 1996 with a stamped addressed return envelope and a covering letter explaining the nature of the investigation. Respondents were given two months to complete and return the questionnaire. Follow up of non-responders was not undertaken.

Table 2.1

The subject areas used to formulate the pilot and definitive questionnaire

1. Defining the clinical situations in which therapeutic antibiotics are prescribed and the antibiotic of choice.
2.The clinical procedures where prophylactic antibiotics were prescribed for patients with no significant medical history.
3. Determining the medical conditions and clinical procedures for which GDPs would prescribe prophylactic antibiotics.
4.The prophylactic antibiotic regimens used.
5.Knowledge of some drug interactions with antibiotics and contra-indications to antibiotic prescription
6.Year and place of qualification
7.Attendance on postgraduate courses on antibiotic prescribing in the previous two years.

Figure 2.1
Pilot questionnaire

NO FORM OF PERSONAL IDENTIFIER IS INCLUDED IN THIS QUESTIONNAIRE AND THEREFORE ALL THE INFORMATION COLLECTED WILL BE TOTALLY ANONYMOUS{PRIVATE }

1. For the following conditions please indicate whether you would prescribe antibiotics?
If yes, please indicate A -always S-sometimes N-never for each antibiotic listed.

{PRIVATE }Condition	Yes	No	Don't know	Amoxicillin	Penicillin	Erythromycin	Metronidazole	Tetracycline
1. Acute pulpitis								
2. Acute periapical infection a) before drainage								
b) with drainage								
c) after drainage								
3. Chronic apical infection								
4. Pericoronitis								
5. Cellulitis								
6. Periodontal abscess								
7. Acute ulcerative gingivitis								
8. Chronic marginal gingivitis								
9. Sinusitis								
10. Chronic periodontitis								
11. Dry socket								
12. Trismus								
13. Avulsion of teeth								

Fig 2.1 cont

2. In patients with NO relevant medical history, do you prescribe antibiotics for the following procedures? If yes, please indicate A-always S-sometimes N-never for each antibiotic listed.

{PRIVATE } Procedure	Yes	No	Don't know	Amoxicillin	Penicillin	Erythromycin	Metronidazole	Tetracycline
1. Extraction a) routine								
b) surgical								
2. Apicectomy								
3. Root canal therapy a) pre-op								
b) post-op								
4. Scaling and polishing								
5. Restorative treatment								

Figure 2.1 cont

3. For patients with a medical history indicated below, which clinical procedures in your opinion require prophylactic antibiotics? Please tick.

{PRIVATE } Medical History	s&p	fill	rct	extraction	imps	other procedures (please specify)
1. Diabetes mellitus						
2. Haemodialysis patients						
3. Hodgkins disease						
4. AIDS						
5. Pts on immunosuppressives						
6. Pts with autoimmune disease						
7. Renal transplant pts						
8. Radiotherapy to head & neck						
9. Pts with prosthetic joints						
10. History of infective endocarditis						
11. Cardiac valve prosthesis						
12. Rheumatic heart disease						
13. Aortic stenosis						
14. Ventricular septal defect						
15. Coronary by-pass surgery						
16. Rheumatic fever–no valvular dysfunction						
17. Coronary heart disease						
18. Pacemakers						
19. Physiolog/functional/innocent murmurs						

s&p=scaling and polishing, rct=root canal therapy, imps=impressions

Figure 2.1 cont

4. What regimen do you routinely use for prophylaxis with adult medically compromised patients with no known hypersensitivity?

{PRIVATE } Antibiotic	Dose	Yes	No
1. Amoxicillin	3g 1 hour pre-op		
2. Amoxicillin	3g 1 hour pre-op + 500mg 6hr later		
3. Penicillin V	2g 1 hour pre-op + 1g 6hr later		
4. Erythromycin Stearate	1g 1 hour pre-op + 500mg 6hr later		
5. Tetracycline	1g 1 hour pre-op + 500mg 6hr later		
6.Clindamycin	600mg 1 hour pre-op		
7. Metronidazole	200mg 3x daily for 3days		

5. Which of the antibiotic regimens listed above would you use for medically compromised patients hypersensitive to penicillin?

Please circle 1 2 3 4 5 6 7

6.Which of the antibiotics listed above would you prescribe to non-medically compromised patients hypersensitive to penicillin?

Please circle 1 2 3 4 5 6 7

7. Which of the antibiotics listed above would you <u>NOT</u> prescribe to pregnant patients?

Please circle 1 2 3 4 5 6 7

Figure 2.1 cont

8. Which of the antibiotics listed above would you NOT prescribe to patients taking oral contraceptives?

Please circle 1 2 3 4 5 6 7

9. Which of the antibiotics listed above would you NOT prescribe to patients on anticoagulant therapy?

Please circle 1 2 3 4 5 6 7

10. Have you attended any postgraduate courses on antibiotic prescribing in dental practice within the last two years?

Yes No

Year of qualification

Place of qualification

Thank you for completing this questionnaire. Please use the enclosed SAE to return it as soon as possible.

2.3.1.1 Study population for pilot questionnaire

General dental practitioners who were contracted to provide National Health Service general dental services within Sefton Health Authority were chosen for the pilot questionnaire study. An up to date list of GDPs was obtained from Sefton Health Authority, Merseyside. The list was edited to remove duplicate entries (some GDPs practise at more than one address) and specialist practitioners. All 104 remaining GDPs were then circulated with the pilot questionnaire including a covering letter and a prepaid envelope.

2.3.1.2 Analysis of the pilot questionnaire and statistical tests

The questionnaires, once returned, were numbered sequentially in order to monitor the response rate and to audit the input of the data. The information was entered into a database set up in the Statistical Package for Social Sciences for Windows (1998). Each sequentially numbered questionnaire was entered into the database with all the questions entered as variables. Answers to each of the questions were coded numerically, including any missing answers. All the questionnaires were scored for the number of correct responses. The correct responses were based on good practice, opinion leaders in the field of antibiotic prescribing and guidelines issued by authoritative bodies (e.g. British Society for Antimicrobial Chemotherapy). The questionnaire with the correct responses is shown in Appendix 1.

Absolute frequencies were used to describe the pilot study sample demographics and examine the distribution of responses for all the variables investigated. Mean scores and standard deviations from the mean were calculated for the number of correct answers along with the range of scores. These were compared using year of qualification and attendance at postgraduate courses in the preceding two years. Parametric statistical tests were carried out to determine if there were any differences or relationships between scores for correct answers, year of qualification, and attendance at any postgraduate courses on antibiotic prescribing in the previous two years. A t-test (Field, 2000) was performed to investigate differences in scores and attendance at postgraduate courses and a Pearson's correlation (Field, 2000) was used to determine if there was any relationship between the number of years since qualification and overall scores on the questionnaire.

2.3.2 Definitive questionnaire development

Following the return and analysis of the data of the pilot questionnaire the definitive questionnaire was developed.

2.3.2.1 Modifications to pilot questionnaire

The content and structure of the pilot questionnaire was examined. The pilot questionnaire was modified by placing easily completed questions first, such as details of the respondents including gender, year of qualification, place of qualification and age. The instructions to dentists on how to complete the questionnaire were simplified, along with the design of the questionnaire, in order to improve ease of completion and handling of the data.

If practitioners answered positively to the questions relating to the clinical conditions and procedures they were asked to indicate their choice of preferred antibiotic from a list, rather than have the option to note whether they prescribed a specific antibiotic "sometimes, always or never". Practitioners were also able to specify an alternative antibiotic to those listed. Further questions were inserted to cover the prescribing of antibiotics to patients allergic to penicillin, clinical signs of severe infection and non-clinical factors that might affect practitioners prescribing of antibiotics. Questions on drug interactions were removed from the questionnaire.

This modified pilot questionnaire, shown in Figure 2.3, was tested on a further group of practitioners asking for their comments on the structure of the questions and ease of completion. The study population for the modified pilot questionnaire was also asked for the time taken to complete the questionnaire.

2.3.2.2 Study population for the modified pilot questionnaire

The modified pilot questionnaire was sent out to 50 GDPs selected at random from 114 general dental practitioners on the list of Sefton Health Authority in October 1998.The GDPs were given six weeks to respond. All practitioners were phoned after four weeks.

2.3.2.3 Analysis of the modified pilot questionnaire

The comments on the structure and the design of the modified pilot questionnaire were analysed. As all the practitioners had been surveyed with the pilot questionnaire, detailed analysis of the responses to the questions was not undertaken. The information gained from the modified pilot questionnaire enabled the design of the definitive questionnaire to be completed.

Figure 2.3
Modified pilot questionnaire

NO FORM OF PERSONAL IDENTIFIER IS INCLUDED IN THIS QUESTIONNAIRE AND THEREFORE ALL THE INFORMATION COLLECTED WILL BE TOTALLY ANONYMOUS

1. Have you received any postgraduate education on antibiotic prescribing within the last two years? Please circle.

Yes No

2. Year of first dental degree ……………………. ….

3. Place of qualification ……………………….

4. Please circle

male female

5. How old are you? Please circle.

21-30 years
31-40 years
41-50 years
51-60 years
61 + years

Figure 2.3 cont

6. In patients presenting with a dental infection, which of the following clinical signs in your opinion would indicate the prescribing of antibiotics? Please tick (4)

Clinical sign	**Yes**	**No**
1. Elevated temperature and evidence of systemic spread		
2. Localised fluctuant swelling		
3. Gross or diffuse swelling		
4. Unrestricted mouth opening		
5. Difficulty in swallowing		
6. Closure of the eye due to swelling		

Comments

Figure 2.3 cont

7. Which of the following non-clinical factors would influence your decision to prescribe antibiotics? Please tick **(4)**

Non-clinical factor	**Yes**	**No**
1. Patient expectation of a prescription		
2. Pressure of time and workload		
3. Patient's social history		
4. Uncertainty of diagnosis		
5. Where treatment has to be delayed		

Comments

8. For patients **HYPERSENSITIVE TO PENICILLIN** requiring an antibiotic for a dental infection **please circle** your preferred choice of antibiotic:

Metronidazole erythromycin tetracycline cephalosporin amoxicillin

Comments

Figure 2.3 cont

9. For the following clinical conditions please indicate (4) whether you would prescribe antibiotics?
If yes, please indicate (4) your preferred choice of antibiotic.

Condition	**Yes**	**No**	**Don't know**	**Amoxicillin**	**Penicillin**	**Erythromycin**	**Metronidazole**	**Tetracycline**	**Other please specify**
1. Acute pulpitis									
2. Acute periapical infection a) before drainage									
b) with drainage									
c) after drainage									
3. Chronic apical infection									
4. Pericoronitis									
5. Cellulitis									
6. Periodontal abscess									
7. Acute ulcerative gingivitis									
8. Chronic marginal gingivitis									
9. Sinusitis									
10. Chronic periodontitis									
11. Dry socket									
12.Trismus									
13. Avulsion of teeth									

Comments

Figure 2.3 cont

10. In patients with **NO MEDICAL HISTORY**, do you prescribe antibiotics for the following procedures? If yes, please indicate (4) your preferred choice of antibiotic.

Procedure	**Yes**	**No**	**Don't know**	**Amoxicillin**	**Penicillin**	**Erythromycin**	**Metronidazole**	**Tetracycline**	**Other please specify**
1. Extraction a) routine									
b) surgical									
2. Apicectomy									
3. Root canal therapy a) pre-op									
b) post-op									
4. Scaling and polishing									
5. Restorative treatment									

Comments

Figure 2.3 cont

11. For patients with a medical history indicated below, which clinical procedures in your opinion require prophylactic antibiotics? Please tick (4)

Medical History	**s&p**	**fill**	**rct**	**extraction**	**imps**	**other procedures (please specify)**
1.Diabetes mellitus						
2.Haemodialysis patients						
3.Hodgkin's disease						
4.AIDS						
5.Pts on immunosuppressives						
6.Pts with autoimmune disease						
7.Renal transplant pts						
8.Radiotherapy to head & neck						
9.Pts with prosthetic joints						
10.History of infective endocarditis						
11.Cardiac valve prosthesis						
12.Rheumatic heart disease						
13.Aortic stenosis						
14.Ventricular septal defect						
15.Coronary by-pass surgery						
16.Rheumatic fever–no valvular dysfunction						
17.Coronary heart disease						
18.Pacemakers						
19.physiolog/functional/innocent murmurs						

s&p=scaling and polishing, rct=root canal therapy, imps=impressions

Figure 2.3 cont

12. What regimen do you routinely use for prophylaxis with adult medically compromised patients with **no known hypersensitivity?**

Antibiotic	Dose	Yes	No
1 Amoxicillin	3g 1 hr pre-op		
2 Amoxicillin	3g 1 hr pre-op + 500mg 6hr later		
3 Penicillin V	2g 1 hr pre-op + 1g 6hr later		
4 Erythromycin Stearate	1g 1 hr pre-op + 500mg 6hr later		
5 Tetracycline	1g 1 hr pre-op + 500mg 6hr later		
6 Clindamycin	600mg 1 hr pre-op		
7 Metronidazole	200mg 3x daily for 3days		

Comments

Figure 2.3 cont

13. Which of the antibiotic regimens listed above would you use for medically compromised patients **hypersensitive to penicillin** requiring prophylaxis?

Please circle 1 2 3 4 5 6 7

Comments

Time taken in completing questionnaire.................minutes

Thank you for taking the time to complete this questionnaire. Please return the questionnaire in the enclosed stamped addressed envelope by 27th **November 1998**

2.3.2.4 Definitive questionnaire

Further changes were incorporated into the questionnaire following comments on the modified pilot questionnaire. A question was inserted asking practitioners to indicate the antibiotic they would prescribe, the dose, frequency and the duration for a patient presenting with an acute dental infection, assuming the patient had no allergy to penicillin. The instructions were made more specific in that the "don't know" option was removed and practitioners were asked to answer "yes or no" for each part of the questions.

Under the section investigating prophylactic use of antibiotics the clinical procedures were modified. It was decided to be more detailed in the investigation of prophylaxis for restorative procedures. The option for practitioners to seek specialist advice was also included in this section. The section investigating the antibiotic regimen for prophylaxis gave practitioners the opportunity to specify an alternative regimen to those listed. The definitive questionnaire is shown in Figure 2.4. A covering letter was sent with the questionnaire explaining the nature of the study, length of time required to complete the questionnaire (this had been assessed from the modified pilot questionnaire) and a request for a return even if practitioners were unable, or unwilling, to complete it.

The questionnaire was sent out to the study population at the beginning of February 1999 with a prepaid envelope. A reply by date was set at the end of February, giving practitioners four weeks to return the questionnaire. The questionnaire was totally anonymous but an area code was incorporated into the prepaid return address label so that replies could be allocated to the Health Authorities included in the survey. No follow up of non-responders was undertaken.

2.3.2.5 Study population for the definitive questionnaire

The study population for the definitive questionnaire was selected from the total number of National Health Service dentists practising within the general dental services in England in December 1998. Dental Practice Board statistics (1999) recorded 17,245 NHS practising dentists in England, including assistants and vocational trainees. GDPs totally independent of the NHS were excluded from the study, as data (names and addresses) on these practitioners were unavailable. Assistants (897) and vocational trainees (563) were also excluded from the total population, as they do not appear on Health Authority lists. Specialist practitioners (e.g. orthodontists) were also excluded from the study. It was estimated by the British Orthodontic Society that there were approximately 400 specialist orthodontic practitioners practising within the general dental services in December 1998.

The total number of dentists that could therefore be included in the study was 15,385. A study population of approximately 10% (1540) of the target population was deemed to be an acceptable sample. Geographically distributed Health Authorities areas were selected to produce the study population. These areas provided a mix of rural and urban areas. It was anticipated that the Health Authorities would produce a study population exhibiting a normal distribution of ages of practitioners, a gender distribution equivalent to that of practitioners practising in the general dental services in England and graduates from all the dental schools in the United Kingdom.

The Health Authority areas selected were Liverpool, Wirral, Oxfordshire, Buckinghamshire, Northumberland, Newcastle and North Tyneside, Nottinghamshire, North Nottinghamshire and Sheffield. The total number of dentists on the lists of the Health Authorities was 1840. A database of the dentists was set up in Microsoft Access (Microsoft Access, 2000) and duplicate entries (GDPs practising at more than one address) were deleted along with specialist practitioners. The Health Authorities provided lists of specialist orthodontic practitioners. The resultant total number of GDPs included in the study was 1544.

2.3.2.6 Analysis of definitive questionnaire and statistical tests

All the questionnaires, when returned, were sorted into the Health Authority areas from the area code incorporated in the address label. Each questionnaire was numbered sequentially in order to monitor the response rate and facilitate audit of the input of data. The responses to each question were coded numerically, including missing responses. All the information was entered into a database set up in SPSS (see section 2.3.1.2).

The overall response rate, distribution of age-bands, gender, university of qualification were calculated. The number of responses and number who had attended postgraduate courses for each Health Authority were calculated, along with the frequencies of all variables to each of the questions asked.

Figure 2.4
Definitive Questionnaire

ANTIBIOTIC PRESCRIBING QUESTIONNAIRE

NO FORM OF PERSONAL IDENTIFIER IS INCLUDED IN THIS QUESTIONNAIRE AND THEREFORE ALL THE INFORMATION COLLECTED WILL BE TOTALLY ANONYMOUS

1. Have you attended any postgraduate courses on antibiotic prescribing within the last two years? Please circle.

Yes No

2. Year of first dental degree ....

3. Place of qualification ....

4. Please circle

male female

Figure 2.4 cont

5. How old are you? Please circle.

21-30 years
31-40 years
41-50 years
51-60 years
61 + years

6. In patients presenting with a dental infection, which of the following clinical signs in your opinion would indicate the prescribing of antibiotics in conjunction with appropriate treatment?

Please tick (4) **YES OR NO** for each clinical sign.

Clinical sign	Yes	No
1 Elevated temperature and evidence of systemic spread		
2 Localised fluctuant swelling		
3 Gross or diffuse swelling		
4 Unrestricted mouth opening		
5 Difficulty in swallowing		
6 Closure of the eye due to swelling		

Figure 2.4 cont

7. For patients presenting with a periapical infection where antibiotics are indicated, please complete the following assuming the patient has no allergy to penicillin.

Antibiotic	Dose	Frequency	Number of days

8. Which of the following non-clinical factors might cause you to prescribe an antibiotic?
Please tick **(4) YES OR NO** for each factor.

Non-clinical factor	Yes	No
1 Patient expectation of a prescription		
2 Pressure of time and workload		
3 Patient's social history		
4 Uncertainty of diagnosis		
5 Where treatment has to be delayed		

9. For patients **ALLERGIC TO PENICILLIN** requiring an antibiotic for a dental infection **please circle** your usual choice of antibiotic:

Metronidazole erythromycin tetracycline cephalosporin amoxicillin

Figure 2.4 cont

10.Do you usually prescribe antibiotics for the following clinical conditions? Please indicate **(4) YES OR NO** for each condition. If yes, please indicate (4) your choice of antibiotic for patients **not allergic to penicillin.**

Condition	**Yes**	**No**	**Amoxicillin**	**Penicillin**	**Erythromycin**	**Metronidazole**	**Tetracycline**	**Other please specify**
1.Acute pulpitis								
2.Acute periapical infection a) before drainage								
b) with drainage								
c) after drainage								
3.Chronic apical infection								
4.Pericoronitis								
5.Cellulitis								
6.Periodontal abscess								
7.Acute ulcerative gingivitis								
8.Chronic marginal gingivitis								
9.Sinusitis								
10.Chronic periodontitis								
11.Dry socket								
12.Trismus								
13.Reimplantation of teeth								

Figure 2.4 cont

11. In patients with **NO RELEVANT MEDICAL HISTORY**, do you prescribe antibiotics for the following procedures? Please tick (4) **YES OR NO** for each procedure.

If yes, please indicate (4) your choice of antibiotic for patients **not allergic to penicillin.**

Procedure	Yes	No	Amoxicillin	Penicillin	Erythromycin	Metronidazole	Tetracycline	Other please specify
1.Extraction a) routine								
b) surgical								
2.Apicectomy								
3.Root canal therapy a) pre-op								
b) post-op								
4.Scaling and polishing								
5.Restorative treatment								

Figure 2.4 cont

12. For patients with a relevant medical history indicated below, which clinical procedures in your opinion require prophylactic antibiotics? Please tick (4)

Medical History	s&p	Fillings-class II subgingival	Fillings-classV subgingival	rct	Extractions	Imps	Seek specialist advice
1.Diabetes mellitus							
2.Haemodialysis patients							
3.Hodgkin's disease							
4.AIDS							
5.Pts on immunosuppressives							
6.Pts with autoimmune disease							
7.Renal transplant pts							
8.Radiotherapy to head & neck							
9.Pts with prosthetic joints							
10.History of infective endocarditis							
11.Cardiac valve prosthesis							
12.Rheumatic heart disease							
13.Aortic stenosis							
14.Ventricular septal defect							
15.Coronary by-pass surgery							
16.Rheumatic fever–no valvular dysfunction							
17.Coronary heart disease							
18.Pacemakers							
19.physiolog/functional/innocent murmurs							

s&p=scaling and polishing, rct=root canal therapy, imps=impressions, fillings classII= e.g. mesio-occlusal fillings, classV = buccal

Figure 2.4 cont

13. What regimen do you use for prophylaxis with adult medically compromised patients **not allergic to penicillin?**
Please tick (4) **YES OR NO** for each regimen.

Antibiotic	Dose	Yes	No
1 Amoxicillin	3g 1 hr pre-op		
2 Amoxicillin	3g 1 hr pre-op + 500mg 6hr later		
3 Penicillin V	2g 1 hr pre-op + 1g 6hr later		
4 Erythromycin Stearate	1g 1 hr pre-op + 500mg 6hr later		
5 Tetracycline	1g 1 hr pre-op + 500mg 6hr later		
6 Clindamycin	600mg 1 hr pre-op		
7 Metronidazole	200mg 3x daily for 3 days		
8.Other regimen please specify below			

14. Which of the antibiotic regimens listed in **Question 13** would you use for medically compromised patients **allergic to penicillin** requiring prophylaxis?

Please circle 1 2 3 4 5 6 7

Other –please specify...

Thank you for taking the time to complete this questionnaire. Please return the questionnaire in the enclosed stamped addressed envelope by **27 FEBRUARY 1999**

2.4 Antibiotic prescribing knowledge of general dental practitioners

The prescribing knowledge of the general dental practitioners was equated to the total score for the questionnaire. Scores for each question were calculated; correct answers were given a score of 1 with a maximum score of 160 in the pilot study and 84 in the definitive study. The correct answers were based on current best practice, the views of opinion leaders on antibiotic prescribing in general dental practice and guidelines issued by authoritative bodies (e.g. British Society for Antimicrobial Chemotherapy). The pilot and definitive questionnaires with the correct responses are shown in Appendices 1 and 2.

Mean scores and standard deviations were compared using gender, age-band, and attendance at postgraduate courses, Health Authority and university of qualification as the grouping variables. Parametric statistical tests were carried out on the data to investigate the presence of any significant relationships between these variables. T-tests (Field, 2000) were done to investigate differences in scores between genders and those that had attended postgraduate courses in the previous two years. A Pearson's correlation (Field, 2000) was used to determine if there was any relationship between the year of qualification and the overall scores on the questionnaire. One-way analyses of variance (ANOVAs) statistical tests (Field, 2000) were used to investigate differences between age bands, Health Authorities and university of qualification and the overall scores. *Post hoc* multiple comparisons statistical tests (Field, 2000) were used where significant differences were found to determine where the significances arose.

2.5 Examination of prescriptions

This part of the study was done in two parts: a pilot study and the definitive study. The pilot study evaluated the method of collection and examination of the data of prescriptions issued by GDPs. The definitive study followed modifications to the design of the pilot study. The aim of this part of the study was to investigate antibiotic prescribing by GDPs from an analysis of prescriptions issued by practitioners.

Prescriptions written by GDPs are taken by patients to a pharmacy for the antibiotic to be dispensed. The pharmacist then sends the prescriptions to the local Regional Prescription Pricing Authority for the pharmacist to receive payment. All prescriptions are then held for a period of two to three months by the Regional Prescription Pricing Authorities.

Dental prescriptions (yellow) differ from medical prescriptions in colour, making easy selection of dental prescriptions from the many medical and dental prescriptions held each month easier. The prescriptions were obtained from the NHS Prescription Pricing Authority, which has regional offices throughout the country and a central office in Newcastle.

2.5.1 Prescription pilot study

Sefton Health Authority was requested to obtain a month's dental prescriptions from the Regional Prescription Pricing Authority in Liverpool. The information collected from the prescriptions is shown in Table 2.2. An employee of the Health Authority collated this information in order to preserve the anonymity of the prescribers and the patients. A pharmaceutical adviser to Sefton Health Authority assessed the legibility of the prescriptions on a 1-4 scale, with 1 being very good and 4 being very poor. The date of qualification of the prescribing practitioner was determined by cross-referencing the prescriber's details with the Dentists' Register (1996).

2.5.1.1 Sample size

All dental prescriptions issued by general dental practitioners, practising within the boundaries of Sefton Health Authority, were collected for the month of March 1997 from the Regional Prescription Pricing Authority in Liverpool. Two hundred prescriptions for antibiotics were selected at random by a Health Authority employee and the information as shown in Table 2.2 was collected.

2.5.1.2 Analysis of prescriptions

The 200 prescriptions were each numbered sequentially and the information obtained from the prescriptions, as shown in Table 2.2, was numerically coded and entered into an SPSS database. Frequencies were used to examine the distribution of all variables recorded in Table 2.2.

Table 2.2

Prescription information collected for the pilot study

Legibility	Scored as very good, good, poor, very poor
Patient details	Must include forename, surname & full address
Antibiotic	Generic or proprietary
Drug prescribed	Written in full or abbreviated
Dose	In g or mg
Frequency	Written in full or Latin abbreviation, number of times a day
Duration	In days
Year of qualification	Prescriber details – from Dentists Register

2.5.2 Definitive prescription study

Following completion of the pilot investigation the method of collection of the prescriptions was modified for the definitive study. The Central Prescription Pricing Authority, Scottish Life House, Archbold Terrace, Jesmond, Newcastle Upon Tyne, arranged for the Regional Prescription Pricing Authorities in the areas involved in the study to photocopy all dental prescriptions for a specified month. The Regional Prescription Pricing Authorities, in order to preserve patient and dentist confidentiality, removed the prescriber and patient details prior to photocopying. This removed the need for MREC approval for this part of the study.

Once the dental prescriptions had been received from the Prescription Pricing Authorities any that did not include antibiotics were excluded from the study. The information collected from the prescriptions included the antibiotic prescribed, dose, frequency and duration in days. Liquid antibiotic preparations were classified as paediatric prescriptions and were analysed separately. The frequency of sugar-free prescriptions was also noted.

2.5.2.1 Sample size

Initially 1000 prescriptions selected at random from each Health Authority area were to be included in the study. It was felt, however, that inclusion of all prescriptions would make the results authoritative for the prescribing of GDPs. All dental prescriptions for antibiotics issued by general dental practitioners for the month of February 1999 from the

Health Authority areas selected for the questionnaire survey (see section 2.3.2.5), were included in the study.

2.5.2.2 Analysis of prescriptions

All the prescriptions selected were given an individual identification number and were grouped into Health Authority areas, facilitating audit of input of the data and statistical analysis. The information collected (see section 2.5.2) from the prescriptions was numerically coded and entered into a database set up in SPSS. Approximately 10% of all the data within the database was audited against the original prescriptions for accuracy. Frequencies were used to describe the sample and examine the distribution of all the variables recorded.

2.6 Formulation of antimicrobial guidelines for general dental practitioners

The author of this thesis, following the results of the pilot studies, suggested that guidelines on antimicrobial prescribing should be written. The Faculty of General Dental Practitioners (UK) commissioned the document with the support of the Department of Health. A Commissioning Committee was formed, consisting of the Dean and Chairman of the Education Committee, education officers of the Faculty of General Dental Practitioners (UK) and a representative of the Department of Health. The main authors of the document, Dr M V Martin and Dr L P Longman, were commissioned to carry out the work, along with the author of this thesis.

All the literature relating to antimicrobial prescribing in dentistry was retrieved by way of Medline (National Library of Medicine), Embase

(Elsevier Science) and Cochrane Library database searches from 1966-1998. The databases were searched using key words and phrases for all aspects of therapeutic and prophylactic antimicrobial prescribing.

2.6.1. Prophylactic prescribing

The search terms used for prophylactic prescribing included prophylactic antibiotics and joints, antibiotic prophylaxis and arthroplasties, antibiotic prophylaxis and total joint, endocarditis, antibiotic prophylaxis, bacteraemia and dentistry, extractions and antibiotics, dry socket and antibiotics, dentoalveolar surgery and antibiotics, antibiotics and endodontics, root canal therapy and antibiotics, prophylaxis and immunocompromised, prophylaxis and immunosuppressed, prophylaxis and rheumatic fever, prophylaxis and heart defects, surgery and antibiotic prophylaxis.

2.6.2 Therapeutic prescribing

The search terms used for therapeutic prescribing of antibiotics included acute dentoalveolar infections, antibiotic prescribing, antimicrobial treatment and orofacial infections, anti-infective treatment, antibiotics and dent*, antimicrobials and dent*, pyogenic infections, anaerobic bacteria and dent* acute periapical infection and antibiotics, acute dentoalveolar infection and antibiotics, chronic apical infection and antibiotics, chronic dentoalveolar infections, pericoronitis, endodontic therapy and antibiotics, oroantral fistula, antivirals and dent*, herpetic infections, viral infections and dent*, fungal infections and dent*, periodontal disease and antimicrobials and all the listed antimicrobials in the Dental Formulary and dent*.

2.6.3 Review of the literature

All the literature retrieved, approximately 5000 references, was reviewed based on the abstracts. Literature that involved randomised control studies, cohort studies, case-controlled studies, surveys or case series, clinical trials, reports of expert committees, review articles on antimicrobial prescribing, and opinions of respected authorities in the field of antimicrobial prescribing and oral microbiology were selected. This literature was subjected to review by the authors.

An attempt was made to provide an evidence-based approach to the guidelines following the SIGN-based (Scottish Intercollegiate Guidelines Network) methodology. There was, however, a lack of high quality research evidence available from the literature reviewed. Most of the evidence supporting the recommendations was obtained from expert committee reports, opinions or clinical experiences of respected authorities. Key references, based on the evidence described above, were included in the document to substantiate the guidelines provided.

2.6.4 Consultation

The document underwent a number of draft revisions before being sent out for consultation and comment from over 40 specialist dental societies, dental associations, educational establishments, dental committees and the Department of Health. The circulation list is included in Appendix 3. All those circulated were given three months to respond with comments. The comments received were analysed and assessed by the authors and the commissioning committee and further modifications were made to the document. A face-to-face meeting was held with the members of the Dental Formulary sub-committee of the British National Formulary and further agreed changes were made.

2.6.5 Production and dissemination

The document shown in Appendix 4 was published by the Faculty of General Dental Practitioners and launched at a public meeting in April 2000.The document has been sold by the FGDP (UK) to GDPs and to many Health Authorities for distribution to general dental practitioners.

2.7 Clinical audit of antimicrobial prescribing

This part of the study was performed to determine the effectiveness of an intervention, using the guidelines produced in section 2.6 and an educational component with feedback, in reducing inappropriate antimicrobial prescribing by GDPs.

2.7.1 Method

The method employed in this part of the study is shown in Figure 2.5. GDPs taking part in the study were divided into groups of fewer than 10 with a lead dentist in each group. The individual groups were assigned a trained audit facilitator to advise and oversee the audit. The participants were asked to audit their antibiotic prescribing to all patients for a six-week period. The information collected included the age of the patient, gender, the antibiotic prescribed, dose, frequency, duration, the diagnosis of the clinically presenting condition, the medical history (if prophylaxis was to be given) and the reasons for prescribing an antibiotic. The reasons for prescribing included prophylaxis due to a medical history, prophylaxis associated with a surgical procedure; clinical signs of gross or diffuse swelling, elevated temperature and evidence of systemic spread and pain. The non-clinical reasons for prescribing were patient expectation, pressure of time and workload, uncertainty of diagnosis and where treatment had to be delayed. GDPs were also given the option to record any other reasons for prescribing antibiotics. The data collection form is shown in Figure 2.6. This information gave initial information of current clinical practice of general dental practitioners before the issuing of guidelines.

Following the initial six-week period of data collection the results were reviewed by the author of this thesis and areas of inappropriate prescribing were noted and made available to two opinion leaders in antimicrobial prescribing, Drs M V Martin and L P Longman. Two meetings were arranged for all the participants to discuss the results of the data collected with the opinion leaders mentioned previously. At these meetings GDPs were made aware of the principles of appropriate therapeutic and prophylactic antibiotic prescribing. Guidelines, based on those produced (see section 2.6 and Appendix 4), were given to all participants.

Following these meetings the groups of practitioners met and discussed the educational content of the meetings and the guidelines given. The individual groups set standards based on the guidelines and the educational component of the meetings held. Practitioners were then asked to audit their antibiotic prescribing for a further six-week period, collecting the data on the sheets shown in Figure 2.6.

2.7.2 Sample size

All 932 general dental practitioners working within South Cheshire, North Cheshire, Liverpool, Wirral and St Helens and Knowsley Health Authorities in the North West of England were invited to participate in this part of the study. Of those invited 175 general dental practitioners took part in the audit.

2.7.3 Analysis

The data from the initial six-week period and that from the post-guidelines period were numerically coded and entered into a database in SPSS (1998). Frequencies were used to examine and describe the distribution of the all the variables for both the data collection periods. Further analysis of the main reasons for prescribing (e.g. pain) was performed to see if there were any relationships between the different variables. Chi-square tests (Field, 2000) were performed to test for significant changes in the participants' prescribing practices and antibiotic regimens between the two periods.

Figure 2.5

Structure and mechanism of the clinical audit of antibiotic prescribing by GDPs

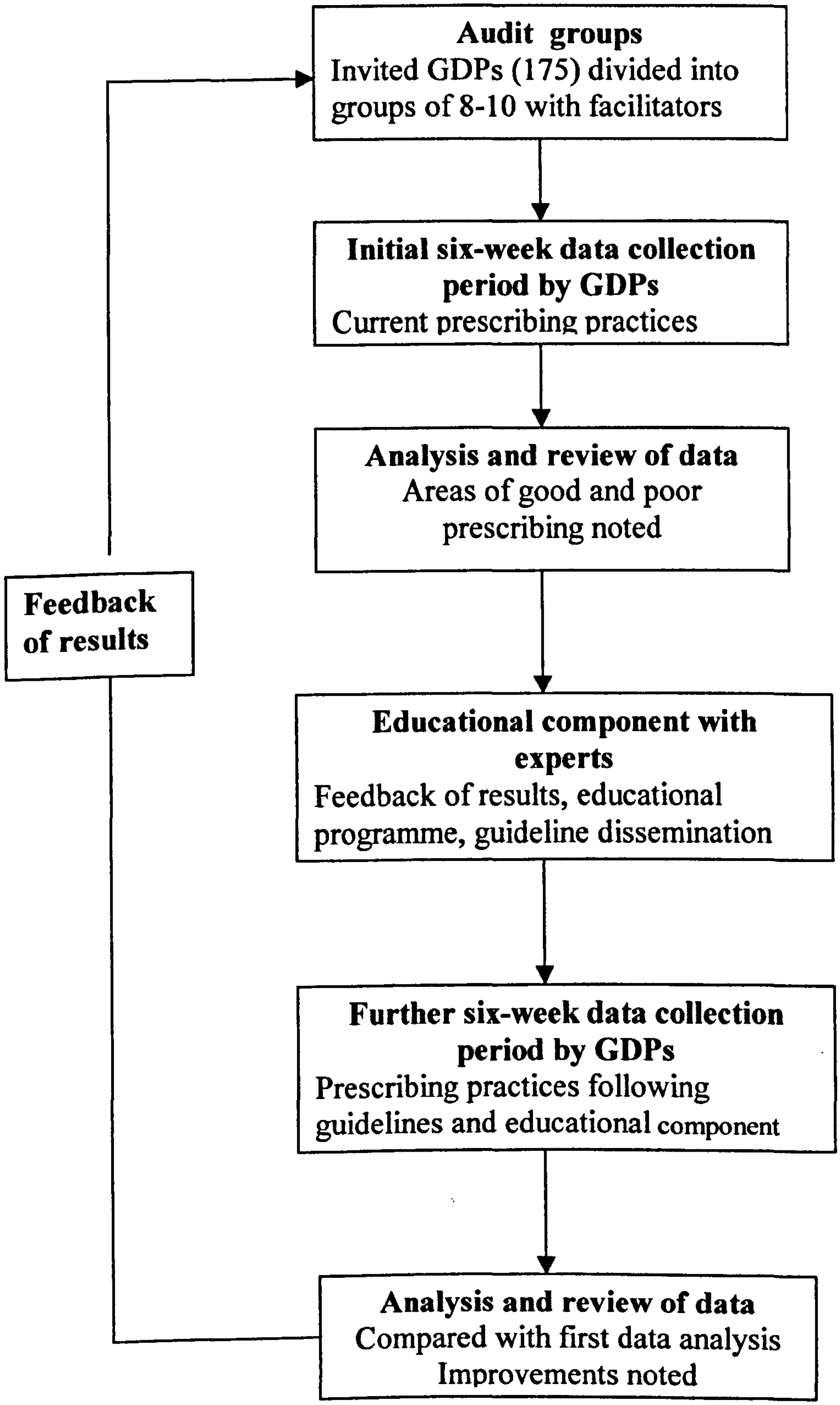


Figure 2.6

Antibiotic prescribing data collection form

Patient

Age............
Sex ....

Prescription:
Drug...
Dose ....
Frequency...
Duration...

Diagnosis of clinical condition

Medical History (if prophylaxis)

Reasons for prescribing

- Prophylaxis due to medical history ☐
- Prophylaxis following surgical procedure ☐
- Localised fluctuant swelling ☐
- Gross or diffuse swelling ☐
- Elevated temperature and evidence of systemic spread ☐
- Pain ☐
- Patient expectation ☐
- Pressure of time and workload ☐
- Uncertainty of diagnosis ☐
- Treatment had to be delayed ☐
- Other............................

3. RESULTS

3.1 Questionnaire studies

3.1.1 Pilot study

Of the 104 GDPs surveyed, 68 (65.5%) replied after two months. The number who had attended a postgraduate course on antibiotic prescribing in the previous two years was 21 (30.9%). The number of years since qualification of the respondents, in five-year bands, is shown in Figure 3.1. Most of the respondents (41) were graduates of Liverpool dental school. The responses to the questionnaire were divided into therapeutic and prophylactic prescribing of antibiotics. The results of the questions relating to drug interactions are not reported in this thesis.

3.1.1.1 Therapeutic antibiotic prescribing-Pilot study

The percentages of GDPs prescribing therapeutic antibiotics for the clinical conditions investigated are shown in Figure 3.2. The majority prescribed for acute periapical abscesses before and with drainage, pericoronitis, acute ulcerative gingivitis, sinusitis, dry sockets, cellulitis and periodontal abscesses. Over 20% prescribed for acute pulpitis and chronic periodontitis. Of the practitioners who prescribed in these situations their choice of antibiotics and whether they would prescribe them sometimes, or always, for each of the clinical conditions is shown in Table 3.1. Overall the choices of antibiotics for the clinical conditions investigated were amoxicillin 33%, metronidazole 27.5%, erythromycin 23%, penicillin 11.5% and tetracycline 5%. Tetracycline was predominantly used for the treatment of chronic periodontitis.

Figure 3.1

Number of years since qualification of the respondents (5-year bands) in the pilot study

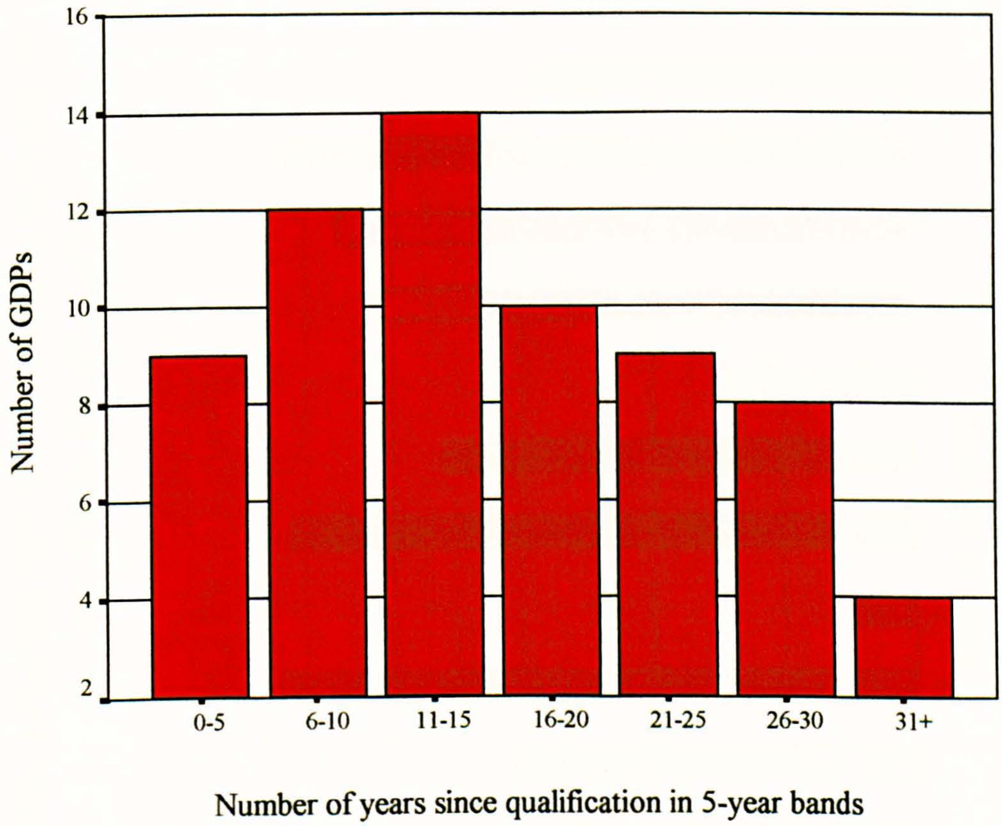


Figure 3.2
Percentage of general dental practitioners prescribing antibiotics for specific clinical conditions (n= 68) in the pilot study

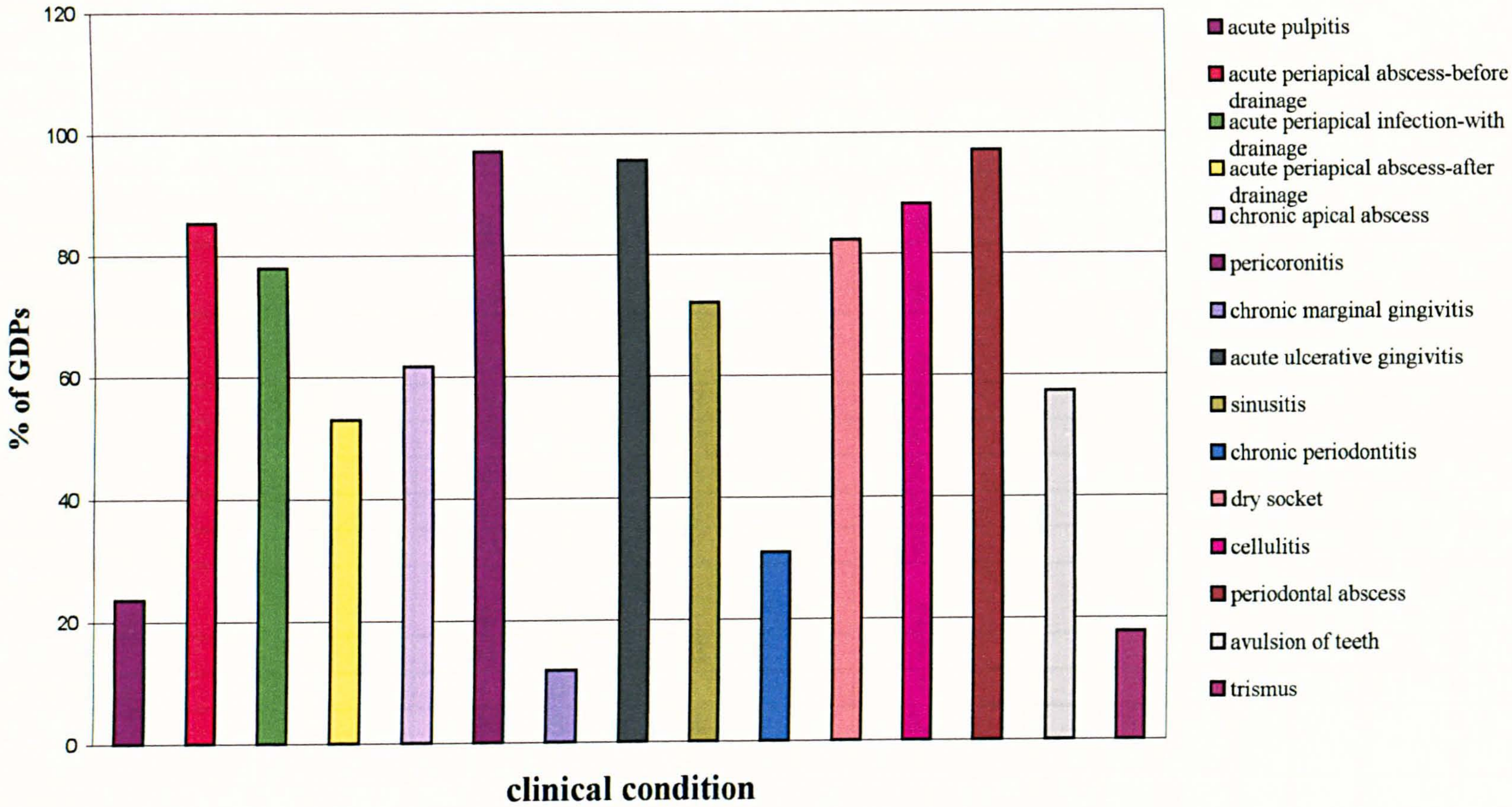


Table 3.1
Number of GDPs who would prescribe antibiotics in the pilot study for the clinical conditions investigated and their choice of antibiotic

Clinical condition	Number of GDPs	Antibiotic choice Number prescribing sometimes (S) or always (A)									
		Amoxicillin		Erythromycin		Metronidazole		Penicillin		Tetracycline	
		S	A	S	A	S	A	S	A	S	A
Acute pulpitis	16	12	2	12	1	9	0	6	0	1	0
Acute periapical infection (a) Before drainage	58	49	10	39	1	44	3	21	1	4	0
Acute periapical infection (b) With drainage	53	47	3	35	1	37	1	19	1	3	0
Acute periapical infection (c) After drainage	36	32	2	23	1	27	0	15	1	3	1
Chronic apical infection	42	36	4	28	0	34	1	13	1	5	1
Pericoronitis	66	45	3	32	1	41	22	19	0	4	1
Cellulitis	60	35	19	34	4	27	10	20	2	5	1
Periodontal abscess	66	43	3	33	1	38	17	18	0	6	1
Acute ulcerative gingivitis	65	14	0	6	2	9	53	6	0	4	1
Chronic marginal gingivitis	8	4	0	2	0	2	1	1	0	1	0
Sinusitis	49	34	10	23	1	7	0	7	0	6	0
Chronic periodontitis	21	7	0	3	0	12	0	1	0	14	0
Dry socket	56	32	6	24	2	32	11	16	0	3	0
Trismus	12	8	2	9	0	5	0	2	0	0	0
Avulsion of teeth	39	28	9	26	0	18	0	10	1	2	0

3.1.1.2 Prophylactic antibiotic prescribing–Pilot study

The results of the questionnaire on the prophylactic prescribing of antibiotics, for the clinical procedures investigated for non-medically compromised patients, are shown in Table 3.2. The majority of GDPs would prescribe antibiotics for surgical extractions and apicectomies and almost 25% before and after root canal therapy. The GDPs' choices of antibiotics for these clinical procedures are shown in Table 3.3. Overall the antibiotics chosen for the clinical procedures investigated were amoxicillin 35%, metronidazole 26%, erythromycin 23%, penicillin 15% and tetracycline 1%.

GDPs were asked to define the clinical procedures and medical conditions for which they would provide prophylactic antibiotic cover, the results of which are shown in Table 3.4. Only a minority of practitioners considered prophylactic antibiotics for patients with a history of diabetes, haemodialysis, Hodgkin's disease and AIDS, immunosuppressive therapy, autoimmune disease, renal transplants, coronary by-pass surgery and innocent heart murmurs.

The response of GDPs to a history of a cardiac condition, with the exception of aortic stenosis, was that the majority would give prophylactic antibiotics for root canal therapy, scaling and polishing and extractions but not for fillings and impressions. Over 30% felt there was an indication for prophylaxis for patients with prosthetic joints. Over 70% would provide prophylaxis for patients with rheumatic fever with no valvular dysfunction when scaling, extracting teeth and performing root canal therapy. Only 47.8% saw a need to provide prophylaxis for extractions with patients who had undergone radiotherapy to the head and neck

Table 3.5 shows the antibiotic regimens used by the GDPs to provide prophylactic antibiotic cover for medically compromised patients not allergic to penicillin. Some dentists selected more than one regimen with amoxicillin being used by over 90% of GDPs. Clindamycin (76.5%) and erythromycin stearate (27.9%) were the main choices of antibiotic for patients allergic to penicillin.

Table 3.2

The percentage of GDPs in the pilot study that would prescribe prophylactic antibiotics for patients with no significant medical history, listed by clinical procedure. (n=68)

Clinical procedure	% of GDPs prescribing
Extraction–routine	4.4
Extraction–surgical	66.2
Apicectomy	66.2
Root canal therapy pre-operative	23.5
Root canal therapy post-operative	25.0

Table 3.3

The number of GDPs prescribing antibiotics in the pilot study for the clinical procedures investigated for non-medically compromised patients. The antibiotic choices for each procedure are also shown.

Clinical procedure	Number of GDPs	Antibiotic choice Number prescribing sometimes (S) or always (A)									
		Amoxicillin		Erythromycin		Metronidazole		Penicillin		Tetracycline	
		S	A	S	A	S	A	S	A	S	A
Extraction a) routine	3	3	0	3	0	3	0	2	0	1	0
Extraction b) surgical	45	32	8	20	0	21	3	14	1	1	0
Apicectomy	45	33	8	23	0	23	3	14	1	1	0
Root canal therapy a) pre-operative	16	16	0	9	0	11	0	4	0	1	0
Root canal therapy b) post-operative	17	18	0	12	0	12	0	6	0	1	0
Scaling and polishing	0	-		-		-		-		-	
Restorative treatment	0	-		-		-		-		-	

Table 3.4
Medical conditions and procedures for which GDPs provide antibiotic prophylaxis (n=68) in the pilot study

sp–scaling and polishing, fills–restorative procedures, rct–root canal therapy, extract–extractions

Medical condition	% of dentists providing prophylaxis for procedures listed			
	sp	fills	rct	extract
Diabetes mellitus	4.4	0	10.3	25.0
Haemodialysis patients	20.6	2.9	16.2	23.5
Hodgkin's disease	10.3	2.9	13.2	26.5
AIDS	20.6	7.4	20.6	36.8
Patients on immunosuppressives	26.9	4.5	23.9	41.8
Patients with autoimmune disease	19.4	3.0	19.4	32.8
Renal transplant patients	19.4	1.5	17.9	26.9
Radiotherapy to head and neck	10.4	4.5	13.4	47.8
Patients with prosthetic joints	31.3	6.0	26.9	31.3
History of infective endocarditis	98.5	22.4	82.1	98.5
Cardiac valve prosthesis	89.1	16.4	70.1	89.6
Rheumatic heart disease	97.0	17.9	82.1	97.0
Aortic stenosis	53.7	11.9	41.8	53.7
Ventricular septal defect	74.6	14.9	62.7	76.1
Coronary bypass surgery	25.4	4.5	22.4	25.4
Rheumatic fever - no valvular dysfunction	70.1	19.4	58.2	73.1
Physiological/functional/innocent murmurs	20.9	0	13.44	22.4

Table 3.5

GDPs' choice in the pilot study of antibiotic regimen for prophylaxis for medically compromised patients not allergic to penicillin (n=68)

Antibiotic regimen (Some dentists use more than one regimen for prophylaxis)	**% of GDPs**
Amoxicillin 3g 1 hr pre-op	86.8
Amoxicillin 3g 1 hr pre-op + 500 mg 6 hr later	13.2
Erythromycin stearate 1g 1 hr pre-op + 500 mg 6 hr later	7.4
Clindamycin 600mg 1 hr pre-op	16.2
Metronidazole 200mg 3 times daily for 3 days	1.5

3.1.2 Definitive study

A total of 929 replies were received giving a response rate of 60.1%; 38 of the returned questionnaires were incomplete, resulting in 891 useable replies. The number of questionnaires sent out and the replies for each Health Authority area are shown in Table 3.6. The distribution of age groups is shown in Figure 3.3, of which 71.5% were males and 28.5% females. The distributions of responses for the dental schools in the UK are shown in Table 3.7. The London dental schools were combined for ease of analysis. All overseas universities of qualification were also combined and listed in Table 3.7. The majority of the responses were graduates from London, Liverpool, Newcastle and Sheffield. Only 21.3% of the respondents had attended postgraduate courses on antibiotics in the previous two years. Table 3.8 shows the number of GDPs who had attended postgraduate courses and the distribution of responses for each Health Authority.

The results for therapeutic and prophylactic antibiotic prescribing from the questionnaire are shown in the following sections.

3.1.2.1 Therapeutic antibiotic prescribing–definitive study

In Table 3.9 the clinical signs for which practitioners would prescribe therapeutic antibiotics is shown. Elevated temperatures, gross diffuse swelling, difficulty in swallowing and closure of the eye, were the principal clinical indications for antibiotic prescribing.

Table 3.6

The total number of GDPs, the number of replies and percentage response rate for each Health Authority area for the definitive study

Health Authority	Total number of GDPs	Number of replies	Percentage response rate
Buckinghamshire	250	171	74.3
Liverpool	162	89	54.9
Newcastle	124	72	58.0
North Notts	113	58	51.3
North Tyneside	55	39	70.9
Northumberland	86	54	62.8
Nottinghamshire	208	107	51.4
Oxfordshire	219	128	58.4
Sheffield	205	128	62.4
Wirral	122	83	68.0
Total	**1544**	**929**	**60.1**

Figure 3.3
Distribution of age groups of respondents for the definitive study

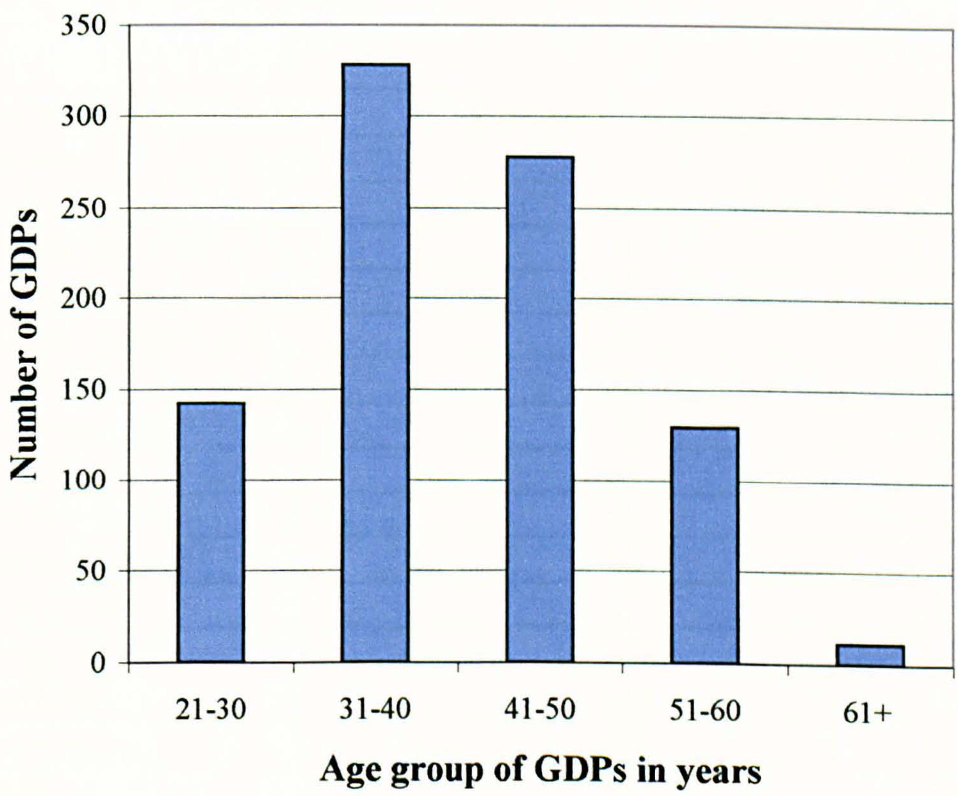


Table 3.7

University of qualification showing the numbers of responses and percentage of the total response for the definitive study

University	Number of responses	%
Unknown	4	0.4
Wales	18	2.0
Edinburgh	19	2.1
Glasgow	22	2.5
Belfast/Dublin/Cork	24	2.7
Dundee	25	2.8
Overseas	30	3.4
Bristol	31	3.5
Leeds	36	4.0
Manchester	43	4.8
Birmingham	47	5.3
Liverpool	125	14.1
Sheffield	136	15.3
Newcastle	158	17.7
London	173	19.4
Total	**891**	**100**

Table 3.8

The number of responses for the definitive study from each Health Authority and the number of GDPs who had attended postgraduate courses on antibiotic prescribing in the previous two years.

Health Authority	**Number of responses**	**Number attending postgraduate courses**
Buckinghamshire	167	31
Liverpool	85	22
Newcastle	68	11
North Notts	55	11
North Tyneside	39	14
Northumberland	51	6
Nottingham	101	19
Oxfordshire	123	27
Sheffield	123	22
Wirral	79	52
Total	**891**	**190**

Table 3.9

The clinical signs for which GDPs (n= 891) would prescribe antibiotics in conjunction with appropriate treatment in the definitive study

CLINICAL SIGNS	%
Elevated temperature & evidence of systemic spread	97.5
Localised fluctuant swelling	34.5
Gross diffuse swelling	96.6
Restricted mouth opening	88.3
Difficulty in swallowing	80.5
Closure of eye due to swelling	96.2

The three main antibiotics prescribed therapeutically by the GDPs in the sample, for adults not allergic to penicillin with an acute dentoalveolar infection, are shown in Table 3.10. This table also shows the variation in the frequency, dose and length of the course of the antibiotics prescribed. Amoxicillin was the principal antibiotic prescribed with 70.5% selecting this antibiotic as their first choice. The principal dosage of amoxicillin was 250mg three times daily for 5 days, but 3g, 200mg and 500mg were also used, the latter two doses for periods of 3-10 days, and 3-4 times daily. Penicillin V was the next most popular first choice of antibiotic with 20.5% using it; the doses and frequency were mainly 250mg and four times daily for five days. Metronidazole was used by 7% of the respondents at doses of 200mg, 250mg and 400mg for 3-7 days. Ampicillin and cephalexin were prescribed by only 0.5% of respondents. The main choice of therapeutic antibiotic for patients allergic to penicillin was either erythromycin 46.7%, or metronidazole 48%: the other choices were tetracycline (0.9 %) or cephalosporins (1.3%).

The non-clinical factors influencing therapeutic antibiotic prescribing are shown in Table 3.11 Almost half the practitioners surveyed used antibiotics when they were uncertain about the diagnosis, or when under pressure of time (30%). Circumstances where treatment had to be delayed accounted for 72.5% of prescribing. Only a small percentage (8%) would prescribe antibiotics because of patient expectation or the patient's social history.

Table 3.10

Antibiotic prescribed by GDPs (n=891) in the definitive study for acute dentoalveolar infection showing dosage, frequency of dose and number of days prescribed

Antibiotic	% of GDPs	Dosage	Frequency				Number of days										Total
			1 dose	3xdaily	4xdaily	1+1, 8 hrs later	0	1	2	3	4	5	6	7	8	10	
Amoxicillin	70.5	3g	2	4	1	22		22	5	1		1					**29**
		200mg		4	2							4		2			**6**
		250mg		346	110	2	1			20	4	356	6	69	1		**459**
		500mg		112	10	2	1			10	2	88		22		1	**125**
		Total	**2**	**466**	**123**	**26**	**2**	**22**	**5**	**31**	**6**	**449**	**6**	**93**	**1**	**1**	**622**
Pen V	20.5	200mg			1							1					**1**
		250mg		4	150					6		119	4	25			**154**
		500mg		2	24				1	1		23		1			**26**
		Total	**0**	**6**	**175**	**0**	**0**	**0**	**1**	**7**	**0**	**143**	**4**	**26**			**181**
Metronidazole	7	200mg		42	2					12		27		5			**44**
		250mg		2						1		1					**2**
		400mg		12	3	1				4	1	11					**16**
		Total	**0**	**56**	**5**	**1**	**0**	**0**	**0**	**17**	**1**	**39**	**0**	**5**	**0**	**0**	**62**

Table 3.11

Non-clinical factors that cause GDPs (n=891) to prescribe antibiotics in the definitive study

NON-CLINICAL FACTORS	%
Patient expectation of a prescription	8.0
Pressure of time and workload	30.3
Patient's social history	8.2
Uncertainty of diagnosis	47.3
Where treatment has to be delayed	72.5

The percentage of practitioners prescribing antibiotics for the specific conditions investigated is shown in Figure 3.4. The majority prescribed for acute periapical lesions before drainage, pericoronitis, acute ulcerative gingivitis, dry sockets, periodontal abscesses and the re-implantation of teeth. Over 10% prescribed for acute pulpitis and chronic periodontitis. The GDPs' choices of antibiotics for specific conditions, assuming no allergy to penicillin, are shown in Table 3.12. Amoxicillin or metronidazole was the most used antibiotic for all the conditions surveyed.

Figure 3.4
The percentage of GDPs prescribing antibiotics for the clinical conditions investigated in the definitive study

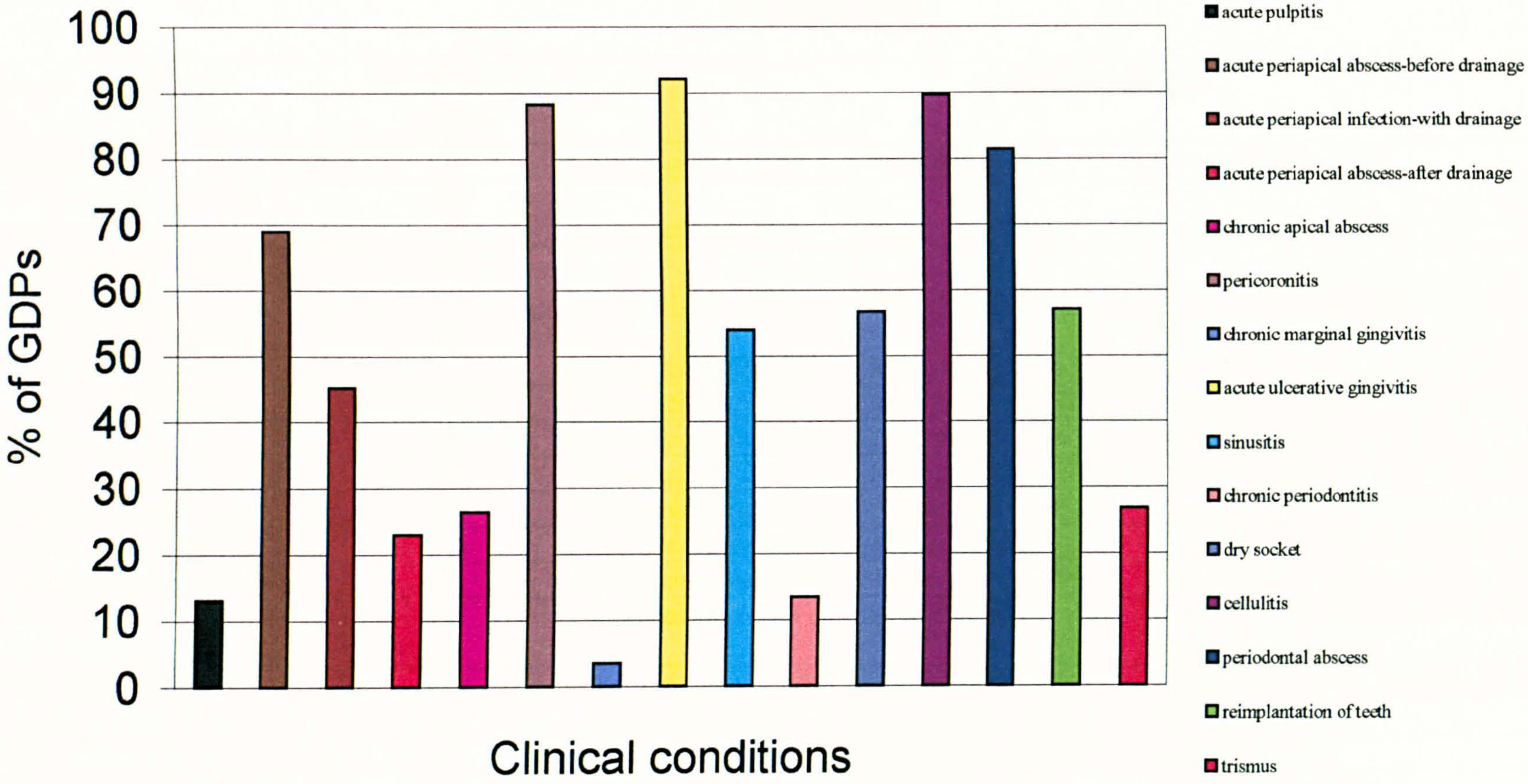


Table 3.12

Antibiotic choices of GDPs in the definitive study for specific clinical conditions, assuming no allergy to penicillin

Clinical condition	Number of GDPs	Antibiotic choice		
Acute pulpitis	116	Amoxicillin (74%)	Penicillin (21%)	Metronidazole (5%)
Acute periapical infection (a) Before drainage	609	Amoxicillin (72%)	Penicillin (20%)	Metronidazole (19%)
Acute periapical infection (b) With drainage	400	Amoxicillin (76%)	Penicillin (18%)	Metronidazole (15%)
Acute periapical infection (c) After drainage	201	Amoxicillin (70%)	Metronidazole (19%)	Penicillin (17%)
Chronic apical infection	233	Amoxicillin (67%)	Metronidazole (20%)	Penicillin (18%)
Pericoronitis	780	Metronidazole (67%)	Amoxicillin (30%)	Penicillin (10%)
Cellulitis	792	Amoxicillin (77%)	Metronidazole (22%)	Penicillin (15%)
Periodontal abscess	720	Metronidazole (58%)	Amoxicillin (34%)	Penicillin (9%)
Acute ulcerative gingivitis	814	Metronidazole (92%)	Amoxicillin (3%)	Tetracycline (3%) Penicillin (2%)
Chronic marginal gingivitis	31	Metronidazole (48%)	Tetracycline (22%)	Amoxicillin (11%) Penicillin (10%
Sinusitis	477	Amoxicillin (65%)	Erythromycin (10%)	Penicillin (7%) Doxycycline (6%) Metronidazole (5%)
Chronic periodontitis	119	Metronidazole (44%)	Tetracycline (39%)	Amoxicillin (15%) Penicillin (6%)
Dry socket	501	Metronidazole (47%)	Amoxicillin (44%)	Penicillin (11%)
Trismus	237	Amoxicillin (67%)	Metronidazole (23%)	Penicillin (15%)
Re-implantation of teeth	502	Amoxicillin (78%)	Penicillin (17%)	Metronidazole (7%)

3.1.2.2 Prophylactic antibiotic prescribing–definitive study

GDPs' uses of prophylactic antibiotics for specific dental procedures, with non-medically compromised patients not allergic to penicillin, are shown in Table 3.13. Practitioners prescribed antibiotics for surgical extractions (38.9%) and apicectomies (43.5%) with a small number prescribing for pre- and post-root canal treatment. Amoxicillin, penicillin and metronidazole were the antibiotics most frequently prescribed for these procedures, with some practitioners indicating more than one choice of antibiotic.

The medical conditions and procedures for which GDPs might consider prescribing prophylactic antibiotics are shown in Table 3.14. Only a minority of dental practitioners considered that a history of diabetes, haemodialysis, Hodgkin's disease and AIDS, immmunosuppressive therapy, autoimmune disorders and renal transplant were an indication for prophylactic antibiotics. With the exception of diabetes, a significant number of respondents felt they would seek specialist advice for these conditions. The response of GDPs to a patient with a cardiac condition, with the exception of patients with aortic stenosis and ventricular septal defects, was that the majority of practitioners would give antibiotics for extractions, restorations involving the gingival margin, scaling and polishing but not impressions. Coronary heart disease and bypasses, pacemakers and physiological murmurs were not generally seen by GDPs as an indication for prophylactic antibiotic cover. Approximately 25% felt that a history of prosthetic joints was an indication for prophylactic cover. Approximately 40% of GDPs would provide cover for patients with a history of rheumatic fever with no valvular dysfunction when scaling and polishing and extracting teeth. Only 21.8% felt there was a need to provide antibiotic prophylaxis for extractions on patients who had undergone radiotherapy to the head and neck, although over 40% would seek specialist advice.

The prophylactic antibiotic regimens used by GDPs for medically compromised patients, not allergic to penicillin, are shown in Table 3.15. A single 3g dose of amoxicillin was the choice of prophylactic antibiotic cover provided by 90.6% of the respondent GDPs; a two-dose regimen of amoxicillin was used by 9.2% of respondents. Other regimens included clindamycin (14.9%), metronidazole (2.8%), penicillin (0.6%) and tetracycline (0.1%). Some GDPs (18.2%) indicated more than one regimen. The antibiotics used for patients allergic to penicillin, shown in Table 3.16, were mainly clindamycin (77.1%), erythromycin stearate (18.6%) with a small percentage prescribing metronidazole and tetracycline.

Table 3.13

Clinical procedures in the definitive study for which GDPs (n=891) prescribe prophylactic antibiotics. The antibiotics chosen are shown for patients with no relevant medical history and no allergy to penicillin

Procedure	% of GDPs	Antibiotic choice (Some practitioners indicated more than one antibiotic)
Apicectomy	43.5	Amoxicillin 28.5% Penicillin 9% Metronidazole 6%
Surgical extractions	38.9	Amoxicillin 26.5% Penicillin 7.5% Metronidazole 4.9%
Before root canal treatment	5.4	Amoxicillin 3.6% Penicillin 1.1% Metronidazole 0.9%
After root canal treatment	2.8	Amoxicillin 1.7% Metronidazole 0.8% Penicillin 0.6%

Table 3.14
Medical conditions and procedures for which GDPs provide antibiotic prophylaxis (n=891) in the definitive study

Medical history	% of dentists providing prophylaxis for procedures listed						
	Scaling & polishing	Fillings-Class II subgingival	Fillings-Class V subgingival	Root canal therapy	Extractions	Impressions	Seek specialist advice
Diabetes mellitus	1.1	0.7	0.7	3.6	15.8	0.1	3.5
Haemodialysis patients	5.1	3.4	3.2	5.0	8.4	0.2	48.9
Hodgkin's disease	2.5	1.1	1.1	1.9	4.4	0.2	43.8
AIDS	6.7	4.2	4.1	5.9	11.3	0.5	58.0
Patients on immunosuppressives	10.7	6.7	6.6	10.0	19.9	0.8	56.0
Patients with autoimmune disease	3.6	1.9	2.0	3.3	6.8	0.3	47.6
Renal transplant patients	13.5	8.6	8.0	10.6	17.4	1.0	51.2
Radiotherapy to head and neck	6.0	3.6	3.5	6.2	21.8	0.8	42.3
Patients with prosthetic joints	21.8	13.8	13.5	17.2	25.2	0.8	16.0
History of infective endocarditis	86.2	64.4	63.7	71.8	88.3	7.6	17.0
Cardiac valve prosthesis	84.4	60.2	59.8	67.9	87.0	5.7	11.0
Rheumatic heart disease	89.4	63.1	63.5	72.1	92.0	5.5	7.8
Aortic stenosis	33.9	23.5	23.0	25.6	33.9	1.9	29.5
Ventricular septal defect	55.1	38.0	38.0	43.0	56.0	3.2	29.0
Coronary by-pass surgery	12.8	9.2	9.0	10.5	14.4	1.1	17.0
Rheumatic fever–no valvular dysfunction	38.8	24.0	24.3	30.1	40.2	2.4	22.5
Coronary heart disease	2.7	1.7	1.8	2.3	3.5	0.2	9.5
Pacemakers	6.8	5.1	5.3	5.9	7.9	1.0	10.1
Physiological/innocent murmurs	8.3	4.9	5.0	6.2	9.6	0.6	23.4

Table 3.15

GDPs' choice of prophylactic antibiotic regimen in the definitive study for medically compromised patients not allergic to penicillin (n=891)

ANTIBIOTIC REGIMEN (Some practitioners indicated more than one regimen)	**% of GDPs**
Amoxicillin 3g 1 hr pre-op	90.6
Clindamycin 600mg 1 hr pre-op	14.9
Amoxicillin 3g 1 hr pre-op +500mg 6 hrs later	9.2
Erythromycin stearate 1g 1 hr pre-op + 500mg 6 hrs later	3.1
Metronidazole 200mg 3 times daily for three days	2.8
Penicillin V 2g 1 hr pre-op + 1g 6 hrs later	0.6
Tetracycline 1g pre-op +500mg 6 hrs later	0.1

Table 3.16

Antibiotic prophylactic regimen used by GDPs in the definitive study (n=891) for medically compromised patients allergic to penicillin

ANTIBIOTIC	REGIMEN (Some practitioners indicated more than one regimen)	% of GDPs
Clindamycin	600mg 1 hr pre-op	77.1%
Erythromycin stearate	1g 1 hr pre-op + 500mg 6 hrs later	18.6%
Metronidazole	200mg 3 times daily for three days	3.3%
Tetracycline	1g 1 hr pre-op 500mg 6 hrs later	2.2%

3.2 General dental practitioners' antibiotic prescribing knowledge

GDPs' prescribing knowledge was assessed from the questionnaires. The correct answers (see Section 2.4 and Appendices 1, 2) were compared to those of GDPs. The results of the pilot and definitive questionnaire study are shown in the two following sections.

3.2.1 Pilot questionnaire

The maximum score for the correct answers to the questionnaire was 160. Table 3.17 shows the range of correct answer scores, mean and standard deviation for each of the questions and the total overall score, and Table 3.18 the total overall score for the number of years since qualification.

The mean percentage of correct answers overall was 78.75% (range 57.5% - 90%). Individual questions, however, showed greater variation. Question 1 looked at the incidence of prescribing and the antibiotic prescribed for a range of conditions such as acute pulpitis, which does not require antibiotics, and cellulitis, which does. The mean percentage correct answers for this question was 66% (range 47% - 93%). Question 2 asked practitioners about antibiotic prescribing for a range of treatments for patients with no relevant medical history. This question had a mean correct response of 71% (range 28% - 100%). Question 3 asked about prescribing habits for different types of treatment on patients with various medical histories. Mean percentage of correct answers for this question was 84% (range 52% - 97%). The final set of questions investigated the prescribing regimens for patients who were either medically compromised, or had hypersensitivity to penicillin. The mean percentage of correct answers was 82% (range 55% - 90%).

The sample included GDPs ranging from those recently qualified to those that had been qualified for over 30 years. The scatter graph in Figure 3.5.shows that there was no relationship between the number of years since qualification and the total number of correct answers. A Pearson's correlation ($r = 0.103$, $p > 0.05$) statistical test also showed that there was no significant relationship between the number of years qualified and total number of correct answers.

A total of 30.9% of practitioners had attended a postgraduate course on antibiotic prescribing in dental practice within the previous two years. To investigate the effect of postgraduate education on antibiotic prescribing knowledge, data were analysed using an unrelated t-test for significant differences between GDPs who had, or had not, attended postgraduate courses in the previous two years. This showed there was no significant difference between the two groups ($t = 0.30$, $p > 0.05$), with a mean score for attendees of 126.5 (s.d 10.61) and for non-attendees of 125.7 (s.d 10.24).

Table 3.17

Range of correct answer scores, means and standard deviations for the questions in the pilot study

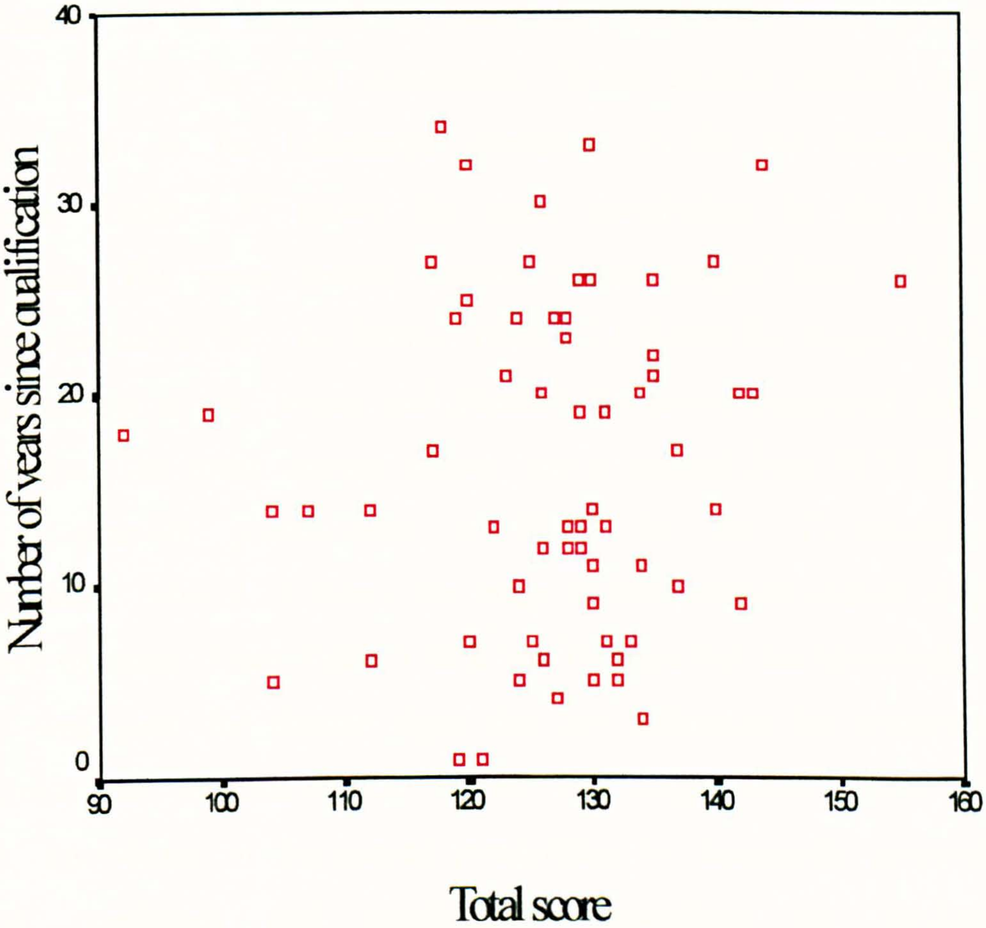
Question	Minimum	Maximum	Mean	Std Deviation
Clinical conditions for which antibiotics are indicated and antibiotic of choice (question 1)	7	14	9.95	1.45
Clinical procedures for which antibiotics are prescribed prophylactically for patients with no relevant medical history (question 2)	2	7	5.07	1.37
Medical histories and clinical procedures for which prophylactic antibiotics are required (question 3)	50	92	79.70	8.59
Prescribing regimens for medically compromised patients, antibiotic interactions with other medications (questions 4,5,6,7,8,9)	23	38	31.38	3.43
Overall total score	**92**	**155**	**126.45**	**10.64**

Table 3.18

A comparison of the number of years since qualification of GDPs (in five-year bands) with the minimum and maximum correct answer scores in the definitive study. Also shown are the mean scores and standard deviations.

Number of years since qualification	Minimum	Maximum	Mean	Std deviation
0-5	104	134	124.22	9.02
6-10	112	142	127.66	8.21
11-15	104	140	125.00	10.32
16-20	92	143	125.00	17.38
21-25	119	135	126.55	5.76
26-30	117	155	132.12	11.49
30-35	118	144	128.00	11.88

Figure 3.5
Scatter graph showing no correlation between the total correct answer score against number of years since qualification of GDPs in the pilot study



3.2.2 Definitive questionnaire

The knowledge of the practitioners taking part in the survey was related to the total correct answer score of each questionnaire. The maximum possible score for the definitive questionnaire was 84, with respondents achieving a range of 25-84 (mean 57.28 s.d 6.73). Table 3.19 shows the range of scores, means and standard deviations for the university of qualification of the respondents (overseas universities were grouped together as were the Irish universities). Mean correct answer scores ranged from 54 for Edinburgh graduates to 60 for Birmingham graduates. Table 3.20 shows the same information for the Health Authorities. The mean correct answer scores ranged from 55.8 for Northumberland to 58.7 for Wirral. Table 3.21 shows the range of mean correct answer scores, means and standard deviations compared against age groups. The mean correct answer scores ranged from 48.7 for the over 61-year-old practitioners to 58.13 for the 21-30-year-old practitioners. Table 3.22 shows the range of total correct answer scores for each question. From Table 3.22 it can be seen that the knowledge of GDPs was good for clinical signs that are indicators for prescribing antibiotics and for non-clinical factors that might affect prescribing. GDPs' knowledge of therapeutic prescribing for commonly presenting clinical conditions and prophylactic prescribing for medically compromised patients was generally poor.

Independent t-tests ($t = 1.798$, $p>0.05$) showed no significant difference between genders, with a female mean score of 57.93 (s.d 6.32) and male mean score of 57.02 (s.d 6.87). A t-test ($t = -3.65$, $p<0.05$), however, showed a small but significant difference between those who had attended a postgraduate course on antibiotic prescribing in the last two years and those who had not, with a mean score of 56.85 (s.d 6.63) for non-attendees and 58.85 (s.d 6.86) for attendees. There was no relationship between the year of qualification and total correct answer score as shown in the scatter graph in Figure 3.3. A Pearson's correlation ($r = 0.061$, $p>0.05$) statistical test showed no significant relationship between the year of qualification and the overall score.

A one-way analysis of variance (ANOVA) using age bands as the grouping variable showed there were significant differences ($F (4,882)= 5.326$, $p<0.01$) between age bands and scores. A Tukey honestly significant difference (HSD) *post hoc* statistical test revealed that there were significant differences ($p< 0.05$) between age bands over 61 years of age (mean score 48.72) and under 60 years (mean score 57.44), with no significant differences ($p> 0.05$) between the four age groupings under 61 years of age.

Further one-way analyses of variance using Health Authorities as the grouping variable showed no significant differences in scores ($F (9,880)=0.951$, $p>0.01$). Using the university of qualification as the grouping variable showed significant differences in scores ($F (13, 872)= 2.582$, $p<0.01$).

Table 3.19

The minimum, maximum, mean correct answer scores and standard deviation in the definitive study for the university of qualification of respondents ranked by the mean score.

University of qualification	Mean score	Std deviation	Min Score	Max score (84)
Edinburgh	53.94	9.44	38	69
Glasgow	54.59	7.58	42	67
Overseas	54.90	6.38	41	65
Newcastle	56.38	7.28	35	75
Ireland	56.41	4.60	49	66
London	56.72	7.13	25	73
Leeds	56.97	6.85	35	66
Wales	57.00	3.81	51	65
Sheffield	57.60	6.11	38	71
Liverpool	58.56	6.72	40	73
Manchester	58.62	5.90	47	70
Bristol	58.76	5.64	45	69
Dundee	58.76	4.63	47	65
Birmingham	59.91	5.95	51	84

Table 3.20

The minimum, maximum, mean correct answer scores and standard deviations in the definitive study for the Health Authorities ranked by mean scores

Health Authority	Mean score	Std deviation	Min score	Max score (84)
Northumberland	55.82	6.32	40	67
Nottingham	56.54	6.67	35	69
Buckinghamshire	57.00	6.63	39	73
North Notts	57.05	5.61	41	71
Oxfordshire	57.13	7.06	25	69
Newcastle	57.44	6.75	39	69
North Tyneside	57.56	8.85	35	75
Liverpool	57.67	7.33	38	84
Sheffield	57.75	5.89	40	72
Wirral	58.70	6.80	40	72

Table 3.21

The minimum, maximum, mean scores and standard deviation compared against the age groups of respondents in the definitive study

Age group	Mean score	Std deviation	Min score	Max score (84)
21-30 years	58.13	5.53	39	73
31-40 years	57.37	6.43	25	75
41-50 years	57.33	6.71	35	73
51-60 years	56.91	7.85	35	84
>61 years	48.72	8.36	37	64

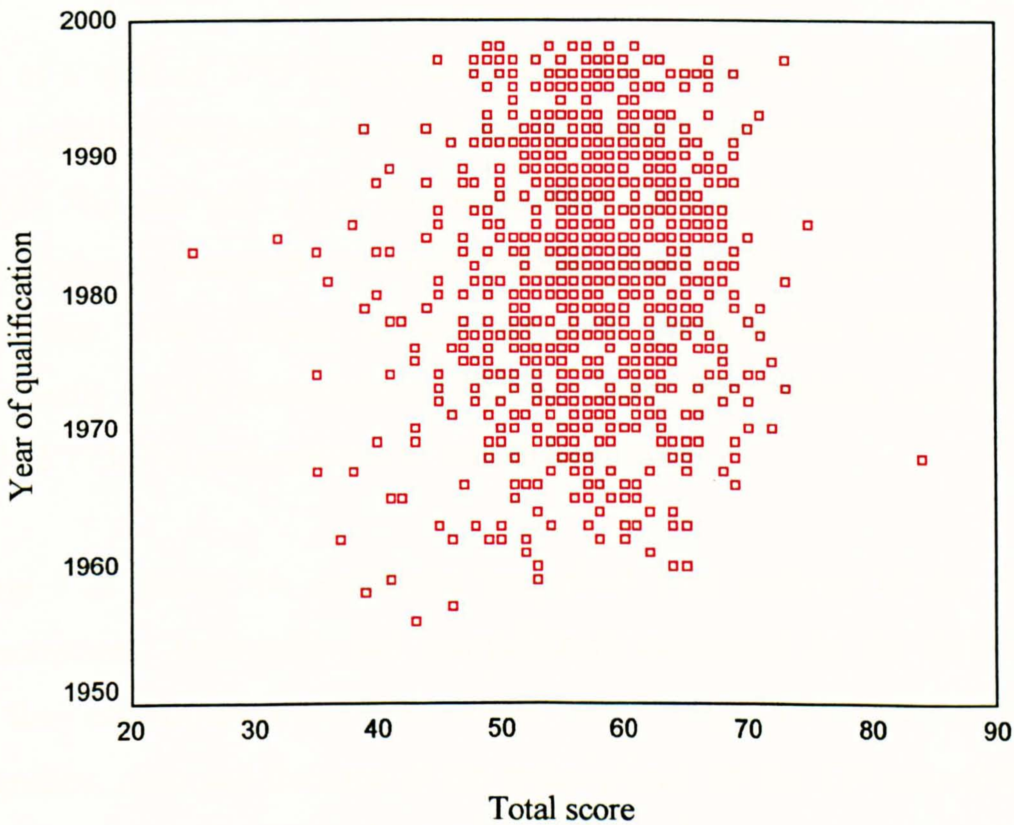
Table 3.22

The range of correct answer scores, mean scores and standard deviations for the questions in the definitive study

Question	Mean score	Std deviation	Min score	Max score
Clinical signs indicating antibiotics (question 6)	5.24	0.83	2	6
Antibiotic of choice for periapical infection (question 7)	2.90	1.01	0	4
Non-clinical factors that might influence prescribing (question 8)	3.31	1.15	0	5
Antibiotic of choice for patients allergic to penicillin (question 9)	0.46	0.49	0	1
Clinical conditions for which antibiotics are indicated (question 10)	8.08	2.24	0	15
Clinical procedures for which prophylactic antibiotics are prescribed in non-compromised patients (question 11)	5.89	1.20	0	7
Medical histories and clinical procedures for which prophylactic antibiotics are required (question 12)	16.95	4.77	0	30
Prophylactic regimen for patients not allergic to penicillin (question 13)	6.89	0.68	2	8
Prophylactic regimen for patients allergic to penicillin (question 14)	7.53	0.81	5	8

Figure 3.3

Scatter graph showing no correlation between year of qualification and overall total score for the definitive study questionnaire



3.3 Prescription studies

The results of the analysis of the prescriptions are presented in two sections: the pilot study and the definitive study.

3.3.1 Pilot study

Out of a total of 1775 prescriptions 200 were examined and analysed. The legibility was rated very good for 88 (44%) prescriptions, good for 99 (45.5%) and only 13 (6.5%) were rated poor. Only nine of the 200 prescriptions contained incorrect patient details. The names of the antibiotics were written in full on 186 prescriptions (93%) and generically on 177 prescriptions (83.5%). Latin abbreviations were used on 142 (73.5%) prescriptions to denote frequency.

Table 3.23 shows the antibiotics prescribed from analysis of the 200 prescriptions. Amoxicillin and metronidazole accounted for the majority of the antibiotics prescribed. There were large variations in the frequency, dose and duration of the prescriptions for the 129 amoxicillin prescriptions (Table 3.24). Metronidazole was the next most prescribed antibiotic (Table 3.25) accounting for 43 prescriptions again with wide variations in doses, frequency and dosage.

Erythromycin and penicillin accounted for only 21 prescriptions and there were also a variety of dosages, frequency and duration in the prescriptions (see Tables 3.26 and 3.27). Clindamycin was only prescribed four times in single doses of 600mg (two prescriptions), and twice for five days, four times daily, at the dose of 150mg.There was one prescription for tetracycline (six days four times daily, 250mg) and one for cephradine (500mg, 90 minutes pre-operatively).

Table 3.23

The frequency of prescriptions for each of the antibiotics prescribed in the pilot study.

Antibiotic Prescribed	**No. Prescriptions**
Amoxicillin	129
Metronidazole	43
Erythromycin	11
Penicillin	11
Clindamycin	4
Tetracycline	1
Cephradine	1
Total	**200**

Table 3.24

The doses, frequency and duration of the prescriptions for amoxicillin in the pilot study

Number of prescriptions	Dose	Frequency	Duration (days)
7	3g	-	-
3	3g	twice	-
1	3g	three times	
2	250mg	three times daily	3 or 4
34	250mg	three times daily	5
9	500mg	three or four times daily	5
21	250mg	four times daily	5
12	125mg	three or four times daily	5
22	250mg	three times daily	6/7
5	250mg	four times daily	6/7
2	500mg	three times daily	7
7	125mg	three or four times daily	7
1	250mg	four times daily	14
3	not specified	not specified	not specified

Table 3.25

The doses, frequency and duration of prescriptions of metronidazole in the pilot study.

Number of prescriptions	Dose	Frequency	Duration (Days)
21	200mg	three times daily	3
1	200mg	three times daily	4
1	200mg	twice daily	5
10	200mg	three times daily	5
2	200mg	four times daily	5
3	200mg	three times daily	7
2	400mg	three times daily	3
3	400mg	three times daily	7

Table 3.26

The doses frequency and duration of prescriptions of erythromycin in the pilot study

Number of prescriptions	Dose	Frequency	Duration (days)
7	250mg	four times daily	5
1	250mg	four times daily	6
1	125mg	three times daily	7
1	500mg	four times daily	5
1	500mg	three times daily	7

Table 3.27

The dose, frequency and duration of prescriptions of penicillin in the pilot study

Number of prescriptions	Dose	Frequency	Duration (days)
5	250mg	four times daily	5
3	250mg	three times daily	5
2	500mg	four times daily	7
1	125mg	three times daily	7

3.3.2 Definitive prescription study

A total of 18,616 prescriptions were issued for antibiotics in the month investigated in the definitive study. Of these 17,007 prescriptions were adult prescriptions and 1609 were prescribed in paediatric doses and in liquid form. These 1609 prescriptions were classified as paediatric prescriptions (see section 2.5.2). The results of the analysis of prescriptions were divided into adult and paediatric prescriptions.

3.3.2.1 Adult prescription analysis

The distribution of prescriptions for each Health Authority and the number of GDPs working in each area is shown in Table 3.28. This table also shows the average number of prescriptions for GDPs in each Health Authority. The average number of prescriptions for antibiotics ranged from seven for each dentist in practising in Sheffield Health Authority to 22 for each dentist in North Nottinghamshire Health Authority.

The prescriptions were analysed and the antibiotics prescribed are shown in Table 3.29. The majority of prescriptions (90.9%) were for generic antibiotics. Combinations of two or three antibiotics were prescribed in 5.6% of prescriptions, with 4% being for a combination of amoxicillin and metronidazole. Other combinations of antibiotics included penicillin and metronidazole, metronidazole and clindamycin, amoxicillin with metronidazole and penicillin, amoxicillin with clindamycin, and amoxicillin with penicillin.

Table 3.28

Distribution of prescriptions for each Health Authority in the definitive study showing the number of GDPs practising in each Authority and the average number of prescriptions for each dentist

Health Authority	Number of GDPs	Number of prescriptions	Average number of prescriptions/dentist
North Notts	113	2498	22.1
Liverpool	162	2369	14.6
Wirral	122	1671	13.7
Northumberland	86	987	11.5
Nottinghamshire	208	2194	10.5
North Tyneside	55	542	9.8
Buckinghamshire	250	2406	9.6
Newcastle	124	1086	8.7
Oxfordshire	219	1765	8.0
Sheffield	205	1489	7.3
Total	**1544**	**17,007**	**11.0**

Table 3.29

Antibiotics prescribed by general dental practitioners from analysis of the prescriptions in the definitive study showing the number of prescriptions for each antibiotic and the percentage of the total

Antibiotic prescribed	Number of prescriptions	Percentage of total
Amoxicillin	9496	55.8
Metronidazole	3773	22.2
Penicillin	1395	8.2
Erythromycin	839	4.9
Amoxicillin + metronidazole	683	4.0
Clindamycin	234	1.4
Cephalexin	158	0.9
Tetracycline	156	0.9
Ampicillin	113	0.7
Cephadrine	51	0.3
Metronidazole + erythromycin	52	0.3
Other combinations of antibiotics	57	0.4

Detailed analysis of the majority of amoxicillin prescriptions is shown in Table 3.30. As can be seen from Table 3.30 there was a wide variation in the dosages employed. The majority of prescriptions were for a regimen of 250mg three times daily for five days, 500mg three times daily for five days or 3g given as a single dose. A further 194 prescriptions for amoxicillin (results not shown in Table 3.30) showed a range of doses from 200mg to 6g with frequencies ranging from three times daily to four times + two times daily for periods of up to 21 days.

Table 3.31 shows the analysis of the main prescriptions for metronidazole. A wide variety of regimens were used by GDPs although the majority consisted of a dosage of 200mg three times daily for five or seven days. A further 114 of the prescriptions (results not shown in Table 3.31) demonstrated wide ranges of doses from 200mg to 600mg with frequencies ranging from twice daily to one dose followed by three times daily or four times daily for durations of 2-21 days.

Analyses of the prescriptions for penicillin are shown in Table 3.32. Most of the prescriptions for penicillin were for dosages of 250mg four times daily for five or seven days. A total of 177 prescriptions were at a dose of 500mg four times daily for five days. Of the total number, 69 prescriptions (analysis not shown in Table 3.32) exhibited ranges of dose from 125mg to 3g for frequencies of one dose to six times daily for periods of 1-15 days.

The analyses of the main prescriptions for erythromycin are shown in Table 3.33. As can be seen from Table 3.33 there was a variation in dosages but the majority of the prescriptions were for dosages of 250mg four times daily for 5 or 7 days. A total of 44 other prescriptions were not included in the table. These showed a range of doses from 250mg to 3g + 500mg, frequencies from three times daily to six times daily for periods of 1-17days.

For combinations of amoxicillin and metronidazole there were over 70 different dosages recorded. In Table 3.34 analysis of the main prescriptions is shown. Over 300 prescriptions were for doses of 250mg or 500mg of amoxicillin together with 200mg or 400mg of metronidazole three times daily for five days. The 128 prescriptions not shown in the table showed doses ranging from 200mg of metronidazole together with 250mg of amoxicillin to 800mg of metronidazole together with 3g of amoxicillin. The duration of therapy ranged from 1- 10 days with wide variations in frequencies.

The majority of the prescriptions for clindamycin (170) were in prophylactic doses of 600mg, as shown in Table 3.35, although there were also a number of therapeutic doses employed. Therapeutically there was a wide variation in the doses (150mg up to 600mg), frequencies (2 times daily to 4 times daily) and duration of the course (up to 10days).

Table 3.36 shows analysis of the prescriptions for a combination of metronidazole and erythromycin. A total of 12 prescriptions, not shown in Table 3.36, showed wide variations in regimens with the doses prescribed ranging from 200mg of metronidazole and 250mg of erythromycin to 500mg of erythromycin + 250mg of erythromycin + 200mg of metronidazole. The frequencies of dose ranged from three times daily to a loading dose of 500mg of erythromycin followed by 250mg four times daily of erythromycin and 200mg of metronidazole.

The combinations of metronidazole and erythromycin were prescribed for periods ranging from 3-12 days.

Analyses of the prescriptions for cephalexin are shown in Table 3.37, the majority of these prescriptions were for doses of 250mg or 500mg at a frequency of four times daily for five or seven days. Of the eight prescriptions, not shown in the results, doses ranged from 250mg to 500mg at frequencies varying from two times daily to four times daily and for durations ranging from 2 -20 days.

Table 3.38 shows the analysis for the cephradine prescriptions. Most of these were at doses of 250mg or 500mg, three or four times daily for five or seven days. There were six prescriptions not recorded showing a range of doses from 500mg to 500mg as a single dose followed by 250mg four times daily for periods ranging from 3-10 days.

Table 3.30
Analysis of the main amoxicillin prescriptions in the definitive study showing dose, frequency and duration prescribed

Number of days	Dose prescribed	Frequency of dose													Total
		1 dose	tds	qds	1 dose + 1 eight hrs later	1 dose followed by 1tab three times daily	1 dose followed by 2tabs x tds	qds +tds	bd	every 4 hrs	tds+bd	1dose + 1 dose 8 hrs later + tds	1dose followed by qds	1dose followed by 1 dose 48hrs later	
1	3g	1085	1		152	1			22						**1261**
2	3g	24							4						**28**
3	3g	3							23					6	**32**
3	250mg		56	1	1										**58**
3	500mg		37	1											**38**
4	250mg		26	11						18					**55**
5	200mg		26	8					1						**35**
5	250mg		2392	952					3	2					**3349**
5	500mg		1526	107					3						**1636**
5	3g+250mg			1	1	26	3		1			3	4		**39**
5	3g+500mg	2	5			52	1		1			14	1		**76**
5	500mg+250mg			1		27							17		**45**
6	250mg		45	80				1							**126**
6	500mg		20	17								1			**38**
7	250mg		1070	242											**1312**
7	500mg		877	18					1						**896**
7	500mg+250mg					17	1						7		**25**
8	250mg		55	19											**74**
8	500mg		36	2											**38**
9	250mg		10	5											**15**
10	250mg		44	69					1						**114**
10	500mg		69	2					1						**72**

Table 3.31
Analysis of prescriptions for metronidazole in the definitive study showing range of doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose											Total
		tds	qds	1 dose + 1 eight hrs later	1 dose followed by 1 tab tds	1 dose followed by 2 tabs tds	bd	every 4 hrs	tds+bd	1 dose + tds + qds	1dose followed by bd	1dose followed by qds	
3	200mg	395	6						1				402
3	400mg	99	1				22						122
4	200mg	81	2				1	1					85
4	400mg	24	1				3						28
5	200mg	1494	86	1			2			1			1584
5	250mg	12	4										16
5	400mg	447	6	2			60	1			1		517
5	1 400mg dose then 200mg				3				1			11	15
6	200mg	54	2			1							57
6	400mg	18					1						19
7	200mg	544	20										564
7	400mg	246	1				9						256
8	200mg	22											22
10	200mg	16					3	1					20

Table 3.32

Analysis of prescriptions for penicillin in the definitive study showing doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose							Total
		1 dose	tds	qds	1 dose + 1 eight hrs later	1 dose followed by 1 tab tds	every 4 hrs	1 dose followed by qds	
5	250mg		28	744		1	6	1	**780**
5	500mg		11	177					**188**
5	500mg +250mg					2		11	**13**
6	250mg		1	41			1		**43**
7	250mg		15	185					**200**
7	500mg		14	10					**24**
8	250mg		1	44					**45**
10	250mg		2	31					**33**

Table 3.33
Analysis of prescriptions for erythromycin in the definitive study showing doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose				Total
		tds	qds	bd	every 4 hrs	
5	250mg	40	430		3	**473**
5	500mg	40	60	1		**101**
6	250mg	2	17			**19**
7	250mg	30	110			**140**
7	500mg	20	12	1		**33**
8	250mg	5	8			**13**
10	250mg	2	13			**15**

Table 3.34
Analysis of prescriptions for amoxicillin combined with metronidazole showing doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose													Total
		1 dose	tds	qds	1 dose followed by 1 tab tds	1 dose followed by 2 tabs tds	qds +tds	bd	every 4 hrs	tds+bd	1 dose + 1 dose 8 hrs later + tds	1 dose followed by bd	1 dose followed by 1 dose 8 hrs+qds	1 dose followed by 1 dose 8hrs+bd	
5	3g+200mg		2		7	3							1		**13**
5	3g+400mg		2		7	1				1	5	2		1	**19**
5	250mg+200mg		109	3			15								**127**
5	500mg+200mg		27	1											**28**
5	500mg+400mg		205				2		1	1					**209**
7	3g+200mg				4	2					4				**10**
7	250mg+200mg		40	1			1								**42**
7	500mg+200mg		33												**33**
5 & 3	250mg+200mg		11				6								**17**
5 & 7	250mg+400mg		12												**12**
5 & 7	500mg+400mg		11												**11**

Table 3.35
Analysis of prescriptions for clindamycin in the definitive study showing doses, frequencies and duration prescribed

No of days	Dose prescribed	Frequency of dose				Total
		1 dose	tds	qds	bd	
1	600mg	168	1			**169**
3	150mg		2	3		**5**
4	150mg		1	3		**4**
	300mg			7	1	**8**
5	150mg		1	20		**21**
7	150mg		7	6		**13**
8	150mg		1	3		**4**

Table 3.36
Analysis of prescriptions for a combination of metronidazole and erythromycin in the definitive study showing doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose					Total
		tds	qds	1 dose followed by 2 tabs tds	qds +tds	1dose+tds+qds	
5	200mg+250mg	1			2		**3**
5	250mg+200mg	3	1		1		**5**
5	250mg+400mg	2			8		**10**
5	500mg+400mg	4			1		**5**
7	250mg+200mg	2	2	1	1		**6**
5 & 3	250mg+200mg				4		**4**
5 & 7	250mg+200mg				3		**3**
5 & 7	250mg+400mg				3		**3**

Table 3.37
Analysis of prescriptions for cephalexin in the definitive study showing doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose			Total
		tds	qds	bd	
5	250mg	4	5	1	**10**
5	500mg		10	7	**17**
7	250mg		5		**5**
7	500mg	2	11		**13**

Table 3.38
Analysis of prescriptions for cephradine in the definitive study showing doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose			Total
		tds	qds	bd	
5	250mg	4	49		**53**
5	500mg	26	7	2	**35**
7	250mg	1	12		**13**
7	500mg	26	6		**32**
7	250mg	1	16		**17**

The analyses of the prescriptions for tetracycline are shown in Table 3.39. Most of the prescriptions were for doses of 250mg or 500mg four times daily for periods of five or seven days. Of the 48 individual prescriptions (results not shown) there was a range of doses from 100mg to a dose of 500mg followed by 250mg prescribed at frequencies ranging from a single dose to a single loading dose of 500mg followed by 250mg four times daily. Tetracycline was prescribed for periods ranging from 2 - 60 days.

All other adult prescriptions were also analysed. Table 3.40 shows the analysis of the prescriptions of ampicillin, with the majority being at doses of 250mg four times daily for five or seven days. A combination of penicillin and metronidazole was noted on 29 prescriptions, with doses ranging from 250mg of penicillin with 250mg of metronidazole to 1000mg of penicillin with 400mg of metronidazole. The frequency of dose with this combination varied from three times daily to four times daily for penicillin, with three times daily for metronidazole, for periods ranging from 5 -10 days.

Two of the prescriptions were for a combination of clindamycin and metronidazole, one at a single dose of 600mg of clindamycin with 200mg of metronidazole three times daily for seven days, the other at a dose of 300mg of clindamycin for three days, with 400mg of metronidazole three times daily for five days. One prescription was for a combination of amoxicillin and tetracycline. The amoxicillin was prescribed at a dose of 3g twice daily for two days with 500mg of tetracycline three times daily for five days. Four prescriptions were written for a combination of ampicillin with metronidazole.

Table 3.39
Analysis of prescriptions for tetracycline in the definitive study showing doses, frequencies and duration

Number of days	Dose prescribed	Frequency of dose			Total
		tds	qds	bd	
4	750mg			16	**16**
5	250mg	1	29		**30**
5	500mg	1	2		**3**
6	250mg		1		**1**
7	250mg		30		**30**
7	500mg	1	32		**33**

Table 3.40
Distribution of prescriptions for ampicillin showing doses, frequencies and duration prescribed

Number of days	Dose prescribed	Frequency of dose			Total
		tds	qds	bd	
5	250mg	1	55		**56**
5	500mg		7		**7**
7	250mg	6	29	1	**36**
10	250mg	1	7		**8**

The doses of this combination ranged from 250mg of ampicillin with 200mg of metronidazole to 500mg of ampicillin with 600mg of metronidazole for a period of five days.

Unusually, two prescriptions were present for a combination of amoxicillin with metronidazole and penicillin. These were at a single dose of 3g of amoxicillin along with 500mg of penicillin, four times daily and 200mg of metronidazole three times daily for five or seven days.

Four prescriptions were for a combination of a single dose of 3g of amoxicillin followed by 500mg of amoxicillin three times daily for five or seven days and 400mg of metronidazole for 3-7 days. A combination of amoxicillin and clindamycin was prescribed on three occasions. In two cases 3g of amoxicillin was prescribed along with 600mg of clindamycin as a single dose. The other prescription showed 600mg of clindamycin prescribed as a single dose followed by 500mg of amoxicillin prescribed three times daily for five days.

Six prescriptions were for a combination of amoxicillin and penicillin, with 3g of amoxicillin prescribed as a single dose followed by 250mg four times daily for five days. A combination of amoxicillin and cephalexin was prescribed on six occasions, with amoxicillin at a single dose of 3g and a single dose of 250mg of cephalexin or a single dose of amoxicillin followed by 250mg of cephalexin four times daily for five days. Metronidazole was also combined with tetracycline in two cases at a dose of 200mg of metronidazole with 250mg of tetracycline four times daily for three or five days. There was one prescription for a combination of a single dose of 3g of amoxicillin followed by 500mg of ampicillin then 250mg of ampicillin three times daily for five days.

Overall analysis showed that many of the prescriptions fell outside the recommendations of the Dental Practitioners Formulary (1998). Only 44% of prescriptions for amoxicillin, 42% for erythromycin and 33% for metronidazole were prescribed at the doses and frequencies recommended in the DPF. For penicillin 87% of the prescriptions followed the recommendations of the DPF.

3.3.2.2 Paediatric liquid formulated prescription analysis

Paediatric liquid formulated prescriptions for antibiotics (1609) were analysed independently from the adult study and are shown in Table 3.41. The distribution of the prescriptions and the number of GDPs for each Health Authority area are shown in Table 3.42. The average number of prescriptions (1-2) for each dentist was almost consistent throughout all Health Authorities. The majority (88.3%) of the prescriptions were for generic antibiotics with most practitioners prescribing amoxicillin (75.5%) followed by phenoxymethylpenicillin (15.2%) and erythromycin (6.6%). Only 29.1% of the prescriptions were in sugar-free form. The dispensing pharmacist changed a further 3.8%, as marked on the prescriptions, to a sugar-free formulation.

Detailed analysis of the commonest antibiotics prescribed, shown in full in Tables 3.43-3.46, demonstrated a wide variation in the doses employed, frequency and duration of the course. Most of the prescriptions for amoxicillin were at a dose of 125mg three times daily for 5 days. Penicillin was prescribed predominantly at a dose of 125mg four times daily for five days whereas erythromycin was prescribed at doses of 125mg or 250mg four times daily for five days. The majority of prescriptions for metronidazole were at a dose of 200mg three times daily for five days.

The other antibiotics prescribed were cephalexin, which was prescribed for five days at a dose of 125mg three times daily (two prescriptions) and four times daily (three prescriptions), ampicillin at doses of 125mg four times daily for five days (one prescription), 250mg four times daily for five days (one prescription) and seven days (one prescription) and 500mg three times daily for five days (one prescription). A combination of amoxicillin and metronidazole was prescribed on two occasions at a dose of 125mg for five days, in one case three times daily and in the other four times daily. One prescription for cephradine was prescribed four times daily at a dose of 250mg for five days.

A significant number of the prescriptions were at frequencies inconsistent with manufacturers' recommendations and for prolonged duration of treatment with some prescribing for up to 10 days.

Table 3.41

Liquid-based antibiotics prescribed with frequency and percentage of the total number

Antibiotic	Frequency	Percentage
Amoxicillin	1219	75.7
Metronidazole	28	1.7
Penicillin V	244	15.2
Erythromycin	106	6.6
Amoxicillin + Metronidazole	2	0.1
Cephalexin	5	0.3
Cephradine	1	0.1
Ampicillin	4	0.2
Total	**1609**	**100**

Table 3.42

Distribution of liquid-based prescriptions in the definitive study. The number of GDPs for each Health Authority and the number of prescriptions issued.

Health Authority	Number of GDPs	Number of prescriptions	Number of prescriptions/ GDP
Buckinghamshire	250	183	0.7
Liverpool	162	309	1.9
Newcastle	124	96	0.8
North Notts	208	225	1.1
North Tyneside	55	57	1.0
Northumberland	86	111	1.3
Nottingham	113	214	1.9
Oxfordshire	219	147	0.7
Sheffield	205	142	0.7
Wirral	122	125	1.0
Total	**1544**	**1609**	**1.0**

Table 3.43

Analysis of liquid-based prescriptions for amoxicillin in the definitive study showing dosage, frequency of dose and duration in days

	Frequency of dose								Total
Number of days	**Dosage prescribed**	**1 dose**	**tds**	**qds**	**1 dose + 1 8 hrs later**	**2 doses followed by 1 dose tds**	**bd**	**1 dose + 1 dose 8 hrs later then tds**	
1	1.5 g	4							**4**
1	750 mg	2			1				**3**
3	125mg		10						**10**
3	250mg		2						**2**
5	125mg		710	193		3	3	2	**911**
5	250mg		104	38					**142**
5	500mg		1						**1**
6	125mg		5						**5**
7	75mg			1					**1**
7	125mg		87	8					**95**
7	250mg		35	2					**37**
7	500mg		1						**1**
8	125mg		1						**1**
10	125mg		2						**2**

Table 3.44

Analysis of liquid-based prescriptions for penicillin in the definitive study showing dose, frequency of dose and duration in days

Number of days	Dosage prescribed	Frequency of dose		Total
		tds	qds	
3	125mg		1	**1**
4	125mg		1	**1**
5	100mg		1	**1**
5	125mg	29	129	**158**
5	175mg		1	**1**
5	250mg	8	54	**62**
5	500mg		1	**1**
7	125mg		16	**16**
7	250mg		2	**2**
8	125mg	1		**1**

Table 3.45

Analysis of liquid-based prescriptions for metronidazole in the definitive study showing dose, frequency of dose and duration in days

Number of days	Dosage prescribed	Frequency of dose			Total
		tds	qds	bd	
3	100mg	2		1	**3**
3	200mg	2			**2**
5	100mg	4		1	**5**
5	125mg	1			**1**
5	200mg	13	1	1	**15**
7	100mg			1	**1**
7	200mg			1	**1**

Table 3.46

Analysis of the liquid-based prescriptions for erythromycin in the definitive study showing dose, frequency of dose and duration in days

Number of days	Dosage prescribed	Frequency of dose							Total
		tds	qds	1 dose + 1 8 hrs later	2 doses + tds	1 dose + tds	bd	1 dose + bd	
1	2g +1g			1					**1**
1	1.5g + 0.5g						1		**1**
5	1g						1		**1**
5	125mg	7	40		2				**49**
5	250mg	6	35					1	**42**
5	750mg+125mg					1			**1**
7	125mg	3	5						**8**
7	250mg		2						**2**
10	125mg						1		**1**

3.4 Antimicrobial guidelines document

The Antimicrobial Guidelines Document, shown in Appendix 4, was derived from reviewing all the relevant literature and consultation with the specialist societies and professional bodies. This document was published and released to the profession by the Faculty of General Dental Practitioners (UK) of the Royal College of Surgeons of England in April 2000. The standards set in the clinical audit were based on this document. The results of the clinical audit are shown in the following section.

3.5 Clinical audit of antibiotic prescribing

A total of 175 GDPs took part in the audit out of a 932 practising in the Mersey region. A total of 3646 prescriptions for antibiotics were issued over the two six-week periods of data collection. The total number of prescriptions for antibiotics issued by all the practitioners before the issuing of guidelines and the educational component was 2316. Following the issuing of guidelines and the educational component 1330 prescriptions were issued representing a 42.5% reduction from the initial data collection period.

Of the prescriptions issued 56% were for females and 44% for males. Approximately 25% of prescriptions were issued to patients in the following age bands – 16-30 years, 31-45years and 41-60 years. This was the same for both collection periods. Fewer prescriptions were written during both data collection periods for the under 15-year-olds (9% of prescriptions) and over 61-year-olds (16% of prescriptions). The results of the antibiotics prescribed, the clinical conditions for which antibiotics were prescribed and the reasons for prescribing are shown in the following sections.

3.5.1 Antibiotic prescribing in the two clinical audit periods

The number of prescriptions for each of the antibiotics prescribed before and after the guidelines and educational component are shown in Table 3.47. Reductions in the number of prescriptions issued following the guidelines and educational component ranged from 17.1% to 100% for the antibiotics prescribed. Associations between the correct prescribing regimens for each of the main antibiotics prescribed, based on the guidelines produced (see appendix 4) and the DPF, and the two audit periods were investigated. Chi-square statistical tests were done to test for significant changes in the proportion of practitioners who were prescribing the appropriate antibiotic regimens.

3.5.1.1 Analysis of the prescribing of amoxicillin for the two clinical audit periods

Analysis of the prescribing of amoxicillin in the first data collection period is shown in Table 3.48. The majority of prescriptions were for dosages of either 250mg three times daily for five days, or a single dose of 3g. A further 54 records, not shown in the table, showed a range of doses from 125mg to 1.5g for periods of 1-15 days at frequencies equivalent to those in Table 3.48. The number of records showing the guidelines recommended therapeutic or prophylactic dose, frequency and duration, for amoxicillin in this first data collection period was 722 out of a total of 1257.

Table 3.49 shows the analysis of prescribing of amoxicillin following the issuing of guidelines and the educational component. In this data collection period the majority of prescriptions were at dosages of 250mg three times daily for five days or a single 3g dose. A number of records (41), not recorded in Table 3.49, showed a range of doses from 250mg to 0.75g. These were prescribed at the same frequencies recorded in Table 3.49 for periods ranging from 1-10 days.

The number of recommended regimens recorded in the second data collection period for amoxicillin, following guidelines and the educational component, was 585 out of a total of 829. A chi-square test showed a significant change in the proportion of practitioners prescribing the appropriate regimen for amoxicillin following the issuing of guidelines and the educational component ($\chi^2 = 36.79$, df=1, $P< 0.001$).

3.5.1.2 Analysis of prescribing of metronidazole for the two clinical audit periods

Analysis of the prescribing for metronidazole in the first data collection period is shown in Table 3.50. Some records (18), not shown in Table 3.50, recorded doses of 200mg to 400mg for periods ranging from 2-7 days, at the frequencies of two, three or four times daily. The number of records showing the recommended regimen for metronidazole in this first data collection period was 142 out of a total of 565.

Table 3.51 shows the analysis of prescribing of metronidazole in the second data collection period following the issuing of guidelines and the educational component. A further 17 records showed individual ranges of doses from 200mg to 400mg for periods of 3-10 days at the frequencies recorded in Table 3.51. Out of 305 records 127 showed the recommended regimen in this second data collection period. A chi-square test showed a significant change in the proportion of practitioners prescribing the appropriate regimen for metronidazole following the issuing of guidelines and the educational component ($\chi^2 = 25.26$, df=1, $P< 0.001$).

Table 3.47

Number of prescriptions issued for each of the antibiotics prescribed for the two audit periods, before and after the guidelines and the educational component

Antibiotic prescribed	Audit		
	1st audit	2nd audit	% reduction between 1st and 2nd audit
Amoxicillin	1275	829	34.9
Metronidazole	565	305	46.0
Penicillin	257	84	67.3
Erythromycin	122	54	55.7
Amoxicillin + Metronidazole	35	29	17.1
Clindamycin	32	22	31.2
Metronidazole + Erythromycin	2	0	100.0
Cephalexin	2	1	50
Cephradine	8	0	100.0
Tetracycline	6	2	66.6
Metronidazole+ Penicillin	9	2	77.7
Clindamycin + Metronidazole	1	0	100
Amoxicillin + Penicillin	2	0	100
Ampicillin + Metronidazole	0	1	-
Amoxicillin and erythromycin	0	1	-
Total	**2316**	**1330**	**42.5**

Table 3.48

Analysis of prescribing of amoxicillin showing dose, frequency and duration during the first data collection period of the audit

Duration (days)	Dose	Frequency							Total
		1 dose prior to treatment	tds	qds	bd	1 dose then 1 dose 8 hrs later	1 dose followed by 1 dose 3 hrs later	1 dose followed by 1 dose 2 hrs later	
1	3g	214			14	35	2	2	**257**
3	250mg		12	8					**20**
5	125mg		48	22	2				**72**
5	250mg		418	191					**609**
5	500mg		84	2					**86**
6	250mg		18	2					**20**
7	250mg		126	9					**135**
7	500mg		11	1					**12**

Table 3.49

Analysis of prescribing of amoxicillin showing dose, frequency and duration for the second data collection period

Duration (days)	Dose	Frequency						Total
		1 dose prior to treatment	tds	qds	1 dose then tds	1 dose then 1 dose 8 hrs later	2 tabs to start then 1 tds	
1	3g	168				12		**180**
3	250mg		32	6				**38**
5	125mg		57	5				**62**
5	250mg		344	81	1		1	**427**
5	500mg		36					**36**
7	250mg		24	20				**44**

Table 3.50

Analysis of prescribing for metronidazole showing dose, frequency and duration for the first data collection period

Duration (days)	Dose	Frequency				Total
		tds	qds	bd	1 dose then 1 dose 8 hrs later	
3	200mg	142				**142**
3	400mg	27		1	1	**29**
5	200mg	258	5			**263**
5	400mg	48		4	3	**55**
7	200mg	52	2			**54**

Table 3.51

Analysis of prescribing for metronidazole showing dose, frequency and duration for the second data collection period

Duration (days)	Dose	Frequency			Total
		tds	qds	2 tabs to start then 1 tds	
3	200mg	127		1	**128**
4	200mg	12			**12**
4	200mg	126	2		**128**
7	200mg	19			**19**

3.5.1.3 Analysis of penicillin prescribing for the two clinical audit periods

Analysis of penicillin prescribing in the first data collection period is shown in Table 3.52. Most of the prescriptions were at a dosage of 250mg four times daily for five days. A further three prescriptions, not shown in Table 3.52, were for 250mg three times daily for 3 days (one), 500mg four times daily for three days (one) and 250mg four times daily for 10 days (one). The number of records showing the recommended dose, frequency and duration, for penicillin in this first data collection period was 209 out of a total of 257.

Table 3.53 shows the analysis of penicillin prescribing in the second data collection period following guidelines and the educational component. Most of the prescriptions in this second data collection period were at a dosage of 250mg four times daily for five days. A further two prescriptions were prescribed at a dose of 500mg four times daily at three and five days, one at 250mg four times daily for six days and one at 125mg four times daily for seven days. The number of records showing the recommended dose, frequency and duration in the second data collection period was 69 out of a total of 84. A chi-square test showed no significant change in the proportion of practitioners prescribing the appropriate regimen for penicillin following the issuing of guidelines and the educational component ($\chi^2 = 0.001$, df=1, $P > 0.05$).

Table 3.52

Analysis of prescribing of penicillin for the first data collection period showing dose, frequency and duration

Duration (days)	Dose	Frequency		Total
		tds	qds	
4	250mg		9	**9**
5	125mg		9	**9**
5	250mg	8	163	**171**
5	500mg	10	37	**47**
7	250mg		18	**18**

Table 3.53

Distribution of prescriptions for penicillin showing dose, frequency and duration for the second data collection period

Duration (days)	Dose	Frequency		Total
		tds	qds	
5	125mg	3	11	**14**
5	250mg	1	57	**58**
7	250mg		8	**8**

3.5.1.4. Analysis of erythromycin prescribing for the two clinical audit periods

Analysis of erythromycin prescribing in the first data collection period showed that the majority (88) prescribed at a dose of 250mg three or four times daily for a period of five days (69) or seven days (19). The remaining 32 records exhibited a range of doses from 100mg to 500mg three or four times daily for periods ranging from 2-7 days. The number of records showing the recommended dose, frequency and duration, for erythromycin in this first data collection period was 67 out of a total of 122.

In the second data collection period 44 GDPs prescribed erythromycin at a dose of 250mg four times daily for five days (39) or seven days (5). The other nine records showed a range of dose between 125mg and 500mg, three or four times daily for periods of three, five or seven days. The number of records showing the recommended dose, frequency and duration, for erythromycin in this second data collection period was 39 out of a total of 54. A chi-square test showed no significant change in the proportion of practitioners prescribing the appropriate regimen for erythromycin following the issuing of guidelines and the educational component ($\chi^2 = 4.67$, df=1, P= 0.045).

3.5.1.5 Analysis of clindamycin prescribing for the two clinical audit periods

The majority of prescribing (82%) for clindamycin in both data collection was in a prophylactic dose of 600mg one hour prior to treatment periods. In the first data collection period eight records showed a therapeutic dose of 150mg four times daily for periods of 5-7 days, whereas in the second data collection period only two records were for a therapeutic dose of 150mg for a period of five days. A chi-square test showed no significant change in the proportion of practitioners prescribing the appropriate regimen for clindamycin following the issuing of guidelines and the educational component (χ^2 = 2.34, df=1, P=0.166).

3.5.1.6 Analysis of amoxicillin together with metronidazole prescribing for the two clinical audit periods

Analysis of a combination of amoxicillin and metronidazole prescribing showed that 36 prescriptions were issued in the first data collection period. Doses ranged from 250mg of amoxicillin and 200mg of metronidazole, to 500mg of amoxicillin and 400mg of metronidazole, three times daily for between 3-7 days. On three occasions 3g of amoxicillin as a single dose and 200mg of metronidazole three times daily for three or seven days were prescribed. One prescription for a single dose of 3g of amoxicillin and 800mg of metronidazole three times daily for three days was issued. Only three prescriptions were of the recommended regimen in the first data collection period.

In the second data collection period 29 prescriptions were written for a combination of amoxicillin and metronidazole. Doses ranged from 250mg of amoxicillin and 200mg of metronidazole, to 500mg of amoxicillin and 400mg of metronidazole for periods ranging from 3-7 days. Only one prescription was at the recommended regimen.

3.5.2 Clinical conditions for which practitioners prescribed antibiotics during the two clinical audit periods

The clinical conditions for which practitioners prescribed antibiotics for the two audit periods are compared in Table 3.54. The clinical conditions for which GDPs prescribed the majority of antibiotics in both audit periods were acute periapical infections followed by periodontal abscesses and pericoronitis. A significant number in both periods also prescribed for infected extraction sockets, acute ulcerative gingivitis, periodontitis and post-surgical procedures. The other clinical conditions recorded included infected cysts, aphthous ulceration, caries and tonsillitis. The decrease in the number of prescriptions issued following the guidelines and educational component (see Table 3.54) ranged from 17.3% to 100% for the clinical conditions listed. There was however an increase in prescriptions for post root canal therapy from 12-15.

3.5.3 Medical conditions for which antibiotics were prescribed in the two clinical audit periods

The medical conditions for which antibiotics were prescribed prophylactically for the two periods are shown in Table 3.55. This amounted to only 11% of the total number of prescriptions issued over the two data collection periods. Most of the prescriptions were issued in both periods for patients with rheumatic fever, murmurs or valvular disease. The only medical condition which showed a marked decrease in the number of prescriptions in the second data collection period related to murmurs.

Table 3.54

The clinical conditions and the number of antibiotic prescriptions issued by practitioners for the two audit periods

Clinical condition	Number of prescriptions for 1st audit	Number of prescriptions for 2nd audit	% reduction in the number of prescriptions between the two audit periods
Acute periapical infection	906	507	44.0
Acute periodontal abscess	237	94	60.3
Pericoronitis	187	124	33.6
Infected socket	69	57	17.3
Acute ulcerative gingivitis	98	68	30.6
Sinusitis	20	6	70.0
Post-surgical procedure	140	86	38.0
During root canal therapy	2	1	50.0
After root canal therapy	12	15	-
Periodontitis	51	45	16.6
Cellulitis	5	1	80.0
Pulpitis	46	13	71.7
Trismus	1	0	100
Gingivitis	16	7	56.0
Re-implantation of teeth	0	1	-
Salivary gland infection	0	2	-
Oral antral fistula	1	1	-
Others	8	2	75.0

Table 3.55

The medical conditions and the number of prescriptions for which GDPs prescribed antibiotics before and during audit

Medical condition	**Number of prescriptions before the audit**	**Number of prescriptions during the audit**
Rheumatic fever	81	70
Murmurs	58	28
Valvular disease	46	46
Congenital heart defects	11	6
Coronary heart disease	16	11
Prosthetic joints	8	1
Radiotherapy/chemotherapy	9	2
Immunocompromised	26	18

3.5.4 Practitioners' reasons for prescribing antibiotics in the two clinical audit periods

The reasons for prescribing antibiotics including clinical signs and non-clinical factors for the two data collection periods are shown in Table 3.56. Some practitioners recorded more than one reason for prescribing, particularly in relation to pain. Nearly a third of all the prescriptions in both collection periods were related to pain. The presence of localised or gross swelling, prophylaxis due to a significant medical history and where treatment had to be delayed were also common reasons for prescribing. Table 3.56 also shows the percentage decrease in the number of prescriptions between the two audit periods. The decreases ranged from 27% to 82% with a marked diminution in the non-clinical factors affecting prescribing, apart from where treatment had to be delayed. There was a decrease of 51% of prescriptions for localised swelling and 54% for pain between the two audit periods. Chi-square statistical tests showed that there was a decrease in the proportion of prescriptions for uncertainty of diagnosis (χ^2 = 16.70, df=1, $P<0.001$) and because of pressure of time or workload (χ^2 = 12.46, df=1, $P<0.001$), patient expectation (χ^2 = 12.99, df=1, $P<0.001$) and pain (χ^2 = 37.49, df=1, $P<0.001$), and patients with a localised fluctuant swelling (χ^2 = 8.75, df=1, $P<0.05$).

Further analysis of the variables of the clinical signs and non-clinical factors associated with pain were explored by means of cross tabulation. The results of this analysis are shown in Table 3.57. From Table 3.57 it can be seen that a high proportion of prescriptions for both audit periods were for pain without the presence of infection, pain associated with a localised fluctuant swelling and pain where treatment had to be delayed. In a small number of cases antibiotics were prescribed where there was no infection but pain was present and additionally the GDP was uncertain of the diagnosis, there was pressure of time or the patient expected a prescription.

Table 3.56
Reasons and the number of prescriptions for antibiotics prescribed by GDPs before and during the audit

Reasons for prescribing	Number of prescriptions issued for 1st audit	Number of prescriptions issued for 2nd audit	% reduction in the number of prescriptions between the two audit periods
Localised fluctuant swelling	724	354	51.1
Gross diffuse swelling	365	319	12.6
Elevated temperature & evidence of systemic spread	179	177	-
Pain	1198	548	54.2
Prophylaxis due to medical history	255	182	28.6
Prophylaxis following surgical procedure	140	86	38.5
Patient expectation	121	36	70.2
Pressure of time & workload	86	22	74.4
Uncertainty of diagnosis	80	16	80.0
Treatment had to be delayed	209	151	27.7
Patient going on holiday/in case of problems	39	7	82.0
Failed local anaesthesia/unco-operative patient	26	14	46.1

Table 3.57

The prescribing of antibiotics for pain in relation to the clinical signs and non-clinical factors showing the number of cases before and after the issuing of guidelines in the clinical audit

Uncertainty of diagnosis	Delayed treatment	Time pressure	Patient expectation	Localised fluctuant swelling	Gross diffuse swelling	Elevated temperature	Pain before guidelines	Pain after guidelines
X	X	X	X	X	X	X	425	170
X	X	X	X	X	√	X	98	77
X	X	X	X	X	√	√	33	39
X	X	X	X	√	X	X	298	98
X	X	X	√	X	X	X	16	18
X	X	X	√	√	X	X	9	1
X	X	√	X	X	X	X	23	5
X	X	√	X	√	X	X	6	2
X	X	√	√	X	X	X	9	2
X	X	√	√	√	X	X	7	0
X	√	X	X	X	X	X	52	22
X	√	X	X	X	√	X	18	20
X	√	X	X	X	√	√	6	8
X	√	X	X	√	X	X	36	14
X	√	X	√	X	X	X	5	2
X	√	X	X	X	X	X	3	2
√	X	X	X	X	X	X	26	8
√	X	X	√	√	X	X	5	0
√	X	√	√	X	X	X	2	0
√	X	√	X	X	X	X	3	0
√	√	X	X	X	X	X	4	1

4. DISCUSSION

The discussion in this thesis is divided into four sections: the questionnaire study, the investigation of prescriptions, the formulation of the guidelines and the audit.

4.1 Questionnaire study

The principal aim of this study was to determine when and how GDPs prescribe antibiotics and to assess their knowledge of antibiotic use. It was decided that the study should consist of a descriptive survey. This type of survey is where information is collected from a sample of the population of interest and descriptive measures are calculated (Moser and Kalton, 1971).

The method of data collection used for this part of the study was a structured self-administered postal questionnaire. This method was used because it had the advantage of covering a large geographically spread population, was economic and allowed anonymity. It is recognised that in quantitative research self-administered questionnaire and interview methods are the most common means of data collection (Bowling, 1997). Questionnaires can be either structured or semi-structured. Structured questionnaires are designed with fixed or standardised questions, which are presented to all respondents in the same way, with mainly pre-coded response choices. Bowling, (1997) suggested that structured questionnaires are only suitable where the questions are straightforward and the sample population understands the information being sought.

Semi-structured questionnaires, in contrast, rely on fixed questions with a few, if any, response codes to allow flexibility for an interviewer to explore responses and enable respondents to express opinions. The possibility of conducting interviews using a questionnaire was considered for this part of the study. Although this method would have provided a high response rate and therefore a low non-responder bias, the disadvantages of this approach were recognised as intimidation of the responder, that it was time-consuming, expensive and subject to both interviewer and responder bias. Conducting interviews using a questionnaire also prevented the possibility of a wide geographical distribution and a large sample size.

One of the advantages of using a structured questionnaire in this study was the ability to provide unambiguous and easily countable data. The structured questionnaire led to greater ease of analysis, was economical and a large sample could be used. The weakness of a structured questionnaire, however, is that the pre-coded responses may not be totally comprehensive and respondents may have been forced into the selection of the pre-coded answers, which may not have been totally representative of GDPs' views. These aspects were taken into account in the planning and structure of the questionnaire, which is discussed in the following section.

4.1.1 Questionnaire design

The most important factors in the construction of the structured questionnaire were planning and piloting. In the planning of the questionnaire the areas of interest that related to the aims of the study were considered. Collation of a number of appropriate and tested questions and development of response formats were centred on how and when GDPs prescribed antibiotics and their current knowledge. Other factors taken into consideration at the planning stage were quality control of the research. These included developing strategies for minimising poor response (see section 2.3.1.1 and 2.3.2.4), missing data and any dubious data that may have been collected or entered into the database (see section 2.3.1.2 and 2.3.2.6).

4.1.1.1 Pilot questionnaire

Initially, the areas to be addressed in the study were discussed with experts in the field of antimicrobial prescribing and members of the target population. A review of previous questionnaire studies was undertaken and evaluated before development of the pilot questionnaire. Shaw (1983) and Shaw and Krejci (1993) in two separate studies asked respondents to specify their choice of antibiotic for localised oral infections and for prophylactic coverage. Lewis *et al.* (1989b) investigated a number of bacterial infections and sought information on the antibiotic regimen used as a first choice for each bacterial infection investigated. In a more comprehensive questionnaire survey a wide range of clinical conditions and the antibiotics of choice for each category was investigated (Preus *et al.*, 1992). Schumann *et al.* (1983) looked at broad categories of patients and enquired of respondents if they would routinely prescribe antibiotics. Holbrook *et al.* (1983) investigated the dental procedures for which antibiotic prophylaxis was required in patients susceptible to infective endocarditis and the regimen prescribed. All these questionnaire studies proved to be of value in providing some information on the questions asked on antibiotic prescribing practices of dental practitioners and aided the development of the pilot questionnaire.

In the development of the pilot questionnaire it was felt important that it was printed clearly and was easy to read and comprehend. Various other factors were considered in the design such as the format of the questions (closed or open-ended) and possible responses. Closed questions with pre-coded responses are thought to be preferable for topics about which much is known and therefore suitable response formats can easily be developed. The view of the author was that GDPs had all received education on the areas under investigation at undergraduate level, although they had varying levels of understanding. It was also recognised, however, that the response choices should have categories to fit all possible answers. Open-ended questions are essential when the replies are unknown, or answers are too numerous to pre-code. It was decided that there was some merit in including open-ended questions in the questionnaire when investigating areas of prophylactic prescribing and therapeutic antibiotic regimens.

The format of the responses was also considered in the design of the pilot questionnaire. Although it was thought that the same form of response scale would make completion of the questionnaire easier, there is evidence that this can lead responders to answer all the questions in a specific direction (Sudan and Bradbury, 1991). It was decided therefore to incorporate a variety of response formats including dichotomous (yes/no) scaled (e.g. sometimes, always, never-Likert scale) and multiple choices. The pilot questionnaire was used to evaluate the design, the areas of questioning, ease of handling of data and to obtain some detailed information on prescribing practices of GDPs.

4.1.1.2 Definitive questionnaire

Following the return and analysis of the pilot questionnaire a critical appraisal was undertaken and modifications were made. The instructions for completion of the questionnaire were simplified and easy and basic questions were placed first. The questions were reworded to contain simple and familiar words that GDPs would understand and the layout was altered to improve ease of completion and data handling. Previously closed questions were altered to open-ended questions. GDPs were able to specify alternative antibiotics to those listed for therapeutic prescribing and clinical procedures requiring prophylaxis. The issues to be addressed in the study were re-evaluated to exclude drug interactions, but to include the prescription of antibiotics to patients who were allergic to penicillin. Clinical signs of severe infection and non-clinical factors affecting prescribing of antibiotics were also included. Sudmann and Bradburn (1991) suggested that following modification of a questionnaire a further pilot investigation is required, thus peer evaluation by respondents to this modified questionnaire were requested to facilitate further changes in format. Following further changes, outlined in section 2.3.2.4, the definitive questionnaire was developed.

The aims of the questionnaire were to determine when and how GDPs prescribe antibiotics and assess their knowledge of antibiotic prescribing. Palmer *et al.* (2000a; 2000b; 2001) showed that the definitive questionnaire successfully achieved these aims. The questionnaire has subsequently been requested and used in studies in Scotland, Kuwait, Switzerland and the USA.

4.1.2 Sample size and sampling

Sample size and sampling is crucial to the validity of the results arising from the methods employed in research (Bowling, 1997). A discussion of these aspects is discussed in the following two sections.

4.1.2.1 Sample size

The total number of GDPs in NHS general dental practice that could have been included in the study was 15,385 (Dental Practice Board, 1999). The ideal sample size should consist of 100% of the target population, but this is unrealistic on grounds of economy. A large sample of GDPs, excluding specialist GDPs, was necessary to get representative data on prescribing practices. For the questionnaire study a total of 1544 GDPs were selected. This equates to 10% of NHS GDPs in England.

A review of previous peer-reviewed publications (see Figure 4.1) showed this to be the largest reported study of antibiotic prescribing by GDPs. For example, Preus *et al.* (1992) in a survey of antibiotic prescribing practices of all Norwegian dentists took a random sample of

10%, of which 63% were general dental practitioners. In a survey of prophylactic antibiotic prescribing Holbrook *et al.* (1983) sampled all GDPs and community dentists (277) in the Lothian area. Lewis *et al.* (1989b) selected 600 dentists from every 25th entry from British Telecom Yellow Pages telephone directories; the equivalent of 4% of the total number of GDPs. Shaw (1983) surveyed drug prescribing of 750 GDPs in Nebraska. Dental specialists were excluded from Shaw's survey because it had been shown by the American Dental Association (1976) that their prescribing activity differs significantly from general dental practitioners. In another study 357 self-selected dentists from five counties in Western New York, representing 36% of the population, volunteered to take part in a survey of drug prescribing practices (Ciancio *et al.*, 1989); 82% were general practitioners. In a survey by Picozzi and Ross (1989) the sample consisted of 402 self-selected dentists.

4.1.2.2. Sample selection

In this study the aims were to produce a study population with a normal age distribution of GDPs, a gender distribution equivalent to that of practitioners in the general dental services in England, a mix of urban and inner city areas geographically spread throughout England and graduates from all UK dental schools. Within this study the results showed that the study population had a statistically normal distribution of age groups (see Figure 3.3), a gender distribution (71.5% male 28.5% female) almost equivalent to that in NHS general dental services (Dental Practice Board, 1999) and that graduates from all UK dental schools were represented (see Table 3.7).

Previous studies have used a variety of sample selection methods. For example, Preus *et al.* (1992) used simple random sampling, Lewis *et al.* (1989b) used systematic random sampling, and Picozzi and Ross (1989) and Ciancio *et al.* (1989) self-selection (volunteers). Simple random sampling uses random number tables to select numbered members of the study population. In contrast, systematic random sampling utilises organised lists and once the sampling fraction is calculated, the random start point determines the rest of the study population to be selected. An error can occur where the sample selected is not representative of the population from which it was drawn. It was felt that this type of error was removed by selecting GDPs from geographically distributed Health Authorities, within which are inner city and rural areas. It was also important to link the questionnaire study with the prescription study. An important aspect of the prescription study was co-operation of the Health Authorities.

Health Authority areas could have been selected on a random basis but this would have produced a geographic sampling error. Certain Health Authorities (London and south coast areas) were excluded because they would produce a further sampling error due to the known lack of provision of NHS general dental services in these areas. It has also been shown that response rates to questionnaires are lower in London than in any other area of the country (Cartwright, 1983).

Figure 4.1
Questionnaire studies done in different countries on antibiotic prescribing by dentists showing the author, sample and sample sizes selected and response rate

Author, Year	Country	Sample	Sample size	% Response rate
Palmer *et al.* (2000a; 2000b)	England	GDPs	1544	60.1
Palmer *et al.* (2001)	England and Scotland	GDPs	2216	60.4
Preus *et al.* (1992)	Norway	All dentists	459	78
Lewis *et al.* (1989b)	UK	GDPs	600	57
Schuman *et al.* (1983)	USA and Canada	Specialist paedodontists	1634	41
Holbrook *et al.* (1983)	Scotland	GDPs & CDS dentists	277	61
Gould (1984)	England	GDPs ,GMPs, surgeons, physicians, anaesthetists	320	64
Muthukrishnan *et al.* (1996)	England	GDPs and GMPs	110 GDPs	58.5
Picozzi and Ross (1989)	USA	All dentists	402*	85
Shaw (1983)	USA	GDPs	750	40
Shaw and Krejci (1993)	USA	GDPs	500	69
Ciancio *et al.* (1989)	USA	All dentists	900	36

* Self-selected volunteers

The Health Authority areas selected for the study were chosen to guard against obtaining, by chance, an unrepresentative sample that would under, or over represent certain characteristics of the target population (e.g. age groups, gender, inner city or urban areas, or geographical distribution). The Health Authority areas selected also had to produce a total sample size equivalent to 10% of the number of GDPs practising in the NHS general dental services. These aspects were calculated from the dental lists supplied by Health Authorities. The Health Authorities were contacted to ensure that co-operation in the prescription part of the study could be obtained before the final selection of areas took place.

4.1.3 Response rate

The response rate to the definitive questionnaire in this study was 60.1% from a total study population of 1544. This compared very favourably with previous studies (see Figure 4.1), particularly as it was the largest study of GDP antibiotic prescribing to date (Palmer *et al.*, 2000a; 2000b; 2001). An examination of previous questionnaire studies showed that Lewis *et al.* (1989b) achieved a 57% response from a total study population of 600 general dental practitioners in their questionnaire study on the presentation and treatment of acute orofacial infections. In the study of antibiotic prescribing patterns of Norwegian dentists a response rate of 78% out of a total of 459 was recorded (Preus, Albandar and Gjermo, 1992). Muthukrishnan *et al.* (1996) in their questionnaire study of antibiotic prescribing for a specific clinical scenario had a 58.5% response from 110 GDPs and 60.9% response from 176 GMPs. Shaw and Krejci (1993) recorded a 69% return from a sample population of 500 dentists in a questionnaire survey of Nebraska dentists and

Schuman *et al.* (1983) in their survey achieved a response of 41% from a total sample of 1634 paedodontists.

The response rate in all studies is calculated from the number of respondents as a percentage of the total eligible study population. There is no generally agreed standard for an acceptable minimum response rate. A high response rate is of greater significance with a small sample size. It has been suggested that response rates of 75% are acceptable as very good for surveys, but that omits 25% which could cause a sample bias (Bowling, 1997). This bias is based on the assumption that those that do not respond may differ in some aspect (e.g. they may be older, younger, or have different opinions or practices) to the total population. It is also recognised that response rates for interviews are much higher than for postal surveys and the difference can be as much as 20% (Cartwright, 1988). Kaner *et al.* (1998) conducted a qualitative study to determine the reasons for general medical practitioners not participating in postal surveys. Of 276 practitioners who had not replied to a postal survey 34% replied that the questionnaire had "got lost in paperwork", 21% were too busy for the extra work involved and 16% stated that questionnaires were routinely binned. It was also concluded from this study that GMPs were more likely to respond if the research was relevant to general practice and it included good explanatory information.

The possibility of non-responder bias was considered but the population who responded showed all the characteristics of the total population in the NHS general dental services. The gender distribution (71.5% male 28.5% female) almost exactly equalled that recorded by the Dental Practice Board (1999) in the general dental services. There was also a normal distribution of age groups (see Figure 3.3) and graduates of all dental schools within the UK were represented (see Table 3.7). An attempt to increase the response rate was considered, but due to the anonymity of the responses this would have entailed sending out further questionnaires to the whole study population. The response rate from all Health Authority areas was over 50% (see Table 3.6) with Nottinghamshire and Liverpool being the lowest. These areas could have been targeted for a further mailing. A number of questionnaire surveys had been done in the Liverpool area in the months just prior to this study. It was considered that time, cost and the over-saturation of GDPs with a further questionnaire mailing would be of little benefit in increasing the response rate.

The demographic results and response rate suggested that the information collected from the questionnaire was representative of GDPs practising in the NHS general dental services in England. It also suggested that a number of conclusions could be drawn from the results and areas of future research identified.

4.1.4 Therapeutic prescribing of antibiotics by GDPs

The clinical and non-clinical factors that affect GDPs therapeutic prescribing of antibiotics were investigated and will be discussed in the following three sections.

4.1.4.1 Clinical signs and conditions

For most of the clinical signs investigated in this survey GDPs showed good awareness of the indications for therapeutic antibiotics. The clinical signs that indicate the use of antibiotics in acute dentoalveolar infections have been defined as signs of spreading infection, patient malaise, temperature elevation and lymphadenitis (Pogrel, 1994; Cawson and Spector, 1989). Although most GDPs saw the importance of elevated temperature and evidence of systemic spread of infection, almost 20% failed to see the relevance of difficulty in swallowing and 12% did not link restricted mouth-opening with a spreading infection. Moreland *et al.* (1988) reviewed the literature on the incidence of Ludwig's angina, a condition that may be fatal if left untreated. Of the 141 cases reviewed by Moreland *et al.* in the post-antibiotic era, most were found to be of dental origin. Moreland *et al.* (1988) stressed the importance of early recognition and appropriate treatment including the prescribing of antibiotics. The fact that a number of GDPs would not prescribe antibiotics for an infection where there was difficulty in swallowing and restricted mouth-opening is a cause for concern. Over one third of GDPs in the survey described in this thesis would prescribe antibiotics inappropriately for a localised fluctuant swelling. There is little indication in this situation for antibiotics, with Cawson and Spector (1989) maintaining that an infection must be severe to justify antibiotic treatment. Donoff (1997) stressed the importance of drainage when infection is present by endodontic treatment, extraction or periodontal treatment.

The clinical conditions investigated in the questionnaire part of the study were selected as being common occurrences within general dental practice. There is no indication for prescribing antibiotics for acute pulpitis, as there is no presence of infection (Olson *et al.*, 1995), yet 13% of practitioners in this study used them for this condition. A prospective study of patients attending the emergency clinic at Cardiff Dental School found that 49% of patients had received antibiotics for pulpal pain (Thomas *et al.*, 1996). Guidelines issued recently by the FDI Commission advocate antibiotic use for acute pulpitis (Samaranayake and Johnson, 1999). There is however, no evidence that antibiotics are of any benefit in the treatment of acute pulpitis (Longman *et al.*, 2000). Similarly, over 10% of GDPs surveyed prescribed antibiotics for chronic marginal gingivitis. Antibiotics are not indicated for chronic marginal gingivitis, which by its very nature is not an acute or spreading infection and responds well to periodontal therapy (Emmerson, 2000). In this study 69% of GDPs used antibiotics in the presence of purulent infection prior to drainage and 45% when it was established. Drainage of a purulent infection is the only treatment necessary in the majority of uncomplicated infected swellings of dental origin (Abbott, Hume and Pearman, 1990; Longman *et al.*, 2000). Antibiotics are only indicated where drainage is difficult to establish or there are signs of a spreading infection. Chronic apical infections rarely need antibiotics unless there is evidence of gross local spread; extraction or root canal therapy are the definitive treatment options (Pogrel, 1994). In this survey over a quarter of those surveyed would prescribe antibiotics for chronic apical infections.

Nearly 90% of GDPs in this survey would prescribe antibiotics for pericoronitis, which can be effectively treated by local measures. Antibiotics are only indicated for pericoronitis when large spreading infections, or systemic involvement is present. Controversy, however, still exists in the prescribing of antibiotics for pericoronitis with Gill and Scully (1991) suggesting routine use for acute pericoronitis. Over 90% of GDPs prescribed correctly for acute ulcerative gingivitis, which is usually associated with an elevated temperature and patient malaise. The use of antibiotics for acute ulcerative gingivitis is recommended as part of the initial therapy (Johnson and Engel, 1986). Approximately 80% of GDPs in this survey would prescribe routinely for periodontal abscesses. Although antibiotic prescribing for periodontal abscesses is advocated by Herrera *et al.* (2000) in the short term, Seymour and Heasman (1995) and Martin (1998) suggest surgical management unless there is evidence of a severe spreading infection. It would appear that many GDPs use antibiotics inappropriately for the treatment of periodontal abscesses.

The majority of GDPs would also prescribe antibiotics for dry sockets where the infection is localised. Most sources suggest that local measures suffice in the treatment of dry sockets (Happonen, Backstrom and Ylipaavalniemi, 1990; Longman and Martin, 1991; Monaco *et al.*, 1999). It would therefore seem inappropriate for GDPs to prescribe antibiotics routinely for dry sockets, as the benefit to risk ratio is unfavourable. Some studies have shown a reduction in incidence of dry socket following extractions with antibiotic pre-medication (Rood and Murgatroyd, 1979; Krekmanov and Hallander, 1980). There may therefore be an indication for prophylactic antibiotics in patients with a history of dry sockets following extractions.

Most of those surveyed would correctly prescribe antibiotics for cellulitis and trismus (Pogrel, 1994). The majority of those surveyed prescribed prophylactically for re-implanting avulsed teeth as recommended (Hammarstrom *et al.*, 1986; Abbott, Hume and Pearman, 1990). Over 50% of GDPs in this survey however, felt it was their remit to prescribe antibiotics for sinusitis. Some controversy exists as to the benefit of antibiotics in this situation. Recent research has shown that antibiotics do not affect the clinical course of sinusitis (van Buchem *et al.*, 1997; Stalman *et al.*, 1997b). Furthermore Williams *et al.* (2000), following a review of all the literature, concluded that antibiotics were only indicated if acute maxillary sinusitis was confirmed radiographically or by aspiration. It would therefore seem inappropriate for GDPs to prescribe antibiotics for sinusitis.

Although controversy does exist for some aspects of therapeutic prescribing, the results of this part of the questionnaire survey showed that the prescribing of antibiotics by dentists is often not based on sound clinical principles. Most of those surveyed used antibiotics routinely for conditions where local treatment would suffice. This may be understandable because the DPF, the only recognised guideline, gives only general advice on therapeutic prescribing. GDPs need clear, simple and practical advice on when to prescribe. Part of the aim of this thesis was to provide specific guidelines and this will be discussed in section 4.3.

4.1.4.2 Non-clinical factors affecting GDPs' prescribing of antibiotics

Patient expectation did not influence the majority of GDPs (90%) in the decision to prescribe antibiotics. This contrasts markedly with patients attending general medical practitioners, where it has been shown that patient demand for antibiotics increases unnecessary prescriptions (Macfarlane *et al.*, 1997a). Other non-clinical factors investigated showed that 30% of GDPs would prescribe because of shortage of time and 47% if they were unable to make a definitive diagnosis. The decision to prescribe antibiotics must be based on a thorough medical history, clinical examination and accurate diagnosis. The use of antibiotics without active treatment of an acute dentoalveolar infection is impossible to support on clinical or medico-legal criteria. There are, however, some clinical situations (Martin, 1998) where antibiotics can be used where treatment has to be delayed (e.g. where drainage cannot be established); 72% of GDPs used them for this purpose. Evidence from a study by Palmer (1996) showed that antibiotics were used without any active treatment in 50% of out of hours emergency consultations. There was however, evidence of infection in only 25% of the consultations. The results of the questionnaire study in this thesis support the conclusion of the survey by Palmer (1996) that practitioners use antibiotics when they are unsure of the diagnosis, or the pressures of workload prevent GDPs providing the appropriate surgical treatment at the appropriate time.

4.1.4.3. Antibiotics prescribed by GDPs

The choices of antibiotics for an acute dentoalveolar abscess in adults not allergic to penicillin are shown in Table 3.10. Over 70% of GDPs chose amoxicillin but at varying doses, frequencies and duration. Only 23 respondents prescribed the antibiotic phenoxymethylpenicillin at the dosage recommended in the DPF for acute dentoalveolar infections. The use of phenoxymethylpenicillin was based on studies that had isolated mainly streptococci and staphylococci as the main bacteria from dental abscesses (Lewis, MacFarlane and McGowan, 1986a; Gill and Scully, 1988;Lewis *et al.*, 1989b). More recent studies have shown that the main isolates from dental abscesses are complex mixtures of facultative and anaerobic bacteria, some of which are penicillin resistant (Lewis, MacFarlane and McGowan, 1990; Lewis *et al.*, 1995; Smith *et al.*, 1999). Amoxicillin, in contrast, has the advantage of being a broad-spectrum antibiotic with an excellent absorption rate and therefore no loading doses are required. The use of amoxicillin for acute dentoalveolar infections by the majority of GDPs is therefore understandable. The disconcerting finding from this survey was the wide variety of doses, frequencies and duration of amoxicillin therapy that would be employed for the treatment of an acute dentoalveolar abscess (see Table 3.10). This will be discussed in detail in section 4.2.2.2.

The results of which antibiotic would be prescribed for the specific clinical conditions investigated showed that the main choices (see Table 3.12) were either amoxicillin or metronidazole. Metronidazole was primarily used for pericoronitis, periodontal abscesses, acute ulcerative gingivitis, chronic marginal gingivitis, chronic periodontitis and dry socket; this is appropriate due to the anaerobic bacteria in these infections. As discussed previously, amoxicillin is justified for the other clinical conditions investigated although it is not the recommended choice of the DPF.

4.1.5 Prophylactic prescribing of antibiotics by GDPs

The prescribing of prophylactic antibiotics for the non-medically and medically compromised patient and the prophylactic antibiotic regimens used will be discussed in the following sections.

4.1.5.1 Prophylactic prescribing of antibiotics for the non-medically compromised patient

This aspect of antibiotic prescribing has not been previously investigated either in general dental practice or in a hospital environment. The questionnaire was designed to investigate a number of clinical procedures where GDPs might prescribe prophylactic antibiotics for non-medically compromised patients. The procedures investigated were based on the common surgical procedures performed in the NHS general dental services. Almost 17,000 apicectomies, 384,374 surgical extractions involving bone removal and over 82,000 wisdom teeth were surgically removed in the year 1999/2000 (Dental Practice Board, 2000). A large proportion of the respondents to the questionnaire prescribed prophylactic antibiotics for apicectomies (43%) and surgical extractions (39%). This is a high proportion considering that the rate of post-operative infection from both procedures is low (Longman and Martin, 1999) and there is some evidence that antibiotics have little or no beneficial effect (Rud, 1970; Happonen, Backstrom and Ylipaavalniemi, 1990; Monaco *et al.*, 1999). Longman and Martin (1991) suggested that antibiotics should never be used as a substitute for good surgical and aseptic operating techniques. Controversy does however exist, particularly with respect to removal of impacted third molars. Piecuch *et al.* (1995) reviewed the literature and came to the conclusion that there was no real scientific evidence to confirm or deny the appropriateness of prophylactic antibiotics for the removal of impacted third molars. Piecuch *et al.* (1995) concluded that many of the studies reviewed were scientifically flawed and therefore no clear-cut guidelines could be given. Future research, in the form of a large randomised controlled trial, is required to settle the controversy of antibiotic prophylaxis for removal of impacted third molars.

Encouragingly, only a small proportion (<6%) of the respondent practitioners used antibiotics before, or after, root canal therapy in this survey. The use of antibiotics before, or after, root canal therapy is controversial so their indiscriminate use should be discouraged (Abbott, Hume and Pearman, 1990; Whitten *et al.*, 1996). Antibiotics used during root canal therapy have been shown to prevent flare-ups during multi-visit treatments and to reduce post-operative pain and swelling when treating asymptomatic teeth with pulpal necrosis and with associated periapical lesions (Morse *et al.*, 1987; Abbott *et al.*, 1988). Whitten *et al.* (1996) maintain that there is little indication for antibiotics in both these situations if good technique is employed in canal preparation and obturation.

For all procedures the first choice of antibiotic by GDPs in this study was amoxicillin, with penicillin and metronidazole also being used.

Amoxicillin is a logical choice (von Konow, Nord and Nordenram, 1981; Gill and Scully, 1990) as it attains high serum concentrations and is effective against facultative and some anaerobic flora that may cause post-operative infection (Gomes, Lilley and Drucker, 1996). Penicillin was the next most popular prophylactic antibiotic but Woods (1988) found that resistance by both the oral facultative and anaerobic bacteria lessens its usefulness. The choice of prophylactic metronidazole is also appropriate as anaerobes are usually involved in post-operative infection (Rood and Murgatroyd, 1979).

One of the areas not investigated in this study were the dosages employed by practitioners in the prescribing of prophylactic antibiotics to non-medically compromised patients and whether this was pre- or post-operatively for surgical procedures. Classen *et al.* (1992) found in a prospective study of 2847 patients undergoing surgery, that pre-operative prophylactic antibiotics reduced surgical wound infections. It would therefore appear that if antibiotics were indicated, they should be given before surgery in prophylactic doses, not post-operatively (Longman and Martin, 1999). There is a need for further research to determine the dosages that are most appropriate in this clinical situation.

4.1.5.2 Prophylactic prescribing of antibiotics for the medically compromised patient

Prior to this study no evidence existed as to when GDPs prescribed prophylactic antibiotics for the medically compromised patients. Several studies have been completed on the awareness of GDPs of the indications and prophylaxis for infective endocarditis (Brooks, 1980; Hashway and Stone, 1982; Scully *et al.*, 1987; Nelson and Van Blaricum, 1989; Forbat and Skehan, 1993; Bennis *et al.*, 1996). None of these studies looked at the other potential "at risk" medically compromised patients investigated in this study.

The results of the investigation of the interaction of clinical treatment with patients who had a history of AIDS, Hodgkin's and autoimmune disease, diabetes or haemodialysis showed that the majority of practitioners would not prescribe any prophylactic antibiotics. Between 4% and 19.9%, however, would prescribe prophylactic antibiotics for extractions with these medical conditions. Longman and Martin (1991) and Walters (1997) have suggested that antibiotic prophylaxis is required because of the increased risk of post-operative infection in these medical conditions following extractions. The value of prophylactic antibiotics in all of these conditions for prevention of post-operative complications is questionable or unproven, with the DPF (1998) stating the view of the Working Party of the BSAC that there is no need for antibiotic prophylaxis for dental treatment in these cases. Some GDPs in this survey were unsure of the need for prophylaxis in these patients, with nearly 50% indicating that they would seek specialist advice before prescribing for all the conditions apart from diabetes.

Within this study only 21.8% of respondents indicated they would prescribe prophylactic antibiotics for extractions for patients who have undergone radiotherapy to the head and neck. A further 42.3% would seek specialist advice before carrying out treatment.

These results again confirm a lack of understanding by GDPs of the risks of osteoradionecrosis with extractions on these patients. Radiotherapy to the head and neck is known to affect the blood supply due to *endarteritis obliterans*. The effect of this is that the damaged tissue can undergo spontaneous necrosis in response to trauma; this is called osteoradionecrosis. Osteoradionecrosis occurs in anything from 0-65% patients following extractions and is more likely to occur in the mandible (Clayman, 1997). Prophylactic antibiotics are therefore essential for extractions in patients who have undergone radiotherapy to the head and neck region to prevent post-operative infection (Beumer *et al.*, 1984; Pallasch and Slots, 1991). There is therefore a clear need to educate GDPs about the need for prophylactic antibiotics to prevent osteoradionecrosis. There is also a need for research into the most effective prophylactic antibiotics to prevent osteoradionecrosis.

In this study a quarter of respondents (25.2%) would prescribe prophylactic antibiotics for patients with prosthetic joints for extractions, between 13.5% to 21.8% would use them for restorative procedures and scaling and polishing. The use of antibiotics for patients with prosthetic joints has been reviewed and it is generally agreed that they are not indicated (Field and Martin, 1991; Little, 1997). The prophylactic use of antibiotics for this group of patients undergoing dental treatment has been investigated, as there is concern that there is a transient bacteraemia produced which could produce infection of the prostheses. Field and Martin (1991) and Little (1997) state that the bacteria associated with late infections of joint replacements are mainly staphylococci and beta-haemolytic streptococci; these do not form part of the normal oral flora and are rarely isolated from dentally-related bacteraemias.

There is little justification for prophylaxis for these patients, with the Working Party of the BSAC (1992a) not supporting the routine use of antibiotics for dental procedures carried out on patients with prosthetic joints. Little (1992) suggests that only patients with joint prostheses who should be considered for prophylaxis are those patients at "high" risk, namely those patients with multiple joint prostheses. The relatively high number of GDPs in this study who would prescribe antibiotics prophylactically may reflect ignorance of recommendations, or advice from overprotective orthopaedic surgeons.

A high proportion of the GDPs followed the Endocarditis Working Party of the BSAC (1990) and American Heart Association (1997) current guidelines on antibiotic prophylaxis for patients with cardiac problems that could predispose to infective endocarditis. The exception was in patients with aortic stenosis and ventricular septal defects. Patients with aortic stenosis and ventricular septal defects are at risk of dentally induced infective endocarditis, yet almost 50% of GDPs in this survey would not provide prophylaxis for these patients when undertaking scaling or extractions. This is important from a medico-legal standpoint as has been shown by Martin *et al.* (1997a) who reviewed 53 cases of litigation associated with dentally-induced infective endocarditis. At present however, a debate exists over whether there is actually an association between dental procedures and infective endocarditis (Seymour *et al.*, 2000). This leads to confusion for the GDP, with between 8% and 30% in the study seeking specialist advice before proceeding with treatment. There is a need for the BSAC to evaluate the recent evidence and issue specific guidelines for GDPs on the need for prophylaxis for cardiac patients.

Ideally, the efficacy of antibiotic prophylaxis to prevent infective endocarditis by way of a randomised controlled trial is required. This type of study would confirm the necessity for prophylaxis in these patients and also evaluate the risk/benefit of the antibiotics administered. This, however, would require a large study sample and has ethical implications.

A high proportion of practitioners (approximately 40%) associated a history of rheumatic fever with no valvular pathology with a risk of infective endocarditis and would prescribe prophylactic antibiotics. In contrast, the majority of practitioners in this survey understood that pacemakers, and coronary heart disease do not need prophylactic antibiotics. There is a consensus view that prophylactic antibiotics are not required in these patients (Pallasch and Slots, 1991; Lockhart and Schmidtke, 1994; American Heart Association, 1997). Only a very small percentage (<10%) of GDPs would prescribe prophylactic antibiotics for physiological or innocent murmurs, with about 23% seeking medical advice. Martin *et al.* (2001) suggest that where there is a vague history of a murmur then the dentist must ascertain in writing from a cardiologist, or general medical practitioner, whether the patient has a predisposition to infective endocarditis. A further investigation is required of how GDPs manage patients with a vague history of heart murmurs.

The investigation described within this thesis is the largest study undertaken to investigate the clinical procedures for which GDPs prescribe prophylactic antibiotics. Within this study there was a large number (>60%) of GDPs who associated any involvement of the gingival margin during dental procedures with a significant risk of bacteraemia and would therefore prescribe prophylactic antibiotics.

The use of prophylactic antibiotics for restorative procedures is contentious and must be based on the likelihood of inducing a bacteraemia. Previous studies investigated the procedures for which dentists would provide prophylactic antibiotics in patients susceptible to infective endocarditis (Holbrook, Willey and Shaw, 1983; Gould 1984; Bennis *et al.*, 1996). Holbrook *et al.* (1983) showed that 33% of dentists would sometimes prescribe prophylaxis for fillings and crown and bridge preparation. Gould (1984) reported that 73% of GDPs would prescribe prophylaxis prior to subgingival fillings, 18% before a supragingival filling and 10% before an impression. As with these previous studies, the results of the study done as part of this thesis showed that doubt existed as to the procedures that required prophylaxis.

The consensus of opinion of the American Dental Association (1997), which gives comprehensive guidelines as to the dental procedures requiring prophylaxis, and Longman and Martin (1999) is that the placement of restorations subgingivally (use of a matrix band) does not require prophylaxis. The controversy surrounding dentally-induced bacteraemias and their association with infective endocarditis has been discussed in section 1.3.3.2. At the present time Durack (1998) suggests that prophylaxis should not be recommended for most dental procedures, except dental extractions, scaling and polishing and gingival surgery, and for most cardiac conditions except prosthetic heart valves and previous infective endocarditis.

4.1.5.3 Prophylactic antibiotic regimens

In this study the choice of prophylactic antibiotic regimen, by most GDPs (99%), for medically compromised patients not allergic to penicillin was that recommended by the Endocarditis Working Party of the BSAC (1990). This result compares favourably with the previous studies reviewed as shown in Table 4.2. A small number of practitioners used regimens (e.g. metronidazole or tetracycline) known to be ineffective against most oral bacteria involved in infective endocarditis. For patients who were allergic to penicillin, erythromycin or clindamycin were the most commonly used prophylactic antibiotics, which conformed to the Endocarditis Working Party of the BSAC (1990; 1993) recommended guidelines. Again, a small number of GDPs used metronidazole or tetracycline inappropriately for prophylaxis with medically compromised patients allergic to penicillin.

As discussed in section 4.1.5.1 the regimen for prophylactic antibiotics in non-medically compromised patients was not investigated. A prophylactic regimen, if used, should follow the recommended guidelines for medically compromised patients. This should be administered pre-operatively in order to provide high serum levels at the time of the surgical procedure to reduce post-operative infection (Classen *et al.*, 1992; Longman and Martin, 1999).

Table 4.2
Surveys performed of GDPs' compliance with infective endocarditis prophylactic antibiotic recommendations by the AHA and BSAC

Author, year	Country, number of GDPs surveyed	% of replies which conformed to BSAC and AHA guidelines
Durack 1975	UK (359)	14.5%
Brooks 1980	USA (359)	23.4%
Hashway *et al.* 1982	USA (614)	15.4% Heart disease 6.7 % prosthetic heart valves
Scully *et al.* 1987	UK (509)	50.4%
Nelson *et al.* 1989	USA (219)	32.9%
Forbat *et al.* 1993	UK (72)	96%
Bennis *et al.* 1996	Morocco (227)	21%
Palmer *et al.* 2000a	UK (891)	99%

4.1.6 Antibiotic prescribing knowledge of GDPs

No previous study has investigated the knowledge of qualified dental practitioners about the use of antibiotics. Knowledge, in the study described, was equated to the number of correct answers (score) of the questionnaire compared to the "correct" answers of experts in the field of antibiotic prescribing.

Less than a quarter of the respondents had attended a postgraduate course in the two years prior to the questionnaire. This is surprising as the SMAC (1998), in its recommendations to reduce antimicrobial resistance, stressed that a greater emphasis should be placed on the education of qualified clinicians about antimicrobial prescribing.

A small but statistically significant difference in the knowledge of those GDPs who had attended a course previously (mean score 58.85 s.d 6.86) was noted in comparison to those that had not (mean score 56.85 s.d 6.63). The lack of attendance of GDPs may in part be due to the fact that Postgraduate Deans had failed to appreciate the recommendations of the SMAC and organise appropriate courses. Alternatively, GDPs may have felt that they had sufficient knowledge and did not feel a need to attend organised courses. Further research is required to investigate the provision of courses on antimicrobial prescribing and the reasons for non-attendance.

Overall the results showed varying degrees of knowledge when compared to the age of respondents, the Health Authority in which the GDPs practised and the university of qualification. Statistical analysis of the results revealed that there was no significant difference in scores relating to age bands, recently qualified GDPs scoring little better than those that had been qualified for 30 years. This result perhaps calls into question the efficacy of present undergraduate teaching and the retention of knowledge. Graduates of some dental schools scored significantly more poorly than others (see Table 3.19). The SMAC (1998) recommended that greater emphasis should be placed on education of clinical students in the use of antibiotics. The SMAC (1998) also recommended that teaching about antimicrobials should be better integrated with teaching about the infections for which they are used. There is a clear need to investigate and re-evaluate the teaching of antibiotic usage to undergraduates to determine if these recommendations have been put into practice. There is also a need to standardise the teaching of the use of antibiotics throughout the UK dental schools. There was no significant geographical difference in antibiotic prescribing knowledge when the scores were compared to Health Authority areas, although some scored more poorly than others. This may have been associated with the geographical provision of postgraduate courses in the previous two years.

There were clear differences in some aspects of antibiotic knowledge. Most practitioners scored well on the clinical signs where there is a clear need for prescribing antibiotics (spreading infection, patient malaise, temperature elevation, lymphadentitis). About a third of GDPs felt that there was a need for antibiotics where there was only localised swelling. Generally, practitioners scored well on the non-clinical factors that should not influence prescribing. A number did feel however, that it was acceptable to prescribe when short of time, if a definitive diagnosis could not be made, or if treatment had to be delayed.

As can be seen from Table 3.22 there were low scores for the questions on the common clinical conditions presenting in everyday practice. This may be due to practitioners thinking that antibiotics are required for conditions which are easily dealt with by routine operative dental treatment. Low scores were also evident for questions on prophylactic prescribing for medical conditions. The total mean score of 56 out of a possible 84 indicates a poor understanding and knowledge of the use of antibiotics in general dental practice.

Whether this level of knowledge can be extrapolated to all dentists is debatable. Further research into the knowledge of antibiotic prescribing of other dental personnel (e.g. hospital dentists, community dentists) is required. The importance of further education in the area of antimicrobial prescribing, as part of clinical governance and continuing professional development, cannot be overemphasized.

4.2 Prescription study

The principal aim of this part of the study was to investigate how and what GDPs prescribe in everyday practice. No published study had been undertaken, prior to this thesis, which investigated what GDPs prescribed by examination of the issued prescriptions. As with the questionnaire study it was decided at the outset that this part of the study should be a descriptive quantitative study.

The method of collection of the data consisted of examination of prescriptions issued by GDPs providing general dental services within England. The planning development and structure of the prescription study is discussed in the following section.

4.2.1 Prescription study design

In the planning stage of this part of the study the data to be collected to fulfil the aims of the study were evaluated. Other factors taken into consideration at the planning stage were the quality control of the research. These included developing strategies for dealing with missing data and any dubious data that may have been collected, or entered, into the database.

4.2.1.1 Pilot prescription study

The information required from the prescriptions to satisfy the aims of the study were the antibiotic prescribed and the dosage. It was also decided to investigate whether GDPs followed the advice of the BNF on prescription writing. The BNF (1998) states that prescriptions should be written legibly in ink, dated, state the full name, address and the age of the patient. The age of the patient is of particular importance as it is a legal requirement for children under 12 years of age. The BNF also recommends that the names of the drugs prescribed should be written in full, not abbreviated and the directions for use should be in English. The BNF recognises that Latin abbreviations are sometimes used. All these aspects of prescription writing were investigated as well as the year of qualification of the prescriber. In order to maintain patient and dentist confidentiality the data were collected by a Health Authority employee, anonymised and placed in a database. This procedure satisfied the Local Research Ethics Committee who approved the protocol.

Following the piloting of the prescription study the method of collection of the prescriptions and the data collected were reviewed. The pilot study showed that the prescription writing was good, legible and patient details, in nearly all of the cases, were correctly entered. The names of the antibiotics were written correctly and were mostly for generic antibiotics. This part of the study did not show any problems in prescription writing by GDPs. The time involved in the assessment of prescription writing by a qualified pharmacist for a large study was thought to be excessive and did not meet the aims of the thesis. In view of the ethical implications of recording dentists details and the Health Authority manpower required to cross-reference the prescriber with the Dentists Register to determine the year of qualification, it was decided to remove the year of qualification of the prescribing GDP from the study. The aim of this thesis was to investigate what GDPs prescribe, rather than to investigate if there was a relationship between the prescriber and the type of antibiotic and the dosage prescribed. Future research could however, determine whether certain age groups of GDPs issue more prescriptions than others.

The method of collection of the prescriptions in the pilot study was laborious, with Health Authority employees collecting the prescriptions from the regional offices of the Prescription Pricing Authority. All the dental prescriptions then had to be separated from the many thousands of medical prescriptions. Dental prescriptions where antibiotics had been prescribed were then selected for the study. This had manpower, financial and ethical implications. Health Authorities were unwilling to co-operate with the methods employed for data collection used in the pilot. The Ethical Committees and Health Authorities also had concerns about patient information being included in the study. Following discussions with Health Authorities, the Central Prescription Pricing Authority and Ethical Committee Chairmen agreed to all confidential information (dentist and patient information) being removed from the prescriptions before the data required were extracted.

4.2.1.2 Definitive prescription study

From the evaluation of the pilot study the method of collection of the prescriptions was simplified to enable copies of all prescriptions to be available for data collection. The aims of the thesis as defined in section 1.4 were applied to this part of the study and the extraneous data as discussed in the previous section were not collected.

4.2.1.3 Sampling and sample size

As discussed in section 4.1.2 the size of the sample and method of sampling is crucial to the validity of the conclusions. The selective method of sampling used for the prescription study was discussed in section 4.1.2.2.

Health Authorities were selected to provide a geographical spread, a mixture of inner city and rural areas, and the prescriptions issued by a representative sample (age, gender, university of qualification) of GDPs working in the GDS. One of the important factors in selection was Health Authority co-operation in allowing release of copies of the prescriptions for data collection. From the pilot study it was found that large numbers of prescriptions were issued in a month (1775) and the most recent PPA figures available during the planning stages showed minor monthly variations, but little seasonal variation (Peel, 1999). Table 4.3. shows the number of dental prescriptions issued monthly for the period April 1996 to March 1997.

The month of February 1999 was chosen for the study as this coincided with the period when GDPs received the questionnaire. The total number of prescriptions investigated (18,616) for the month was equivalent to 5.4% of the total issued throughout England for the month of February 1997. Ideally, the sample should have been selected from a month showing the average number of prescriptions issued over the whole year. It was however difficult to predict from the statistics provided by the PPA the month when this was likely to occur.

Rather than randomly selecting prescriptions from the chosen month's sample it was decided to include all the prescriptions. This resulted in the largest ever investigation of dental prescriptions. It was considered that the sample provided an accurate picture of which antibiotics GDPs prescribed and the regimens employed.

Table 4.3
Number of dental prescriptions processed monthly by the Prescription Pricing Authority for April 1996-March 1997

Month	Number of dental prescriptions processed by PPA (in thousands)
April	357.6
May	374.0
June	335.9
July	373.8
August	349.1
September	361.6
October	388.6
November	367.6
December	345.5
January	371.2
February	347.1
March	349.4

There is only one other systematic published study of dental prescriptions (Roy and Bagg, 2000) and in this study they investigated a random 10% of prescriptions (3554) issued over a six-month period from one Health Board in Scotland. Their data were retrieved for comparative purposes from a database on general practice prescribing held by the Information and Statistics Division, Primary Care Information Unit, Edinburgh.

Of the 18,616 prescriptions 17,007 were adult prescriptions and 1609 were prescribed in paediatric doses in liquid form. The results of the analysis of the prescriptions are discussed in the following two sections.

4.2.2. Adult antibiotic prescribing from analysis of prescriptions from the definitive study

The distribution of prescriptions for each of the Health Authorities investigated (see Table 3.28) showed a wide variation in the average number of prescriptions/GDP. This ranged from 22 for North Nottinghamshire Health Authority GDPs to seven for Sheffield Health Authority. This variation is difficult to explain and will require further research. The majority (90.9%) of the antibiotics prescribed were for generic antibiotics. This follows the recommendations of the DPF (1998), which states that generic antibiotics should be prescribed whenever possible to save expense to the Health Service. Most proprietary oral antibiotics have excellent generic equivalents with comparable bioavailability, side-effects and efficacy (Tam, 1996).

The only exception to the use of generic antibiotics is where bioavailability problems exists for a small group of patients, in which case the patient should always receive the brand that is acceptable. It is therefore difficult to justify GDPs prescribing nearly 9% of proprietory antibiotics.

4.2.2.1 Antibiotic choices of GDPs

The majority of prescriptions issued were for amoxicillin (55.8%) or metronidazole (22.2%). The antibiotic of choice, however, for most dental infections recommended by the DPF (1998) is phenoxymethylpenicillin four times daily, at a dose of 500mg increased to 750mg for severe cases. Only 1.2% of the prescriptions in this study were for penicillin at the recommended dose and frequency. The reasons why amoxicillin or metronidazole might be considered to be more appropriate than phenoxymethylpenicillin have been discussed (see section 4.1.4.3).

Erythromycin was used in 4.9% of prescriptions. Quayle *et al.* (1987) have shown that in the treatment of dental infections erythromycin is ineffective as a first choice, due to poor absorption and rapid emergence of resistant strains. It is, however, recommended by the DPF (1998) as the antibiotic of choice for patients allergic to penicillin, along with metronidazole.

Within this study 4% of prescriptions were for a combination of amoxicillin and metronidazole. Combinations of antibiotics are only indicated in the treatment of severe infections, with the DPF (1998) recommending phenoxymethylpenicillin (or erythromycin) with metronidazole. The choice of GDPs in this study of a combination of amoxicillin and metronidazole reflects the belief held by many GDPs that penicillin is less effective than amoxicillin in the treatment of dental infections. Some of the combinations prescribed were difficult to comprehend and showed a lack of understanding of the spectrum and pharmacokinetics of the antibiotics used (e.g. amoxicillin with metronidazole and penicillin). From the prescriptions studied very few GDPs follow the recommendations of the DPF for the antibiotic of choice. Further research in the form of a large randomised double-blind trial is required to clear up the controversy as to the most efficacious antibiotic for the treatment of dental infections.

4.2.2.2. Dose, frequency and duration of the antibiotics prescribed by GDPs

The wide range of doses, frequencies and duration for all the antibiotics prescribed was a serious cause for concern. The importance of antibiotics being prescribed at the correct frequency, dosage and duration so that the minimum inhibitory concentration is exceeded, but side-effects and the development of resistant bacteria are prevented, cannot be overemphasised. Longman and Martin (1991) suggested that prolonged courses of antibiotics, for periods up to 21 days, which were evident in this study, could be harmful by selecting resistant bacteria and abolishing colonisation resistance.

Although recommendations are given in the DPF on doses and frequencies, practitioners are only advised, with most antibiotics, to refrain from unduly prolonged courses as these are wasteful and may lead to side effects. There is evidence that short courses of antibiotics, with appropriate clinical treatment, are adequate for the resolution of dental infections (Martin *et al.*, 1997b). Large doses of amoxicillin (500mg, 750mg) and metronidazole (400mg, 600mg) recorded in this study are not indicated, as the absorption in the standard doses is good enough to be therapeutically effective (Lewis *et al.*, 1995). The two-dose 3g regimen for amoxicillin, however, has been shown to be effective in specific situations (Lewis, McGowan and MacFarlane, 1986b).

The recommendation of the Endocarditis Working Party of the BSAC (1993) and the AHA (1997) for prophylaxis of infective endocarditis in patients with cardiac defects or prosthetic heart valves is 3g of amoxicillin one hour pre-operatively. Clindamycin at a dose of 600mg is the accepted alternative, in preference to erythromycin, for patients allergic to penicillin (Endocarditis Working Party of BSAC, 1993; American Heart Association, 1997). Most of the high dose regimens prescribed for amoxicillin and clindamycin fell into this category.

The results of this investigation of adult prescriptions support the conclusion that there is inappropriate prescribing of antibiotics within NHS general dental practice in England. In order to prevent the further development of antibiotic resistance, general dental practitioners urgently need clear guidelines and educational initiatives on antibiotic prescribing. Guidelines should indicate the antibiotic of choice, the dose, frequency and duration for specific clinical situations. The DPF (1998) fails to provide this information so one of the aims of this thesis was to produce guidelines to fulfil this need.

4.2.3 Paediatric antibiotic prescribing from analysis of prescriptions from the definitive study

This was the first recorded study that had investigated the antibiotics prescribed for children by analysis of prescriptions. There is very little evidence of what antibiotics and regimens GDPs prescribe for children. Schuman *et al.* (1983) conducted a questionnaire survey of paedodontists on paediatric prescribing and Mason *et al.* (1997) investigated the medication children had received prior to attending a casualty department with dental pain. Neither of these reported studies, which have been described in section 1.2.2., investigated the antibiotics prescribed and the regimens employed by GDPs. Prescriptions for children were not identifiable from the prescriptions received from the Prescription Pricing Authorities, as the age of the patient was removed along with the other patient information from the prescriptions to maintain confidentiality. It was assumed that the liquid-based preparations of antibiotics prescribed would be mainly for younger children. It is recognised, however, that a number of these prescriptions may have been written for elderly patients. No published evidence exists of the use and number of liquid-based antibiotic preparations for the elderly (aged 60 years and over) in general dental practice. The results of the clinical audit done as part of this thesis (see section 3.5.1), however, showed that only 16% of prescriptions for antibiotics were for patients over 61 years of age and none were for liquid-based preparations of antibiotics. It is therefore likely that most of the liquid-based preparations in the prescription study were for young children.

Of the 1609 paediatric prescriptions selected and analysed the average number of antibiotic prescriptions (one) for each dentist was fairly consistent throughout all Health Authorities. Most of the prescriptions were for generic antibiotics (88.3%), which almost accords with the BNF recommendations that generic antibiotics should be prescribed at all times. There is a belief that brand name oral liquid medications taste better than their generic counterparts (Samulak, El-Chaar and Rubin, 1996). This may have accounted for a number of proprietary antibiotics (11.7%) being prescribed in this study. Samulak *et al.* (1996) in a randomised double-blind trial using 42 volunteers however, did not find any appreciable difference in taste between the generic or proprietary oral liquid medications. It would appear that there is no indication for GDPs to prescribe proprietary liquid-based antibiotics to children.

Only a small amount (10%) of liquid-based antibiotic preparations were prescribed in the definitive prescription study. It was disappointing to note that only 29% of the prescriptions were sugar-free. A further 3.8% of the prescriptions were changed and dispensed by pharmacists in sugar-free form. Pharmacists cannot dispense sugar-free generic prescriptions without contacting the prescriber and marking the prescription accordingly, so the proportion of antibiotics without fermentable carbohydrates was unlikely to have been higher than the 29% and 3.8% recorded in the study. There is evidence that liquid medicines, many of which contain sugar, can cause decay with prolonged or frequent use and should not be used whenever possible (Marathaki, Pollard and Curzon, 1995; Maguire, Rugg-Gunn and Butler, 1996).

In the DPF (1998) the products marked "sugar-free" do not contain glucose, fructose or sucrose, but may contain hydrogenated glucose syrup, mannitol or sorbitol, which have been shown not to be cariogenic. There is a clear need to educate GDPs to prescribe sugar-free liquid preparations of antibiotics whenever possible.

4.2.3.1 Antibiotic prescribed and dose

The majority of prescriptions issued were for amoxicillin (75.5%), followed by phenoxymethylpenicillin (15.2%), erythromycin (6.6%) and metronidazole (1.7%). The other antibiotics prescribed were cephalexin, cephadrine and ampicillin. The antibiotic of choice recommended by the DPF for most therapeutic prescribing is phenoxymethylpenicillin at a dose for children below five years of age of 125mg every six hours; this is increased to 250mg for children aged 6-12years. The BNF section of the combined formulary is more specific and suggests that children's doses should be calculated from adult doses by using age (in age ranges), body weight, or body surface area. There was a wide variation in doses in this study from 75mg to 1.5mg for amoxicillin, 100mg to 500mg for penicillin and 125mg to 2g for erythromycin. This may be a result of the BNF recommendations. As the age of patients for whom the antibiotics were prescribed was unavailable, it was not possible to see if there was a relationship between the age of the patient and the dose prescribed. Further investigations of the relationship between the age of the patient and dose would be of benefit to determine the basis upon which paediatric antibiotics should be prescribed.

4.2.3.2 Frequency and duration of the antibiotics prescribed

There were wide variations in frequency of dose for all the antibiotics prescribed, with over 19% of all the prescriptions failing to be within the frequencies recommended in the DPF. The importance of prescribing at the recommended frequency has been discussed in section 4.2.2.2.

As discussed previously, no indication is given within the DPF or BNF (1998) on the duration of the antibiotic, other than a recommendation that treatment should not be unduly prolonged. It has been shown that compliance by children to complete a conventional course of antibiotics is poor (Charney *et al.*, 1967). Lewis *et al.* (1986b), Paterson and Curzon (1993) and Martin *et al.* (1997b) have shown that short courses of antibiotics, with appropriate surgical treatment, are adequate for resolution of most acute suppurative dental infections. Within this study there was evidence of prolonged duration of antibiotics, with prescribing for up to 10 days. In view of the published evidence of poor compliance and the efficacy of short courses it would seem advisable to prescribe paediatric antibiotics for periods of 3-5 days.

The antibiotics of choice for prophylaxis in this study were amoxicillin, at doses from 750mg to 1.5g and erythromycin at doses from 1g to 2g. The DPF (1998) follows the Endocarditis Working Party of the BSAC's recommendation for prophylaxis. This is a single dose of amoxicillin (750mg for children under five years of age and 1.5g for children aged 5-10 years) for patients not allergic to penicillin, and clindamycin (150mg for the under 5years and 300mg for children aged 5-10 years) for patients allergic to penicillin.

Clindamycin has replaced erythromycin as the choice for patients allergic to penicillin for prophylaxis (Longman and Martin, 1993; Roberts *et al.*, 1998). No prescriptions for paediatric clindamycin were recorded in this study suggesting that a number of GDPs may not be aware that clindamycin has replaced erythromycin for patients who are allergic to penicillin and require prophylaxis.

There may be evidence that antibiotic prescriptions for children are increasing. The removal of general anaesthetics from general dental practice has given rise to a delay in extracting abscessed teeth under general anaesthetic due to waiting lists and the need for pre-anaesthetic patient assessment. Patients may therefore be prescribed antibiotics to "contain" their suppurative infections until definitive treatment can be provided. In this thesis it has been shown that GDPs prescribe antibiotics when treatment has to be delayed (Palmer *et al.*, 2000b). Delayed treatment with paediatric prescribing of antibiotics requires investigation to establish how common this practice is in paedodontics.

The wide variations in dosages of the antibiotics prescribed from the study of paediatric prescriptions and lack of specific guidelines, show a need for nationally agreed guidelines on paediatric prescribing of antibiotics.

4.3 Antibiotic prescribing guidelines

Lack of knowledge and the inappropriate prescribing of antibiotics by GDPs in NHS general dental practice is a cause for concern (see sections 4.1.4, 4.1.5, 4.1.6, 4.2.2 and 4.2.3). Present recommendations provided in the DPF (1998) fail to provide specific clinical indications for therapeutic prescribing with little, or no, advice on the duration of therapy. Existing recommendations for GDPs also fail to be specific on the clinical procedures requiring prophylaxis and which patients are at risk. It has been suggested throughout this thesis that the production of guidelines might assist GDPs to prescribe more rationally. One of the aims of this thesis was to develop antibiotic prescribing guidelines to improve antibiotic prescribing. Harvey *et al.* (1983) have shown in medical practice that the publication of antibiotic guidelines can improve prescribing. In Harvey's study there was an increase in appropriate prescribing of 20% following the issuing of guidelines.

But what are guidelines? Field and Lohr, (1990) have defined clinical guidelines as:

"Systematically developed statements to assist practitioner decisions and patient decisions about appropriate health care for specific clinical circumstances".

Clinical guidelines can be important aids to reducing inappropriate variations in clinical practice (Berg, 1997). Grimshaw and Russell (1993) showed that well developed and implemented guidelines could improve clinical practice and improve patient treatment outcomes.

It was the intention of the authors of the antimicrobial guidelines, developed as part of this thesis, to evoke a change in GDPs' antibiotic prescribing habits, and in so doing, to improve patient care.

4.3.1 Perceived problems with guidelines

The perceived problems with guidelines are that they may be portrayed as the "gold standard" for clinical practice and as a consequence there could be medico-legal implications surrounding their use (Hurwitz, 1994; Benech, Wilson and Dowell, 1996). Hurwitz (1995) reviewed the role of guidelines in relation to the law and came to the conclusion that guidelines provide the courts with examples of ideal clinical standards. Hurwitz (1995) reported that guidelines in America played a relevant role in proof of negligence in only 6.6% of medical malpractice actions. Guidelines have no special legal status and have a deferential role to that of expert witnesses in court proceedings (Hurwitz, 1999). Another concern is that guidelines might reduce clinical freedom. It has been suggested that guidelines may represent diagnosis and treatment as a rational process where there are clear-cut answers (Berg, 1997; Rappolt, 1997). In everyday practice, however, decision-making is complicated by a number of clinical and non-clinical factors. Other barriers to using guidelines are that they can be threatening, or produce financial disincentives. Even if a guideline is of high scientific quality, clinicians may still not follow it unless it is uncontroversial, specific, evidence based and requires no change to existing routine (Grol *et al.*, 1998).

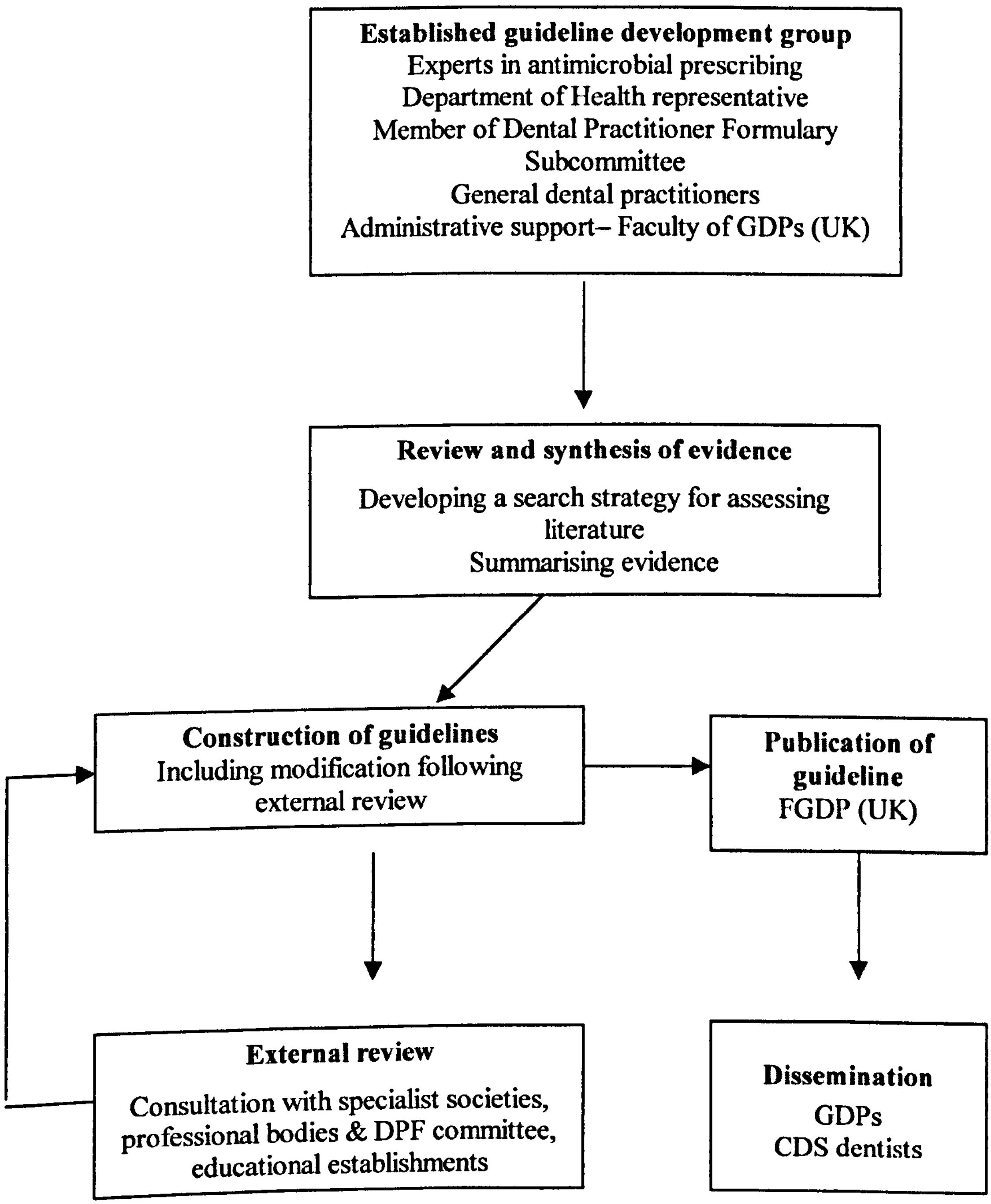
It has been shown that the publication of guidelines alone is seldom of value in changing clinical practice (Freemantle *et al.*, 2001). A review of evaluations of guidelines concluded that many studies showed no dissemination strategy and that guidelines were likely to be implemented only if disseminated as part of an educational initiative (Grimshaw and Russell, 1994). The success of guidelines therefore depends on the process by which the guidelines are developed and how they are disseminated, implemented and monitored; all these aspects were considered in the developmental process of the guidelines.

4.3.2 Development of Antimicrobial Guideline document

The process of development of the antimicrobial guideline document in this thesis is shown in Figure 4.4. The production of national guidelines usually requires a consensus group consisting of professionals who are going to use them, interested parties and independent experts (Grol, 1993; McComb, Wright and O'Brien, 1997). Figure 4.4 shows that the development group for the guidelines in antimicrobial prescribing conformed to this view. The review and synthesis of the evidence is described in section 2.6. Ideally a systematic review of the literature is the best method of obtaining the evidence and then a grading process is undertaken (e.g. SIGN-based methodology). It was evident from a review of the literature that very little high quality research had been published on antimicrobial prescribing. Double-blind randomised controlled trials are considered the gold standard in research, but very few high quality studies have been published in dentistry. It was therefore decided to use a mixture of evidence-linked recommendations, consensus views from expert committee reports and the clinical experiences of respected authorities.

Figure 4.4

The stages in the development of the antimicrobial prescribing guidelines document (Modified from Bailey and Gabbay, 1999)



Following construction of the guidelines document, external review by as many interested parties (see Appendix 3) as possible was carried out. The information and evidence submitted was reviewed. As the DPF is the only source of information for GDPs, a meeting was held with their committee members to obtain a consensus view. Having produced the guidelines document it was important to ensure its wide dissemination. This was done through the Faculty of Dental Practitioners (UK) who arranged advertising and dissemination to Health Authorities and educational establishments. McComb *et al.* (1997) in a literature review of guidelines concluded that the effectiveness of guidelines should be vigorously tested. It has been suggested that auditing of the impact of a guideline is important before implementing it in practices (Bailey and Gabbay, 1999). Planned testing, by the use of audit, of the efficacy of the guidelines and a means of implementation was done before publication. This is discussed in the next section of this thesis.

4.4 Clinical audit of antibiotic prescribing

Antibiotic use has been the subject of many audits and educational activities within medical practice (De Santis *et al.*, 1994; Swann and Clarke, 1994; Gyssens *et al.*, 1997; Zwar *et al.*, 1999). Palmer (2000b) suggested that guidelines for GDPs along with educational initiatives and audit may encourage safe, effective, rational and economic use of antibiotics and at the same time reduce the likelihood of dentists contributing to the problem of antibiotic resistance.

Very few audits on antibiotic prescribing in dental practice have been reported. Steed and Gibson (1997) showed in an audit involving a small number of GDPs that locally agreed guidelines reduced the number of prescriptions issued by 50% over two four-month periods. In the past GDPs have relied on information in the DPF (1998) for antibiotic prescribing standards. The information available in the DPF does not provide specific information on when and what to prescribe in specific clinical situations, and therefore cannot be used to set standards for audit. The audit part of the thesis was used to test the proposed guidelines in setting standards and to investigate improvement in antibiotic prescribing by GDPs.

Audit consists of reviewing, monitoring and evaluating current practice against agreed predefined standards, usually in the form of guidelines (Standing Committee for Postgraduate Medical Education, 1989). The Secretaries of State for Health (1989) have defined clinical audit as:

"The systematic, critical analysis of the quality of dental care, including the procedures and processes used for diagnosis, intervention and treatment, the use of resources and the resulting outcome and quality of life as assessed by both professionals and patients."

The Clinical Resource and Audit Group (1994) suggested that the criteria for undertaking an audit are that the issue to be addressed should be:

"A common, significant or serious problem; any changes following audit should benefit patients and lead to greater effectiveness; that the issue is relevant to professional practice and that there is a realistic potential for improvement."

The results of the questionnaire and prescription study in this thesis showed that there is significant inappropriate prescribing. It was considered that clinical audit, with guidelines, might lead to an improvement in prescribing. The innovative audit described in this thesis measured the outcome of using guidelines on antimicrobial prescribing in general dental practice.

4.4.1 Sample size and selection

All GDPs in the Mersey region were invited to take part in the audit. The sample size in the audit was 175 out of a total 932 GDPs. These GDPs were volunteer participants. The advantages of using volunteer participants were ease of monitoring during the audit and retention of the sample members. It is accepted that these volunteers may be different in their approach to antibiotic prescribing from non-volunteers, perhaps influencing the validity of the results. An attempt was made, however, to reduce any bias by advertising for all GDPs to take part, in a specific geographical area. The geographical area was chosen as a result of a request from the Local Audit and Peer Review Assessment Panel of the National Clinical Audit scheme. The panel requested a region-wide audit on antibiotic prescribing to involve as many GDPs in audit as possible. Funding was available for GDPs to take part under the National Clinical Audit Scheme introduced by the Department of Health in 1995. There also were a number of trained facilitators willing to assist in the running of the audit. It was not known whether the sample was representative of the general population of GDPs in England and therefore the results cannot be extrapolated for all GDPs.

The guidelines are at present being used by three London Health Authorities to set guidelines for a clinical audit of antibiotic prescribing by GDPs. Further investigation of the use of guidelines to reduce inappropriate antibiotic prescribing will be required using a larger geographically distributed sample.

4.4.2 Methods employed

A direct comparison was made of antibiotic prescribing between two six-week periods. The prescribing data collected by GDPs have been discussed in section 2.7.1. All these data were anonymous and therefore it is likely that GDPs recorded the data truthfully. Davis *et al.* (1995) in a systematic review of the effect of continuing medical educational strategies showed that opinion leaders (100%) and audit with feedback (42%) are more effective than formal continuing education (14%) in persuading practitioners to accept guidelines. Mugford *et al.* (1991) showed that information feedback was most likely to influence clinical practice if the information was presented close to the time of the decision-making and the practitioners had agreed to a review of their practice. The audit described in this thesis (see section 2.7.1) followed the strategies of Mugford *et al.* (1991) and Davies *et al.* (1995).

4.4.3 Antibiotic prescribing in the two clinical audit periods

Following the issuing of guidelines and the educational component in this audit there was a decrease of 42.5% in the number of prescriptions for antibiotics written by GDPs when compared to the initial data collection period.

The guidelines produced as part of this thesis reduced prescribing of antibiotics in general dental practice, especially after being linked with the educational component led by opinion leaders. It also confirmed that the guidelines produced were used effectively by GDPs in the audit.

It was interesting to note that in the audit 8.9% of the prescriptions were for patients in the 0-15 years of age-band and within the prescription survey 8.6% were classified as paediatric prescriptions by virtue of their formulation and dose (see section 3.3.2). The majority of prescriptions (75%) in both the audits were issued for the 16-60 year group.

The main antibiotics prescribed were amoxicillin, metronidazole and penicillin. The results concurred with those shown in both the questionnaire study (see section 3.1.2.1) and the prescription study (see section 3.3.2.1). Most GDPs favoured amoxicillin or metronidazole as the commonest prescribed antibiotics. The reasons why amoxicillin or metronidazole may have been used more often than penicillin, recommended by the DPF, have been discussed in section 4.1.4.3. There was a wide range of dosages for all the antibiotics prescribed in the first data collection period, a result found in the prescription study reported in this thesis (see section 3.3.2.1).

Following guidelines and the educational component there was a statistically significant change in the proportion of GDPs prescribing the recommended regimen for amoxicillin and metronidazole. This suggested that the guidelines were effective in improving appropriate prescribing of these antibiotics. There was however, no significant change in the proportion of GDPs prescribing the recommended regimen for penicillin, erythromycin and clindamycin. The majority of GDPs prescribed these antibiotics appropriately in both data collection periods. The effectiveness of the guidelines in reducing the use of combinations of antibiotics was evident with percentage reductions varying from 17.1% for amoxicillin with metronidazole (the recommended combination), to 100% for metronidazole and erythromycin.

4.4.4 Clinical conditions for which GDPs prescribed antibiotics during the two clinical audit periods

In nearly every clinical condition recorded there was a marked decrease of prescriptions for therapeutic antibiotics issued between the two audit periods. It was pleasing to note that there was a marked fall in prescriptions for sinusitis (70%), pulpitis (71.1%), gingivitis (56%), where there is no indication for antibiotics (see section 4.1.4.1.). It would also appear that many GDPs followed the guidelines recommended for acute periapical and periodontal infections; there was a decrease of 44% and 60% respectively for these two conditions between the two audit periods. Diminution in numbers of prescriptions for pericoronitis and infected sockets, although significant, was not as marked. Further definitive trials in the use of antibiotics for these conditions may convince GDPs of the inappropriateness of prescribing in these situations. Unfortunately there was one area where prescribing of antibiotics increased following the issuing of guidelines. There was a 25% increase in the use of antibiotics following root canal therapy. Although Morse *et al.* (1987) and Abbott *et al.* (1988) suggest that antibiotics can prevent post-obturation flare-ups, it is generally recognised that good technique during canal preparation and obturation will prevent flare-ups (Longman *et al.*, 2000).

Overall it was concluded that the guidelines used with audit, the educational component and feedback from opinion leaders, reduced some of the inappropriate prescribing of antibiotics.

4.4.5 Medical conditions for which prophylactic antibiotics were prescribed in the two clinical audit periods

As described in section 3.5.3 only 11% of the total number of prescriptions issued over the two data collection periods were prescribed for prophylactic purposes. Most of the conditions listed by GDPs were appropriate for prophylaxis as recommended by the Endocarditis Working Party of the BSAC (1993) and the AHA (1997). The only medical condition that showed a marked reduction (51.7%) in the second data collection period, following guidelines and the educational component, related to murmurs. This may have been as a result of the advice given during feedback by the opinion leaders on the procedures to follow in this medical condition (Martin *et al.*, 2001). A decrease in prophylactic prescriptions for coronary heart disease, prosthetic joints, radiotherapy and chemotherapy patients, and patients who were immunocompromised was also evident. This may have been a result of GDPs complying with the guidelines given during the audit. It is possible however, that the number of patients presenting for treatment with these conditions may have been less in the second data collection period.

A further questionnaire study following the production of the guidelines might have confirmed whether GDPs had a better understanding of the use of prophylactic antibiotics for medically compromised patients.

4.4.6 GDPs' reasons for prescribing antibiotics

The use of guidelines and the educational component in this audit were effective in decreasing the inappropriate reasons why GDPs prescribe antibiotics. Statistically, there was a decrease in the proportion of GDPs who prescribed when they were uncertain of the diagnosis, pressure of time and workload, patient expectation, pain and localised swelling. There was a marked decrease in the use of prescriptions "just in case" of problems associated with treatment. Cawson and Spector (1989) specifically state that the use of antibiotics in this situation can cause serious harm to the patient by delaying diagnosis and subjecting patients to side effects or toxicity. The Dental Protection Society (1998), which insures dentists against litigation, advises that before prescribing any medicine dentists should consider carefully the rationale for use and balance this against any alternative treatment approach. There are, at present, no recorded medico-legal cases of patients claiming negligence where antibiotics have been prescribed inappropriately. Forde (2000) however, suggests that inappropriate prescribing falls under the tort of negligence, which could be proved if antibiotics are prescribed where there is no indication and a serious side-effect ensues. This could be a problem for GDPs in the future, as patients become more aware of the effects of inappropriate prescribing through the media.

The prescribing of antibiotics associated with pain was investigated further. Nearly one-third of all the prescriptions in both data collection periods were related to pain. A high proportion of prescriptions in both audit periods were for pain without the presence of infection. Although, there was a significant reduction in the number of prescriptions for pain between the two periods, there still remained a significant number of

GDPs who prescribed for pain only following the issuing of guidelines and the educational component. This is totally inappropriate as the only accepted indications for antibiotics are where there is a spreading infection, elevated temperature and lymph node involvement (Cawson and Spector, 1989; Pogrel, 1994). In circumstances where drainage is difficult to establish Martin (1998) suggests that antibiotics may be appropriate.

Although the guidelines were effective in reducing inappropriate prescribing there still remained a number of GDPs who failed to follow the recommendations. This inappropriate antibiotic use could also contribute to the problem of antimicrobial resistance as discussed in section 1.1. Further research is required to establish why GDPs fail to follow guidelines. Further research is also required, in the form of re-audit, to investigate whether those previously involved in this study have maintained changes in their prescribing habits.

4.5 Conclusions

The results obtained from the questionnaire survey support the conclusion that the therapeutic prescribing of antibiotics varies widely. Many GDPs prescribe antibiotics inappropriately for commonly presenting clinical conditions in NHS general dental practice in England. The evidence of the questionnaire survey also shows that a significant number of GDPs also prescribe prophylactic antibiotics inappropriately, both for surgical procedures for non-medically compromised patients and for patients at risk of infective endocarditis. There is also evidence that GDPs prescribe antibiotic prophylaxis for clinical procedures and medical conditions for which there is little evidence of benefit to the patient.

The knowledge of GDPs was good for the clinical signs that are indicators for prescribing antibiotics and for a number of non-clinical factors that might affect antibiotic prescribing. Knowledge of therapeutic and prophylactic prescribing for medically compromised was generally poor. There was no significant difference in the level of knowledge between the age groups of GDPs surveyed suggesting that an urgent review of undergraduate and postgraduate education in antibiotic usage is required.

The results of the prescription study showed that many GDPs prescribed antibiotics inappropriately for both adults and children. There were wide variations in doses for all antibiotics prescribed. A significant proportion of GDPs prescribed at frequencies inconsistent with manufacturers' recommendations and for prolonged periods.

The audit study confirmed that there is inappropriate prescribing of therapeutic and prophylactic antibiotics, similar to that found in the definitive questionnaire and prescription studies. The audit study also confirmed the lack of knowledge of GDPs in certain areas of prescribing of antibiotics. The results of the audit showed that guidelines, developed as part of this thesis, can change prescribing practices of GDPs leading to a more rational and appropriate use of antibiotics in general dental practice. Clinical audit, when combined with guidelines an educational component and feedback, has been shown to be an effective method of disseminating guidelines and improving patient care.

4.6 Suggestions for further research

4.6.1 Antimicrobial resistance surveillance

The long-term effects of inappropriate and over prescribing of antibiotics by GDPs on antimicrobial resistance have not yet been elucidated. Collaborative studies are required to continue monitoring the resistance of oral commensals to antimicrobials.

4.6.2 Randomised controlled trials in therapeutic and prophylactic prescribing

The lack of good randomised controlled trials in many areas of antibiotic use in dentistry means that there is little good evidence for the appropriate use of antibiotics and therefore controversy exists. In view of the controversy in the first choice antibiotic in therapeutic prescribing a large randomised double-blind controlled trial comparing the efficacy of phenoxymethylpenicillin with amoxicillin would be of merit. Randomised control trials are required to test the efficacy of antibiotics in oral surgery in reducing post-operative infection, particularly in relation to the surgical removal of third molars, apicectomy, surgical removal of teeth with bone removal. Randomised control trials are also required in endodontics in relation to post-operative pain and swelling. Further research is also required on the efficacy of prophylactic antibiotics in the re-implantation of avulsed teeth and the relationship between the dosage and age of the child patient.

Randomised control trials in the efficacy of antibiotic prophylaxis to prevent infective endocarditis are urgently needed in view of the controversy that exists, to confirm the necessity of antibiotics and assess the risk or benefit to patients.

4.6.3 Research in general dental practice

The results of this thesis have highlighted areas for further research that could be done in general dental practice. The reasons why treatment has to be delayed and why GDPs are unable to make a diagnosis needs further investigation. An investigation of how GDPs manage patients with a history of heart murmurs is required to reduce the inappropriate prescribing in such patients. Barriers to acceptance of guidelines in general dental practice require investigation as further guidelines are published to improve the standard of patient care. Further audit with a large geographical sample, utilising the guidelines produced in this thesis, is required to test their effectiveness. A re-audit, utilising the same study sample as used in this thesis, is necessary to investigate whether the changes GDPs implemented as a result of the audit have been maintained or improved. Antibiotic prescribing profiling for GDPs with feedback would also be of benefit. The use of profiling could then be investigated to see if this improves antibiotic prescribing.

4.6.4 Teaching of antibiotic usage

An investigation into the provision of postgraduate courses on antibiotic prescribing would determine the educational needs for GDPs. Evaluation of courses provided could determine their efficacy in improving antibiotic prescribing. Research is urgently required into teaching about antibiotic usage at undergraduate level to ensure that there is an implementation of the recommendations of the SMAC and that there is some conformity throughout the universities in the UK. An investigation of knowledge of other dental personnel (hospital, community, defence services and university) would determine their educational needs. Information technology, including the use of the Internet and computer-aided learning packages should be fully exploited in the educational and decision making process.

4.6.5 Provision of further guidelines

The existing guidelines developed as part of this thesis will require modification as a result of continuing research and published findings. A guideline on paediatric prescribing would also be of benefit to all dentists providing care to children.

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APPENDICES

APPENDIX 1

Pilot questionnaire

NO FORM OF PERSONAL IDENTIFIER IS INCLUDED IN THIS QUESTIONNAIRE AND THEREFORE ALL THE INFORMATION COLLECTED WILL BE TOTALLY ANONYMOUS

1.For the following conditions please indicate whether you would prescribe antibiotics?
If yes, please indicate A-always S-sometimes N-never for each antibiotic listed.

Condition	Yes	No	Don't know	Amoxicillin	Penicillin	Erythromycin	Metronidazole	Tetracycline
1.Acute pulpitis		√						
2.Acute periapical infection a) before drainage		√						
b) with drainage	S			S	N	S	S	N
c) after drainage	S			S	N	S	S	N
3.Chronic apical infection		√						
4.Pericoronitis	S			S	N	S	S	N
5.Cellulitis	√			S	N	S	S	N
6.Periodontal abscess	S			S	N	S	S	N
7.Acute ulcerative gingivitis	√			N	N	N	A	N
8.Chronic marginal gingivitis		√						
9.Sinusitis		√						
10.Chronic periodontitis		√						
11.Dry socket	S			S	N	N	S	N
12.Trismus	√			S	N	N	S	N
13.Avulsion of teeth	√			S	N	N	S	N

2.In patients with NO relevant medical history, do you prescribe antibiotics for the following procedures? If yes, please indicate A-always S-sometimes N-never for each antibiotic listed.

Procedure	Yes	No	Don't know	Amoxicillin	Penicillin	Erythromycin	Metronidazole	Tetracycline
1.Extraction a) routine		√						
b) surgical		√						
2.Apicectomy		√						
3.Root canal therapy a) pre-op		√						
b) post-op		√						
4.Scaling and polishing		√						
5.Restorative treatment		√						

3.For patients with a medical history indicated below, which clinical procedures in your opinion require prophylactic antibiotics? Please tick.

Medical History	s&p	fill	rct	extraction	imps	other procedures (please specify)
1.Diabetes mellitus						
2.Haemodialysis patients						
3.Hodgkins disease						
4.Aids						
5.Pts on immunosuppressives						
6.Pts with autoimmune disease						
7.Renal transplant pts						
8.Radiotherapy to head & neck				√		surgery
9.Pts with prosthetic joints						
10.History of infective endocarditis	√		√	√		surgery
11.Cardiac valve prosthesis	√		√	√		surgery
12.Rheumatic heart disease	√		√	√		surgery
13.Aortic stenosis	√		√	√		surgery
14.Ventricular septal defect	√		√	√		surgery
15.Coronary by-pass surgery						
16.Rheumatic fever-no valvular dysfunction						
17.Coronary heart disease						
18.Pacemakers						
19.physiolog/functional/innocent murmurs						

s&p=scaling and polishing, rct=root canal therapy, imps=impressions

4. What regime do you routinely use for prophylaxis with adult medically compromised patients with no known hypersensitivity?

Antibiotic	Dose	Yes	No
1 Amoxicillin	3g 1 hour preop	√	
2 Amoxicillin	3g 1 hour preop + 500mg 6hr later		√
3 Penicillin V	2g 1 hour preop + 1g 6hr later		√
4 Erythromycin Stearate	1g 1 hour preop + 500mg 6hr later		√
5 Tetracycline	1g 1 hour preop + 500mg 6hr later		√
6 Clindamycin	600mg 1 hour preop		√
7 Metronidazole	200mg 3x daily for 3days		√

5. Which of the antibiotic regimes listed above would you use for medically compromised patients hypersensitive to penicillin?

Please circle 1 2 3 4 5 6 7

6.Which of the antibiotics listed above would you prescribe to non-medically compromised patients hypersensitive to penicillin?

Please circle 1 2 3 4 5 6 7

7. Which of the antibiotics listed above would you <u>NOT</u> prescribe to pregnant patients?

Please circle 1 2 3 4 5 6 7

8. Which of the antibiotics listed above would you <u>NOT</u> prescribe to patients taking oral contraceptives?

Please circle 1 2 3 4 5 6 7

9. Which of the antibiotics listed above would you NOT prescribe to patients on anticoagulant therapy?

Please circle 1 2 3 4 5 6 7

10. Have you attended any postgraduate courses on antibiotic prescribing in dental practice within the last two years?

Yes No

Year of qualification

Place of qualification

Thank you for completing this questionnaire. Please use the enclosed SAE to return it as soon as possible.

APPENDIX 2

Definitive Questionnaire

ANTIBIOTIC PRESCRIBING QUESTIONNAIRE

NO FORM OF PERSONAL IDENTIFIER IS INCLUDED IN THIS QUESTIONNAIRE AND THEREFORE ALL THE INFORMATION COLLECTED WILL BE TOTALLY ANONYMOUS

1. Have you attended any postgraduate courses on antibiotic prescribing within the last two years? Please circle.

Yes No

2. Year of first dental degree ....

3. Place of qualification ....

4. Please circle

male female

5. How old are you? Please circle.

21-30 years
31-40 years
41-50 years
51-60 years
61 + years

6. In patients presenting with a dental infection, which of the following clinical signs in your opinion would indicate the prescribing of antibiotics in conjunction with appropriate treatment?

Please tick (✓) **YES OR NO** for each clinical sign.

Clinical sign	Yes	No
1 Elevated temperature and evidence of systemic spread	√	
2 Localised fluctuant swelling		√
3 Gross or diffuse swelling	√	
4 Unrestricted mouth opening		√
5 Difficulty in swallowing	√	
6 Closure of the eye due to swelling	√	

7. For patients presenting with a periapical infection where antibiotics are indicated, please complete the following assuming the patient has no allergy to penicillin.

Antibiotic	Dose	Frequency	Number of days
Amoxicillin	250mg	Three times daily	5

8. Which of the following non-clinical factors might cause you to prescribe an antibiotic?
Please tick **(✓) YES OR NO** for each factor.

Non-clinical factor	Yes	No
1 Patient expectation of a prescription		√
2 Pressure of time and workload		√
3 Patient's social history		√
4 Uncertainty of diagnosis		√
5 Where treatment has to be delayed		√

9. For patients **ALLERGIC TO PENICILLIN** requiring an antibiotic for a dental infection **please circle** your usual choice of antibiotic:

metronidazole erythromycin tetracycline cephalosporin amoxicillin

10. Do you usually prescribe antibiotics for the following clinical conditions? Please indicate (✓) **YES OR NO** for each condition.
If yes, please indicate (✓) your choice of antibiotic for patients **not allergic to penicillin.**

Condition	Yes	No	Amoxicillin	Penicillin	Erythromycin	Metronidazole	Tetracycline	Other please specify
1.Acute pulpitis		√						
2.Acute periapical infection								
a) before drainage		√						
b) with drainage		√						
c) after drainage		√						
3.Chronic apical infection		√						
4.Pericoronitis	√					√		
5.Cellulitis	√		√					
6.Periodontal abscess		√						
7.Acute ulcerative gingivitis	√					√		
8.Chronic marginal gingivitis		√						
9.Sinusitis		√						
10.Chronic periodontitis	√						√	
11.Dry socket		√						
12.Trismus	√		√					
13.Reimplantation of teeth	√		√					

11. In patients with **NO RELEVANT MEDICAL HISTORY**, do you prescribe antibiotics for the following procedures? Please tick (✓) **YES OR NO** for each procedure.

If yes, please indicate (✓) your choice of antibiotic for patients **not allergic to penicillin.**

Procedure	Yes	No	Amoxicillin	Penicillin	Erythromycin	Metronidazole	Tetracycline	Other please specify
1.Extraction a) routine		√						
b) surgical		√						
2.Apicectomy		√						
3.Root canal therapy a) pre-op		√						
b) post-op		√						
4.Scaling and polishing		√						
5.Restorative treatment		√						

12. For patients with a relevant medical history indicated below, which clinical procedures in your opinion require prophylactic antibiotics? Please tick (✓)

Medical History	**s&p**	**Fillings-class II subgingival**	**Fillings-class V Subgingival**	**rct**	**Extractions**	**Imps**	**Seek specialist advice**
1.Diabetes mellitus							
2.Haemodialysis patients							
3.Hodgkins disease							
4.Aids							
5.Pts on immunosuppressives							
6.Pts with autoimmune disease							
7.Renal transplant pts							
8.Radiotherapy to head & neck					√		
9.Pts with prosthetic joints							
10.History of infective endocarditis	√			√	√		
11.Cardiac valve prosthesis	√			√	√		
12.Rheumatic heart disease	√			√	√		
13.Aortic stenosis	√			√	√		
14.Ventricular septal defect	√			√	√		
15.Coronary by-pass surgery							
16.Rheumatic fever-no valvular dysfunction							
17.Coronary heart disease							
18.Pacemakers							
19.physiolog/functional/innocent murmurs							

s&p=scaling and polishing, rct=root canal therapy, imps=impressions, fillings classII= e.g. mesio-occlusal fillings, classV = buccal

13. What regimen do you use for prophylaxis with adult medically compromised patients **not allergic to penicillin?**
Please tick (✓) **YES OR NO** for each regime.

Antibiotic	Dose	Yes	No
1 Amoxicillin	3g 1 hour preop	√	
2 Amoxicillin	3g 1 hour preop + 500mg 6hr later		√
3 Penicillin V	2g 1 hour preop + 1g 6hr later		√
4 Erythromycin Stearate	1g 1 hour preop + 500mg 6hr later		√
5 Tetracycline	1g 1 hour preop + 500mg 6hr later		√
6 Clindamycin	600mg 1 hour preop		√
7 Metronidazole	200mg 3x daily for 3 days		√
8.Other regime please specify below			√

14. Which of the antibiotic regimens listed in **Question 13** would you use for medically compromised patients **allergic to penicillin** requiring prophylaxis?

Please circle 1 2 3 4 5 6 7

Other –please specify...

Thank you for taking the time to complete this questionnaire. Please return the questionnaire in the enclosed stamped addressed envelope by **27**

FEBRUARY 1999

APPENDIX 3

Faculty of General Dental Practitioners (UK)
The Royal College of Surgeons of England

CIRCULATION LIST
Standards in Antimicrobial Prescribing for General Dental Practitioners
Final Draft, May 1999

American Dental Society of Europe

Association of Anaesthetists of Great Britain and Ireland

Association of Basic Science Teachers in Dentistry

Association of Dental Anaesthetists

Association of Dental Hospitals

Association of Dental Implantology (UK)

Association of Industrial Dental Surgeons

British Association for the Study of Community Dentistry

British Association of Oral and Maxillofacial Surgeons

British Association of Teachers of Conservative Dentistry

British Dental Association

British Dental Association

British Dental Health Foundation

British Dental Laser Association

British Dental Trade Association

British Endodontic Society

British Orthodontic Society

British Society for Antimicrobial Chemotherapy

British Society for Behavioural Science in Dentistry

British Society for Dental Research

British Society for General Dental Surgery

British Society for Oral Medicine

British Society for Oral Pathology

British Society for Restorative Dentistry

British Society for the Study of Prosthetic Dentistry

British Society of Dentistry for the Handicapped

British Society of Gerodontology

British Society of Paediatric Dentistry

British Society of Periodontology

BUPA DentalCover

Committee on Vocational Training for England and Wales

Council of Deans of Dental Schools

Denplan Ltd

Dental Formulary Sub-Committee

Dental Practice Board

Dental Practitioners' Formulary

Dental Protection Ltd

Department of Health

Department of Health

European Orthodontic Society

APPENDIX 4

Adult Antimicrobial Prescribing in Primary Dental Care for General Dental Practitioners

Faculty of General Dental Practitioners (UK)
The Royal College of Surgeons of England

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Preface

The Faculty of General Dental Practitioners (UK) has a declared commitment to 'improving the standards of patient care'. By the provision of standards and guidelines it aims to help the profession achieve this goal. Standards and guidelines are simply tools a dentist may use to improve treatment planning and care outcomes.

This is the fourth document in a series which includes the *Self-assessment Manual and Standards* (SAMS), *Selection Criteria for Dental Radiography* and *Current Guidance for General Dental Practice*. As with all these publications, this document's purpose is a practical one; it is not intended to be limiting or restrictive but to be useful in the decision-making process and to be an aid to effective treatment planning and patient care.

I believe that you will find this work useful.

Malcolm E Pendlebury

Dean, FGDP(UK), 1997-2000.

Prescription Writing*

Prescriptions should be written legibly in ink or otherwise so as to be indelible, be dated, state the full name and address of the patient, and be signed in ink by the prescriber. The age and date of birth of the patient should preferably be stated, and is a legal requirement in the case of prescription-only medicines for children under 12 years of age.

In general dental practice the following should be noted:

1. The unnecessary use of decimal points should be avoided, e.g. 3 mg not 3.0 mg.

2. Quantities of:

   One gram or more should be written 1 g, and so on.

   Less than one gram should be written in milligrams, e.g. 500 mg not 0.5 g.

   Less than 1 mg should be written in micrograms, e.g. 100 micrograms, not 0.1 mg.

   When decimals are unavoidable a zero should be written in front of the decimal point where there is no other figure, e.g. 0.5 ml, not .5 ml

   Micrograms should **not** be abbreviated. Similarly 'units' should not be abbreviated.

3. The term 'millilitre' (ml or mL) is used in medicine and pharmacy and cubic centimetres (cc or cm^3) should not be used.

4. Dose and dose frequency should be stated; in the case of preparations to be taken 'as required' **a minimum dose interval** should be specified.

5. The names of drugs and preparations should be written clearly and **not** abbreviated, using approved titles **only**.

6. The symbol 'NP' on NHS forms should be deleted if it is required that the name of the preparation should not appear on the label.

* Adapted from the *British National Formulary* with the kind permission of the Royal Pharmaceutical Society of Great Britain.

7. The quantity to be supplied may be stated by indicating the number of days of treatment required in the box provided on NHS forms. In most cases the exact amount will be supplied. This does not apply to the terms directed to be used as required–if the dose and frequency are not given the quantity to be supplied needs to be stated.

When several items are ordered on one form the box can be marked with the number of days of treatment, provided that the quantity is added for any item for which the amount cannot be calculated.

8. Although directions should be preferably in **English without abbreviation**, it is recognised that some Latin abbreviations are used.

Never prescribe a drug unless there is a good clinical indication.

Make prescriptions clear.

Use approved names.

Always make the source of the prescription clear.

Always record prescription details in the clinical notes.

Avoid prescribing during pregnancy whenever possible.

Avoid abbreviations–give the name of the drug in full.

Notes on the Use of Antimicrobials

Microbial resistance to antimicrobials is increasing at an alarming rate. Microbial resistance is a major health problem and contributes significantly to deaths from nosocomial (hospital-acquired) septicaemia. The indiscriminate prescribing of antimicrobials is thought to be a major cause of resistance in microorganisms. Antimicrobials lead to the selection and dominance of resistant microorganisms; they can also increase the incidence of resistance and transfer of genes from resistant strains to antibiotic-sensitive microorganisms.

Serious drug interactions can occur with antimicrobial agents. Always check the *DPF* or other authoritative source before prescribing antimicrobials when other drugs are being taken concomitantly (e.g. miconazole and warfarin). Information on drug therapy relating to dental treatment can be obtained by telephoning the Drug Information Service on 0151-794-8206.

The following represent the inappropriate use of antimicrobials:

- Use of antimicrobials in unwarranted clinical situations.
- Incorrect dosage and duration of antimicrobials.
- Wrong choice of antimicrobials (e.g. pathogens are not susceptible to the chosen antimicrobial).

Antimicrobials should be used in appropriate clinical situations; this has the advantage that it:

- Reduces the selection of antimicrobial-resistant oral flora.
- Will have less impact on colonisation resistance. Colonisation resistance is the ability of an established microbial eco-system to resist colonisation.
- Allows alternative recommended antimicrobials to be held in reserve for life-threatening situations.

Indications for prescribing antimicrobials

In dental practice, antimicrobials are indicated:

- As an adjunct to the management of acute or chronic infection.
- For the definitive management of active infectious disease.
- For the prevention of metastatic infection such as infective endocarditis

The Antimicrobials in the Dental Practitioner's Formulary

3.1 Antibacterials

Phenoxymethylpenicillin	A penicillin, kills susceptible bacteria.
Spectrum	Gram-positive, facultative bacteria, some anaerobes. Susceptible to bacterial penicillinases.
Absorption	Poor, if taken within 30 minutes of eating. Loading doses can increase serum concentration.
Side-effects	Hypersensitivity reactions, anaphylaxis. Do not prescribe to patients taking methotrexate.
Amoxicillin	Penicillin derivative, kills susceptible bacteria.
Spectrum	Gram-positive facultative bacteria, some anaerobes, some action on respiratory tract and antral flora. Susceptible to bacterial penicillinases.
Absorption	Excellent, loading doses unnecessary.
Side-effects	Hypersensitivity reactions, maculopapular rashes. Do not prescribe to patients taking methotrexate.
Ampicillin	Penicillin derivative, kills susceptible bacteria.
Spectrum	Gram-positive and negative facultative bacteria, respiratory flora and some anaerobes. Susceptible to bacterial penicillinases.
Absorption	Not good, especially if given within 30 minutes of food.
Side-effects	Hypersensitivity, maculopapular rashes. Do not prescribe to patients taking methotrexate.

Cefradine	Cephalosporin, kills susceptible bacteria.
Spectrum	Gram-positive, facultative bacteria and some anaerobes.
Absorption	Good, loading doses not required. Reputed to have good bone penetration.
Side-effects	Hypersensitivity, possible interference with blood clotting.
Cefalexin	Cephalosporin, kills susceptible bacteria.
Spectrum	Gram-positive facultative bacteria and some anaerobes.
Absorption	Good, loading doses not required. Reputed to have good bone penetration.
Side-effects	Hypersensitivity, possible interference with blood clotting.
Clindamycin	Lincosamide, inhibits the growth of susceptible bacteria.
Spectrum	Gram-positive, facultative bacteria and some anaerobes.
Absorption	Excellent, loading doses generally not required.
Side-effects	Antibiotic-associated colitis.
Erythromycin	Macrolide, only inhibits bacterial growth. Available in three different tablet formulations, i.e. as erythromycin stearate, ethylsuccinate and base. There is no clear evidence to recommend one formulation in terms of efficacy, or safety of the drug. It is therefore recommended that the generic erythromycin base is used.
Spectrum	Gram-positive and negative bacteria.
Absorption	Variable, can be poor.
Side-effects	Gastro-intestinal discomfort.

Metronidazole	Kills susceptible anaerobic bacteria.
Spectrum	Anaerobes, some protozoa.
Absorption	Excellent, loading doses not usually required.
Side-effects	Nausea if alcohol is taken concomitantly.
Tetracycline	Inhibits growth of some oral microorganisms.
Spectrum	Useful for some oral anaerobes, respiratory, maxillary antral or sinus flora.
Absorption	Reduced by food.
Side-effects	Intrinsic staining of teeth, should not be given to children under 12 years of age or pregnant women. Contra-indicated if there is renal impairment.
Oxytetraycline	Inhibits growth of some oral microorganisms.
Spectrum	Useful for some oral anaerobes, respiratory or maxillary antral flora.
Absorption	Fair, but reduced by food.
Side-effects	Intrinsic staining of teeth and should not be given to children under 12 years of age or pregnant women. Contra-indicated if there is renal impairment.
Doxycycline	Inhibits the growth of some oral microorganisms.
Spectrum	Useful for some oral anaerobes, respiratory, maxillary antral or sinus flora.
Absorption	Good but inhibited by food.
Side-efffects	Intrinsic staining of teeth, should not be given to children under 12 years of age or pregnant women. Contra-indicated if there is renal impairment

3.2 Antifungals

Nystatin	Kills most imperfect fungi.
Spectrum	Most fungi.
Absorption	Not absorbed, a topical agent only.
Side-effects	Nausea.
Amphotericin	Kills most fungi.
Spectrum	Most fungi.
Absorption	Used as a topical preparation in dental treatment, not absorbed.
Side-effects	Nausea.
Miconazole	Inhibits the growth of some imperfect fungi.
Spectrum	Most imperfect fungi and static for Gram-positive bacteria.
Absorption	Used as a topical preparation in dental treatment. Small amounts are absorbed.
Side-effects	Potentially serious interactions with anticoagulants, antidiabetics, antiepileptics, antihistamines, cisapride and cyclosporins.
Fluconazole	Inhibits the growth of some fungi.
Spectrum	Most perfect and some imperfect fungi.
Absorption	Excellent absorption, half-life 24 hours.
Side-effects	Potentially serious side-effects can occur with some antibacterials, antiepileptics, anticoagulants, antihistamines, anxiolytics and hypnotics, cisapride, cyclosporin and theophylline.

3.3 Antiviral agents

Aciclovir

Spectrum	Most of the herpes viridae.
Absorption	Both topical and systemic preparations are available. Absorption of the systemic preparation is poor.
Side-effects	Nausea, rashes. Stinging locally with topical preparation.

Penciclovir

Spectrum	Most of the herpes viridae.
Absorption	Used as a topical agent.
Side-effects	Stinging locally.

Acute Dento-alveolar Infections

The initial assessment of an infection is important. The clinician should decide whether treatment should be undertaken in practice, or if referral is necessary, if for example:

- There are indications of septicaemia (grossly elevated temperature, lethargy, tachycardia).
- Spreading cellulitis.
- Swellings involving the floor of the mouth that may compromise the airway.
- Difficulty in swallowing.
- Dehydration.
- Failure to respond to treatment.

Acute dento-alveolar infections are treated by:

- Identifying the cause of the infection.
- Defining the extent of spread of infection.
- Recording the temperature (normal axillary temperature 36.5°C).
- Establishing drainage and, where possible, eliminating the cause of infection. Consider taking a microbiological sample.
- Ensuring fluid balance is maintained.
- If drainage is attempted but cannot be obtained and the patient condition is worsening seek specialist advice.

Antimicrobials are an **adjunct** to treatment[3-7] which:

- Limit the local spread of infection.
- Prevent metastatic spread.

First choice antimicrobial

Amoxicillin, 250 mg, three times daily (up to five days).[1,3]

Or:

Amoxicillin, 3g, two doses, eight hours apart.[7]

Or:

Phenoxymethylpenicillin, 500 mg, four times daily (for up to five days). Severe infections 750 mg four times daily.

If a predominately anaerobic infection is suspected or microbiologically proven, add to the above:

Metronidazole, 200mg, three times daily (maximum three days).[1]

Second choice antimicrobial

Metronidazole, 200mg, three times daily (maximum three days).[1]

Third choice antimicrobial

Erythromycin, 250 mg, four times daily (maximum five days)[1]
or 0.5-1g every 12hr.

Follow-up

Review in 2-3 days. If temperature normal and swelling resolving:

Discontinue antimicrobial.[3]

Management of the acute dento-alveolar abscess

Acute dento-alveolar abscess

Raised axillary temperature or diffuse swelling	Defined swelling apyrexial
Remove cause, establish drainage,* prescribe antimicrobial	Remove cause, establish drainage*
Review in 2-3 days	Review in 2-3 days
Resolution of swelling, normal temperature	Resolution
Discontinue antimicrobial	

*Drainage may sometimes be necessary before removing cause. Microbiological sampling may be useful to establish cause and sensitivity.

Failure of resolution is usually caused by failure to establish adequate drainage, poor host resistance, poor patient compliance or the wrong diagnosis.

Do not change antimicrobial. The failure of the antimicrobial is usually not caused by microbial resistance.

Re-establish drainage. Consider taking a microbiological swab or aspirate.

If drainage is impossible to obtain, refer for specialist advice.

Pericoronitis

The treatment of pericoronitis is local and involves:

- Debridement and irrigation of accessible stagnation areas (abscesses may need incision and drainage).
- Relieve occlusion, or extract opposing tooth if it is traumatising any inflamed pericoronal tissues, which will give immediate symptomatic relief to the patient.
- Extract impacted tooth, if appropriate to do so, when infection is under control.

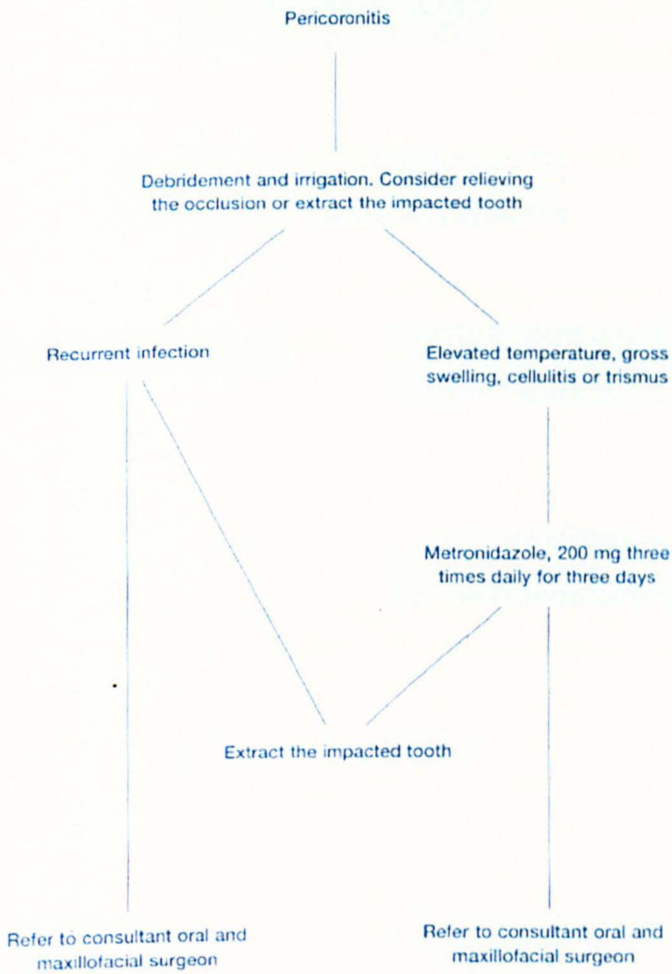
Consider antimicrobials, if:

- Temperature is raised.
- There is gross local or diffuse swelling that is not amenable to incision and drainage.
- Trismus is present.

Recurrent pericoronitis usually requires extraction of the impacted tooth to eliminate the stagnation area, as operculectomies rarely achieve this goal. Local measures are essential. Mouthrinses such as chlorhexidine will keep the area clean.

Antimicrobial choice: metronidazole, 200 mg three times daily for three days.

Management of pericoronitis



Chronic Dento-alveolar Infections

Chronic dento-alveolar infections do **not** usually require antimicrobial therapy unless:

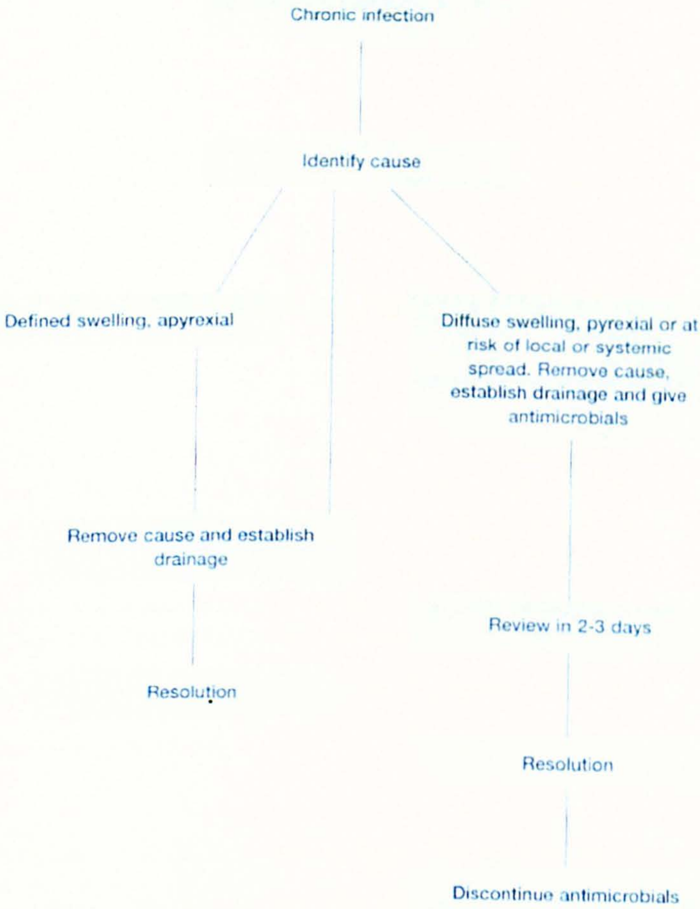
- There is evidence of gross local spread.
- There is systemic involvement shown by elevated temperature or malaise.
- The patient is medically compromised.

The principles of treatment are:

- Drainage of the infection.
- Removal of the cause.

Long-standing chronic infections which do not respond to simple treatment should be referred to a consultant. Such infections include osteomyelitis.

Chronic dento-alveolar infections



Oro-antral Communication and Fistulae

Oro-antral communications are a well-recognised complication of tooth extraction. They may also be caused by operative treatment, or by the patient not following post-operative instructions. If an oro-antral communication is present:

- Primary closure should be attempted by a suitably competent and trained practitioner if there is no infection present.
- If primary closure is not possible, consider referral to a specialist.
- Prescribe antimicrobials.

First choice:	Amoxicillin, 250 mg three times daily for five days.
Second choice:	Doxycycline, 200 mg initial dose, then 100 mg daily for five days.

Oro-antral fistulae need careful assessment and surgical closure. If they have arisen because of chronic infection then this must be resolved prior to attempting closure. The cause of the fistula must be established and removed. Oro-antral fistulae can be complicated to resolve and may require referral.

Endodontic Therapy

Antimicrobials are **not** indicated in endodontic therapy unless:

- There is evidence of gross local spread of infection.
- There is systemic evidence of infection (e.g. pyrexia).
- Drainage cannot be achieved or treatment has to be delayed.[12-14]
- The patient is medically compromised and antimicrobial prophylaxis is necessary to prevent serious sequelae (e.g. infective endocarditis).

The management of infection of endodontic origin is:

- Root canal therapy.
- Retreatment of existing root canal therapy.
- Periradicular surgery.
- Extraction.

Antiviral Therapy

Primary or secondary infections due to human herpes type 1 (herpes simplex, herpes type 1) can be treated in dental practice. All other suspected viral infections should be referred to a consultant in oral medicine or oral and maxillofacial surgery. Two antiviral preparations, which are nucleoside analogues, are available: **aciclovir** and **penciclovir**.

Reactivated herpes simplex (HSV) infections

Aciclovir or penciclovir topical preparations should ideally be applied in the prodromal phase of herpes simplex infections when the patient feels:

- Lip-tingling.
- Other altered lip sensations.[15,16]

Recurrent HSV infections of the lips and perioral tissues

- Aciclovir cream should be applied every four hours until lesions have resolved.[15,16]
- Alternatively, penciclovir should be applied every two hours.[17,18]

Herpetic gingivostomatitis

Primary herpetic stomatitis is primarily managed with supportive measures (soft diet, adequate fluid intake, analgesics and chlorhexidine mouthwashes). Systemic aciclovir may be required for severe cases of infection. Immunocompromised patients require specialist management.

Aciclovir oral suspension (200 mg/5 ml) 5 ml five times a day for five days.

Or:

Aciclovir tablets, 200 mg, five times a day for five days.

Orofacial varicella zoster

Orofacial varicella zoster can give a variety of signs and symptoms. Antiviral therapy may prevent serious complications (e.g. ocular involvement, post-herpetic neuralgia). A medical practitioner or specialist should prescribe systemic therapy.

Antifungal Therapy

Most oral fungal infections are caused by imperfect yeasts (reproduce without sexual phase) and Candida species are usually responsible. Candidosis is often a 'disease of the diseased' and therefore, where possible, the underlying cause (e.g. concomitant antibiotic therapy, diabetes, AIDS) should be identified and treated.[20] The classification of oral candidosis used in this section is that of Samaranayake and McFarlane.[23]

10.1 Chronic erythematous candidosis

Synonym: denture sore mouth, denture-induced stomatitis, chronic atrophic candidosis

This is usually characterised by inflammation on a denture-bearing area of the maxillary mucosa. Predisposing factors should be eliminated before administering antifungals. The treatment is:

- Advise the patient to leave denture out at night.
- Advise the patient on denture hygiene (mechanical cleaning of the fitting surface, use of chlorhexidine).
- Antifungal agents (if above measures are unsuccessful).[20-23]

First choice

Nystatin pastilles, 100,000 units. Allow the pastille to dissolve in the mouth, use four times daily. Continue to use the pastilles for 48 hr following resolution of inflammation.[21]

Second choice

Amphotericin lozenges, 10 mg. Allow the lozenge to dissolve in the mouth, use four times daily. Continue to use the lozenges for 48 hr following resolution of inflammation.[1]

Third choices

Patients who cannot suck pastilles (e.g. elderly or handicapped) 50 mg capsule of fluconazole, once daily, 14 days maximum until inflammation has resolved.[22]

Or:

Apply miconazole oral gel to the cleaned fitting surface of the denture, three times daily[1]. Continue for 48 hr after inflammation is resolved.

If the erythematous candidosis is not associated with dentures or fails to resolve with therapy, then refer the patient to a consultant in oral medicine to find the cause (e.g. AIDS).

10.2 Chronic plaque-like candidosis or chronic nodular candidosis

Synonym: chronic hyperplastic candidosis

This lesion should always be biopsied to ensure that there is no neoplastic change. These lesions are best managed by a consultant in oral and maxillofacial surgery or oral medicine.

10.3 Chronic pseudomembranous candidosis

Usually associated with other serious systemic illnesses. Refer to a consultant in oral and maxillofacial surgery or oral medicine.

10.4 Acute pseudomembranous candidosis

Synonym: oral thrush

Characterised by white plaques, which can be dislodged to leave a raw, bleeding area beneath the pseudomembrane. This condition may be associated with steroid sprays used for the treatment of asthma. Patients who use oral steroid sprays should be encouraged to wash out their mouths after using them to help prevent thrush.

First choice

Nystatin pastilles, 100,000 units, allow the pastille to dissolve in the mouth, use four times daily, until 48 hr after lesion is resolved.

Second choice

Amphotericin lozenges, 10 mg, allow the lozenge to dissolve in the mouth, use four times daily until 48 hr after lesions resolve.

Third choice

- In the elderly, where compliance may not be good, fluconazole capsules, 50 mg, once daily, continue until 48 hr after lesions resolve.
- In neonates, nystatin suspension applied for 5-6 days with cotton buds until 48 hr after lesions resolve.

10.5 Acute erythematous candidosis

Synonym: acute atrophic candidosis, antibiotic sore mouth

Usually secondary to long-term therapy with broad-spectrum antibiotics or corticosteroids. The mucosa is sore and some patients may not tolerate nystatin pastilles. Alternative antifungal agents are miconazole gel or fluconazole.

First choice

Nystatin suspension 100,000 units/ml, use four times daily for at least seven days.

Or:

Miconazole oral gel, 5-10 ml, four times daily for at least seven days.

10.6 Candida-associated angular cheilitis

This may be due to a reduction in vertical height of occlusion (decrease in facial height) or anaemia.[10,23] If anaemia is suspected, refer to the patient's medical practitioner for further investigations. If the angular cheilitis is due to decreased facial height, then:

- Remake the dentures with correct facial height.

- Examine for concomitant chronic erythematous candidosis and treat (see 10.1).

- Prescribe antifungals.

Nystatin ointment (100,000 units/g, 30 g tube). Apply externally to perioral lesions 2-4 times a day, and for 48 hr after lesions have healed.

Or:

Miconazole and hydrocortisone cream, 1-2 times a day, for a maximum of seven days.

Angular cheilitis may be caused by a dual infection of Candida species and Staphylococci; sometimes facultative cocci may also be present.

If the lesion fails to resolve and staphylococci are microbiologically proven to be present, then topical sodium fusidate ointment 2% (w/v) is the antimicrobial of choice. Use 3-4 times daily until the lesion resolves (avoid long-term use).

When angular cheilitis is associated with chronic erythematous candidosis, treat this concurrently to eliminate the palatal reservoir of infection.

Periodontal Disease

11.1 Acute periodontal abscess

The optimum treatment is drainage of the pus and thorough debridement of the area, if possible. Removal of the tooth or further periodontal treatment is usually necessary. If there is evidence of systemic involvement (raised temperature) or gross local spread, then metronidazole, 200 mg, three times daily for three days is the drug of choice.[1]

11.2 Acute ulcerative gingivitis

Synonym: acute ulcerative necrotising gingivitis, acute ulcerative periodontitis

This is characterised by acutely inflamed, tender, bleeding gums with necrosis and loss of the interdental papillae, the patient may be pyrexial. There is usually a marked halitosis.

The treatment of choice is metronidazole, 200 mg, three times daily for three days.

When the acute phase is resolved, scaling and root planing are always necessary, plus a full periodontal assessment.[1,4]

11.3 Antimicrobials for chronic periodontal diseases

The prescription of antimicrobials for chronic periodontal diseases is a controversial subject. Antimicrobials may be an adjunct in the treatment of chronic periodontal diseases. Systemic antimicrobials are only indicated for:

- Rapidly advancing periodontal disease that has failed to respond to local operative measures.
- Refractory periodontal disease.
- Juvenile periodontitis.

Antimicrobials should never be the first treatment.[25,26]

First choice

Metronidazole, 200 mg, three times daily for seven days.

Second choice

Doxycycline, 200 mg for the first day, 100 mg daily for two weeks.

11.4 Local antimicrobial delivery systems

Local antimicrobial delivery systems should only be considered as an adjunctive treatment not an alternative to instrumentation. Thorough debridement and any surgery should **precede** any consideration of local therapy.[27] The instructions in the product literature should be followed at all times.

Prophylactic Antimicrobials

Antimicrobial prophylaxis is the prevention of infection by the administration of antimicrobial agents; this is a contentious issue in all surgical and medical specialities. Ideally the administration of antimicrobials should reduce morbidity and mortality. In reality they may cause drug interactions, allergic and other untoward reactions, and reduce colonisation resistance; this can result in infections with resistant microorganisms. When used injudiciously prophylactic antimicrobials, therefore, may cause the patient to suffer more than if they had not been prescribed.

To achieve any protective effect, prophylactic antimicrobials must be administered pre-operatively to provide adequate tissue concentrations at the time of surgery. The most effective use of prophylactic antimicrobials has been shown to be in short-term, high-dosage regimens that are active against the common pathogens. While no regimen will guarantee prevention of infection, it is more likely to be successful if the following can be identified:

- Those patients who are 'at risk' from infection and hence require prophylaxis.
- The procedures which present an infection risk to susceptible patients.
- Which antimicrobial can kill the predominant pathogenic bacteria.
- The timing and period of administration for chemoprophylaxis.

Table 1 summarises the use of antimicrobial prophylaxis in dentistry.

Table 1: Recommendations for the use of antimicrobial prophylaxis in dental patients who are medically compromised

Predisposing medical condition

Dental procedure	Endocardial disease	Total joint replacement	Immunocompromised, renal dialysis and transplants	Radiotherapy to head and neck
Minor oral surgery, extractions biopsy, implant placement	Yes	No, unless requested by specialist	Liaise with specialist*	Yes
Periodontal surgery, surgical endodontics	Yes	No, unless requested by specialist	Liaise with specialist*	No*
Suture removal	No	No	No	No
Scaling, root planing	Yes	No, unless requested by specialist	Liaise with specialist*	No
Incision of an abscess	Yes	No	Liaise with specialist*	No
Full mouth periodontal probing, bleeding index	Yes	No	No	No
Radiographic determination of root canal length	Yes	No	No	No
Root canal obturation	No	No	No	No
Matrix bands, crowns, impressions	No	No	No	No

* The British Society for Antimicrobial Chemotherapy (BSAC) does not consider that these patients require antibiotic prophylaxis.

The elevation of mucoperiosteal flaps is not recommended for patients susceptible to osteoradionecrosis especially in the mandible.

The following points are of paramount importance when managing patients who require antibiotic prophylaxis:

- The dental clinician's greatest contribution to the prevention of infection in medically compromised patients is in the maintenance of oral health. An effective preventive care strategy is, therefore, required (oral hygiene instruction, dietary advice, fissure sealing, fluoride supplements).
- The recognition that dental health is important to any person susceptible to infection. Compliance with a preventive philosophy is essential for maintenance of his/her dentition throughout life. Patient education, however, requires constant reinforcement.
- Realistic and detailed treatment plans are essential. Treatment planning requires skill and thought. The order of treatment is important. Procedures that require antimicrobial cover should be organised into a **minimum** number of visits; preferably only one.
- Patients should be reviewed regularly to ensure that their dental health is maintained. The recall interval of these patients should be individually assessed but should not exceed six months.
- When susceptible patients are receiving dental treatment, pre-operative chlorhexidine should be instituted as a routine measure. This will reduce the magnitude of any dentally-induced bacteraemia.
- Co-operation between the medical and dental professions should be encouraged. Ideally patients should be examined by dentists prior to surgery for total joint replacement surgery, renal dialysis, organ transplantation, endocardial surgery, chemotherapy and radiotherapy to the head and neck region. These patients need to be rendered dentally fit and should be counselled about the importance of their dental status.

12.1 Antimicrobial prophylaxis for surgical procedures in healthy patients

Antimicrobials are sometimes prescribed for healthy patients when they have minor oral surgery (MOS). The rationale is to prevent infection at the site of surgery. Evidence for the effectiveness of prophylaxis for routine oral surgery procedures is scarce. Antimicrobial prophylaxis in the majority of MOS cases is unnecessary. Post-operative morbidity after oral surgery is rarely serious and is readily amenable to simple treatment.

Surgical removal of mandibular third molars

Post-operative infection in the form of dry socket (localised infective osteitis) is sometimes encountered after removal of impacted third molars. Despite the fact that the majority of patients are healthy young adults whose physiological response to surgery is good, many authors advocate the routine use of antimicrobial prophylaxis.[28] Some limit their prescribing to cases where a history of pericoronitis is given[29] or when the procedure involves bone removal.[30] Rud[31] has reported that the use of prophylactic antimicrobials may confer no advantage, even when surgically removing mandibular third molars in the presence of acute pericoronitis or acute ulcerative gingivitis.

Guideline: Prophylactic antimicrobials are not usually required.

Extractions and the removal of retained roots and teeth

There is no rationale for routine chemoprophylaxis for the removal of teeth unless the patient is medically compromised. The risk-benefit ratio for antimicrobial prophylaxis is unfavourable and the morbidity associated with the procedure is low. Dry sockets occur following 3-4% of routine extractions.[32,33] Patients who present with a clear history of repeated dry sockets following exodontia may warrant the use of chemoprophylaxis when extracting mandibular teeth. Metronidazole has been shown to be an efficacious drug in this situation.[34]

Guideline: No prophylactic antimicrobials required unless there is a clear history of dry sockets following exodontia.

Periodontal surgery

Antimicrobial prophylaxis is not routinely required for the prevention of local post-operative infection following periodontal surgery. It is acknowledged, however, that antimicrobials are thought to have beneficial actions, such as the reduction of post-operative pain and the inhibition of anticollagenase activity, which may influence healing.

Guideline: Antimicrobials are not usually required for periodontal surgery.

Endodontic therapy

Antimicrobials have been used to reduce post-operative pain and swelling, when root filling asymptomatic teeth with pulpal necrosis and associated periapical lesions.[35] There is no indication for the use of antimicrobials in this situation. In the absence of oro-antral communications and a relevant medical history, apicectomies should not require cover.

Guideline: Antimicrobials are not usually required for endodontic therapy.

Which antimicrobial?

Prophylaxis should be directed against microorganisms commonly responsible for post-operative infection.[36] There are no widely accepted recommendations for surgical prophylaxis in dentistry. When antimicrobials are deemed necessary, it would seem reasonable and convenient to adapt the standard regimen used to prevent infective endocarditis (IE), shown in *Table 2*.

Guideline: If prophylactic antimicrobials are to be prescribed, follow the BSAC guidelines.[37,41] Use only perioperative antibiotics.

Table 2: Suggested antibiotic regimen for the prevention of post-operative infection in healthy patients who are undergoing minor oral surgery

Local anaesthetic

No penicillin allergy	Allergic to penicillin
Amoxicillin (3 g) orally, 1 hr pre-op	Clindamycin* (600 mg) orally, 1 hr pre-op

General anaesthetic

No penicillin allergy	Allergic to penicillin
Amoxicillin (3 g) and probenicid (1 g) orally, 4 hr pre-op **Or:** Amoxicillin (3 g) orally, 4 hr pre-op and amoxycillin (3 g) post-op **Or:** Amoxicillin (1 g) IV at induction and 500 mg orally, 6 hr later	**Special risk: refer to hospital**

* Patients who have been prescribed clindamycin must be advised to consult their doctor if diarrhoea develops. Clindamycin tablets should be swallowed with a glass of water to prevent oesophageal irritation. IV antibiotics should preferably be given in a hospital environment.

12.2 Patients susceptible to infective endocarditis

Infective endocarditis (IE) is one of the few potentially fatal consequences of dental treatment. Patients with acquired or congenital endocardial disease are at risk of developing IE during dental procedures, which cause a transient bacteraemia. Endocardial conditions that predispose to IE are listed in *Table 3*.

Patients with heart murmurs usually require antimicrobial prophylaxis. It is possible, however, that a murmur may not be due to a minor congenital abnormality but may be an innocent murmur of childhood; such murmurs also occur in pregnancy. In an emergency situation it would be prudent to give appropriate antimicrobial cover to patients with heart murmurs unless a consultant paediatrician or cardiologist has advised to the contrary. When doubt exists as to the susceptibility of a cardiac condition it is advisable to obtain a specialist opinion.

The BSAC[37-41] has recognised a subgroup of patients with endocardial disease who they consider as 'special risk'; these are considered to be particularly susceptible to IE and are normally referred to hospital for dental treatment that requires prophylaxis. Special risk patients are classified as those patients who, in addition to their endocardial disease, have:

1. Had IE before *or*
2. Require a general anaesthetic *and*
   a. Have a prosthetic heart valve *or*
   b. Are allergic to penicillin or have had penicillin more than once in the previous month.

Table 3 Endocardial lesions and infective endocarditis

Patients at risk from infective endocarditis
History of infective endocarditis
Ventricular septal defect
Patent ductus arteriosus
Coarctation of the aorta
Prosthetic heart valve
Acquired valvular disease
History of rheumatic fever resulting in valvular dysfunction
Surgically constructed systemic-pulmonary shunts
Persistent heart murmur
Atrial septal defect repaired with a patch
Hypertrophic cardiomyopathy
Atrial septal defect
Mitral valve prolapse
Marfan's syndrome
Patients not at risk from infective endocarditis
After cardiac bypass surgery
Six months after surgery for:
Ligated ductus arteriosus
Surgically closed atrial septal defects (without Dacron patch)
Isolated secundum atrial septal defect

Special-risk patients

The BSAC[37] has recognised a group of patients, with endocardial disease, who they consider as 'special risk'; these are considered to be particularly susceptible to IE and *are normally referred to hospital for dental treatment requiring prophylaxis*. Special-risk patients are classified as those patients with endocardial disease who:

1. Have had IE before

Or:

2. Require a general anaesthetic *and*

   a) have a prosthetic heart valve *or*

   b) are allergic to penicillin or have had penicillin more than once in the previous month

Dental procedures that may precipitate infective endocarditis

It is likely that the importance of dental treatment as a cause of IE has been historically overstated.

Bacteraemias may result from many operative oral procedures; even non-invasive activities such as toothbrushing or mastication may place a patient at risk from IE.[42] Poor dental hygiene, periodontal and periapical infections may produce a bacteraemia in the absence of dental procedures.[42] It is of fundamental importance, therefore, to assess and manage patients susceptible to IE with great care. *Table 4* summarises the dental procedures that require antimicrobial cover; this has been modified from the BSAC[37] and the American Heart Association (AHA)[43] recommendations.

Systemic antimicrobial prophylaxis against dentally-induced infective endocarditis

Antimicrobial regimens recommended for the prevention of IE have in the past been complicated and required parenteral administration. Compliance with these regimens was poor.[44] The introduction of a single oral dose of amoxicillin for chemoprophylaxis in 1982 by the BSAC has greatly improved compliance. There is now also considerable similarity between regimens recommended by various national agencies. In the UK clinicians have been advised to follow the recommendations issued by the Working Party of the BSAC, which has constantly reviewed its recommendations.[37-41] The current guidelines are shown in *Table 5*.

Table 4: Dental procedures requiring antimicrobial prophylaxis for the prevention of infective endocarditis (adapted from reference numbers 37 and 43)

Procedures that always require antimicrobial prophylaxis
Scaling, root planing
Extractions
Oral surgery e.g. removal of roots, osseous recontouring
Placement of implants
Periodontal surgery
Surgical endodontics, incision of an abscess, biopsy
Initial placement or removal of orthodontic bands (but not brackets)
Procedures where it may be prudent to give antimicrobial prophylaxis
Full mouth periodontal probing to assess attachment levels*
Radiographic determination of root canal length
The restoration of multiple subgingival cavities
Procedures where antimicrobials are not usually required
Restorative dentistry (including any restoration of teeth, placement of matrix bands) with or without retraction cord
Oral impressions
Placement of rubber dam
Intracanal endodontic treatment
Orthodontic appliance adjustment
Suture removal
Local anaesthetic injection
NB: Avoid intraligamentary anaesthesia

* Antimicrobial prophylaxis should not normally be prescribed for the sole purpose of assessing loss of attachment, which could be carried out in conjunction with other procedures that merit antimicrobial cover e.g. scaling

Table 5: Antimicrobial regimens recommended for the prophylaxis of dentally induced infective endocarditis

Local anaesthetic

No penicillin allergy	Allergic to penicillin
Amoxicillin (3 g) orally,1 hr pre-op	Clindamycin (600 mg) orally,1 hr pre-op

General anaesthetic

No penicillin allergy	Allergic to penicillin*
Amoxicillin (3 g) and probenicid (1 g) orally, 4 hr pre-op **Or:** Amoxicillin (3 g) orally, 4 hr pre-op and amoxicillin (3 g) post-op **Or:** Amoxicillin (1 g) IV at induction and 500 mg orally, 6 hr post-operative	**These patients are classified as special risk**

* Or patients who have been prescribed penicillin more than once in the previous month

Time interval between repeat administrations of amoxicillin and clindamycin.

Amoxicillin may be given twice in one month as it is unlikely that proliferation of clinically significant amoxicillin-resistant strains will occur after one 3 g dose of amoxicillin. A third dose of amoxicillin, however, should not be given until after an interval of 3-4 months. Clindamycin prophylaxis should not be repeated at intervals of less than two weeks.

12.3 Immunocompromised patients

Patients may be immunocompromised for a large variety of reasons. The aetiology of the impaired host defences will influence the patient's susceptibility to infection. The white blood cell count may be an important marker of a patient's vulnerability to infection. The Working Party of the BSAC states that, in the absence of any other indication, patients who are immunocompromised (including transplant patients), or have indwelling intraperitoneal catheters, do not require antibiotic prophylaxis for dental treatment. In clinical practice it is not unusual for a physician or surgeon specifically to request that their patient is given systemic prophylaxis for certain dental procedures. When managing immunocompromised patients it is prudent for the dentist to liaise with the supervising specialist to seek his/her views on prophylaxis. The practitioner should state the position of the BSAC to the specialist and if chemoprophylaxis is recommended a single dose antimicrobial regimen should be used *(Table 2)*. When antimicrobial cover has been requested by the supervising specialist, the practitioner should record this advice clearly in the patient's records and comply with the request. Dental procedures such as extractions, minor oral surgery and scaling would require systemic prophylaxis; root canal therapy and periodontal assessment do not need cover. When prophylaxis is advised the antimicrobial should be effective against both the oral flora and the most likely potential pathogens; amoxicillin (3 g), or clindamycin (600 mg), would be suitable *(Table 2)*. Some renal specialists object to the use of clindamycin as they are fearful of antimicrobial-associated colitis, and may recommend alternative regimens, such as 1.5 g of erythromycin one hour pre-operatively.

Transplant patients are immunosuppressed by their drug therapy and have traditionally been considered to have an increased risk for local and systemic infection. In the immediate post-transplant period operative complications and acute rejection of the organ are the major medical concerns. Routine dentistry should not be undertaken during this critical period; emergency dental treatment should only be undertaken in this phase after medical consultation. Elective dental treatment should be delayed until the patient is deemed to be in a stable post-transplant phase; this is usually considered to be six months after surgery.

There now appears to be a consensus amongst specialists that heart transplant patients do not usually require antibiotic cover in the stable post-transplant period. It is advisable to liaise with the supervising specialist as immunosuppressant drug regimens do vary and may influence the decision as to whether to provide cover. Cardiac transplant patients are not considered to be at risk from IE.

12.4 Total joint replacements

Bacteraemias of dental origin have been implicated in infections of total joint replacements;[45-47] this is a serious complication and usually necessitates removal of the prosthesis. However, the evidence linking bacteraemias of dental origin to infection of total joint replacements is tenuous and unproven, relying mainly on anecdotal case reports.[48-51] Oral streptococci have infrequently been isolated from infected prostheses. Approximately 46% of the bacteria cultivated from infected joint replacements are staphylococci.[47,49]

In 1992 the BSAC Working Party found no evidence to support the routine use of antibmicrobial cover for dental procedures on patients with prosthetic joints.[45] The BSAC did not think that the advantages of antimicrobial prophylaxis outweighed the potential risks.[1,48]

12.5 Patients who have received radiotherapy to the head and neck region

Patients who have previously been exposed to, or who are currently receiving, therapeutic radiation to the head and neck may be susceptible to local infection. After radiotherapy there is a diminution of the vascular supply in the irradiated area especially in the mandible. This is a progressive risk that increases with time.

The risk of infection in irradiated patients is much greater with extractions than endodontics. General dental practitioners should not normally extract teeth in this group of patients and liaison with the local oral and maxillofacial surgeon is recommended. The efficacy of antimicrobials is questionable in this group of patients because of poor blood flow and tissue penetration in the irradiated area. Nevertheless patients who are at risk from osteonecrosis require antimicrobial prophylaxis for extractions. In the absence of national recommendations for prophylaxis, it is suggested that a single dose of either amoxicillin or clindamycin is used for patients at risk from osteoradionecrosis *(Table 2)*. Endodontics is the preferred treatment in irradiated patients for a necrotic pulp. The value of chemoprophylaxis for root canal therapy is doubtful and is not routinely recommended.

12.6 Miscellaneous prosthetic implants

Patients with cardiac pacemakers, intra-ocular lenses, breast implants, penile implants and prosthetic vascular grafts are not considered to be susceptible to infection from dental bacteraemias.[38,43,52] Intravascular access devices, such as central intravenous lines used for total parenteral nutrition or chemotherapy and catheters used for haemodialysis and plasmapheresis, do not require antibiotic cover for dental procedures. Patients who are receiving renal dialysis are immunocompromised as a consequence of uraemia in end-stage renal disease. This is because uraemia is associated with metabolic and haematological abnormalities. As a consequence these patients have an enhanced susceptibility to infection; septicaemia is a real possibility and is potentially life-threatening. A bacteraemia during dental treatment may cause infection in a central dialysis line along the surgically created arteriovenous fistula. Antimicrobial prophylaxis is recommended therefore by some renal specialists, prior to certain dental treatments for dialysis patients. This is in contrast to the recommendation of the BSAC.[1] The antimicrobial regimen given in *Table 2* is recommended.

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APPENDIX 5

Published papers

Palmer N, Martin M. An investigation of antibiotic prescribing by general dental practitioners: a pilot study. *Primary Dental Care* *1998*;**5**:11-14

Palmer N, Ireland R, Palmer S. Antibiotic prescribing patterns of a group of general dental practitioners: results of a pilot survey. *Primary Dental Care* 1998;**5**:137-141

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Papers in press

Palmer N.O.A, Martin M.V, Pealing R, Ireland R.S. Paediatric antibiotic prescribing by general dental practitioners in England.*International Journal of Paediatric Dentistry*. Accepted for publication December 2000.

Palmer N.O.A, Dailey Y.M, Martin M.V. Can audit improve antibiotic prescribing in general dental practice? *British Dental Journal.*Accepted April 2001.

An Investigation of Antibiotic Prescribing by General Dental Practitioners: A Pilot Study

Nikolaus Palmer and Michael Martin

Purpose of study: This pilot study was designed to investigate how general dental practitioners prescribe antibiotics.
Methods: A total of 200 prescriptions were selected at random from 1775 prescriptions dispensed in 55 pharmacies across a Liverpool district. The type of antibiotic prescribed, the duration, frequency and dose were analysed. The legibility and any other errors or omissions were also noted.
Results: The legibility of the prescriptions was good with very few errors or omissions from the patient details. Seven different types of antibiotics were used with amoxycillin being the most frequently prescribed (64.5%), followed by metronidazole (21.5%). Penicillin, erythromycin, clindamycin, tetracycline and cephradine were the other antibiotics prescribed. There was a wide variation in the duration, frequency and doses prescribed.
Conclusion: The results of this pilot study show that many practitioners prescribe antibiotics for inappropriately long periods and with inconsistent frequency and duration.

KEY WORDS: ANTIBIOTICS, GENERAL DENTAL PRACTICE, PRESCRIPTIONS

© PRIMARY DENTAL CARE 1998;5(1):11-14

Introduction

Antibiotics are prescribed by general dental practitioners to manage oral and dental infections. How and what general dental practitioners prescribe is limited by the *Dental Practitioners Formulary (DPF)* but this document does not provide definitive or standardised prescribing policies for these infections. Most practitioners prescribe on the basis of what they were taught at dental school, their hospital or postgraduate experience. A questionnaire survey of what dental practitioners prescribed for acute dental infections showed great variations between practitioners and concluded that awareness of the rational use of antibiotics needed to be increased.[1] Similar variations in prescribing practices were also found in a study of out-patients with acute infections at Cardiff Dental School.[2] These two studies were based on questionnaires returned by general dental practitioners, or from questioning out-patients. This pilot study aimed to assess antimicrobial prescribing for both therapeutic and prophylactic reasons and employed a survey of prescriptions.

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Method

The protocol for this study was approved by the Local Research Ethics Committee of the Liverpool University Dental Hospital.

Prescription Survey

A total of 200 prescriptions for antibiotics by dental practitioners were selected at random from one month's prescriptions to the Prescription Pricing Authority. This selection was made from a total of 1775 prescriptions dispensed by 55 pharmacies in a district of Merseyside.

The information collected was:

- Legibility: scored as very good, good, poor or very poor.
- Correct patient details: must include surname, forename and full address.
- Generic or proprietary.
- Drug written in full or abbreviated.
- Antibiotic prescribed.
- Duration.
- Dose.
- Frequency, and whether written in full or abbreviated.
- Year of qualification.

This information was collected on a pro forma by members of the Health Authority to preserve the anonymity of the prescribers.

Results

Legibility, Patient Details, Antibiotic and Frequency

The legibility of the prescriptions examined was rated very good for 88 (44%) prescriptions, good for 99 (45.5%); only 13 (6.5%) were rated poor. Only nine of the 200 prescriptions contained incorrect patient details.

The names of the antibiotics were written in full on 186 prescriptions (93%) and generic names were used on 177 prescriptions (83.5%). Latin abbreviations were used on 142 (73.5%) of prescriptions to denote frequency.

Antibiotic Prescribed, Dose and Duration

Table 1 shows the antibiotics prescribed in the 200 prescriptions. Amoxycillin and metronidazole accounted for the majority of the antibiotics prescribed. There were large variations in the frequency, dose and duration of the prescriptions for the 129 amoxycillin prescriptions *(Table 2)*. Metronidazole was the next most prescribed antimicrobial accounting for 43 prescriptions with wide variations in doses, frequency and dosage *(Table 3)*.

Erythromycin and penicillin accounted for only 21 prescriptions and there was also a variety of dosages, frequency and duration in the prescriptions (*Tables 4 and 5*).

Clindamycin was only prescribed four times in single doses of 600 mg (two prescriptions), and twice for five days, four times daily, at the dose of 150 mg.

There was one prescription for tetracycline (six days, four times daily, 250 mg) and one for cephradine (500 mg, 90 minutes pre-operatively).

Table 1: Antibiotics and frequency of prescription

Antibiotic prescribed	No. prescriptions
Amoxycillin	129
Metronidazole	43
Erythromycin	11
Penicillin	11
Clindamycin	4
Tetracycline	1
Cephradine	1
Total	200

Year of Qualification

The prescriptions analysed were from general dental practitioners showing an even distribution over the full range of years since qualification (0-30+ years).

Discussion

This study shows that the legibility of the scripts was of a high standard (93.5%), being satisfactory or better. The majority of dentists conformed to the guidelines laid down in the *BNF (British National Formulary)* in recording the correct patient details (95.5%) and writing the drug in full (93%). The *BNF* does suggest that in order to avoid confusion the frequency with which the antibiotic should be taken ought be written out in full; preferably in English and without abbreviation. The majority in this sample favoured Latin abbrevia-

Table 2: Doses, frequency and duration of the prescriptions for amoxycillin

Number of prescriptions	Dose	Frequency	Duration (days)
7	3 g	-	-
3	3 g	twice	-
1	3 g	three times	
2	250 mg	three times daily	3/4
34	250 mg	three times daily	5
9	500 mg	three or four times daily	5
21	250 mg	four times daily	5
12	125 mg	three or four times daily	5
22	250 mg	three times daily	6/7
5	250 mg	four times daily	6/7
2	500 mg	three times daily	7
7	125 mg	three or four times daily	7
1	250 mg	four times daily	14
3	not specified	not specified	not specified

Table 3: Doses, frequency and duration of prescriptions of metronidazole

Number of prescriptions	Dose	Frequency	Duration (days)
21	200 mg	three times daily	3
1	200 mg	three times daily	4
1	200 mg	twice daily	5
10	200 mg	three times daily	5
2	200 mg	four times daily	5
3	200 mg	three times daily	7
2	400 mg	three times daily	3
3	400 mg	three times daily	7

Table 4: Doses, frequency and duration of prescriptions of erythromycin

Number of prescriptions	Dose	Frequency	Duration (days)
7	250 mg	four times daily	5
1	250 mg	four times daily	6
1	125 mg	three times daily	7
1	500 mg	four times daily	5
1	500 mg	three times daily	7

Table 5: Frequency and duration of prescriptions of penicillin

Number of prescriptions	Dose	Frequency	Duration (days)
5	250 mg	four times daily	5
3	250 mg	three times daily	5
2	500 mg	four times daily	7
1	125 mg	three times daily	7

tions to record the frequency (71%) although English is to be preferred. Most of the antibiotics were prescribed using generic (88.5%) rather than proprietary names.

Seven different antibiotics were used and the two most popular were amoxycillin (64.5%) and metronidazole (21.5%). The use of amoxycillin and metronidazole is in accordance with the sensitivity of microorganisms found in oral and dental infections. This does not accord with the results of the Torbay study where erythromycin and penicillin were widely used.[1] The use of erythromycin (base) in the treatment of dental infections has been shown to be ineffective as the first choice due to poor absorption and rapid emergence of microbial resistance.[3] Penicillin is an effective treatment against dental infections although several oral microorganisms are resistant to it.[4] Very little cephradine was prescribed in this study although it has been shown to be effective in the management of acute infections.[5]

The most worrying aspect of the study was the variation in the duration of the antibiotic treatment. Amoxycillin was prescribed for periods which did not conform in many cases to that recommended within the *BNF*[6] and was contrary to current views on shorter periods of prescribing.[7-9] There also was considerable variation from recommended frequencies and doses.

This was a small pilot study which would require a multicentre investigation for definitive conclusions to be drawn. Despite these limitations there were considerable inconsistencies in the prescribing of antimicrobial agents. It is important that antibiotics are taken in the correct frequency so that minimum inhibitory concentration is exceeded and the antimicrobial is cidal. One reason for these inconsistencies is that the recommendations as to the indications for antimicrobials, their duration and frequency are not available to practitioners. A 'standards' document with up-to-date views could help practitioners prescribe more appropriately.

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Antibiotic Prescribing Patterns of a Group of General Dental Practitioners: Results of a Pilot Survey

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Objective: To investigate antibiotic prescribing patterns of a group of general dental practitioners and assess the implications for postgraduate education.

Design and setting: Study in general dental practice in the Mersey region carried out in 1996-97.

Materials and method: All general dental practitioners on the health authority list of a district in Merseyside were circulated with an anonymised written questionnaire concerning therapeutic and prophylactic antibiotic prescribing.

Results: Of 104 dentists surveyed, 68 responded (65.5%) within a two-month period. Antibiotics were frequently prescribed outside the guidelines suggested by expert opinion, both therapeutically and prophylactically. There was no statistically significant difference in the prescribing habits of practitioners who had attended postgraduate courses within the previous two years and those who had not. There was no correlation between the length of time since qualification and prescribing patterns.

Conclusions: This pilot study demonstrated that antibiotic prescribing in general practice is suboptimal. The results of the study suggest that existing educational initiatives may be ineffective and this area would benefit from further study.

KEY WORDS: ANTIBIOTICS, PRESCRIBING, GENERAL DENTAL PRACTICE, POSTGRADUATE EDUCATION

Introduction

Antibiotics are prescribed on a regular basis, either therapeutically or prophylactically, to manage oral and dental infections by general dental practitioners (GDPs).The potential benefits of prescribing antibiotics are limited by a number of problems associated with their use. Therefore systemic antibiotics should be used with restraint because of the possibility of allergic reactions, toxicity, side effects and the development of resistant strains of microbes.[1]

GDPs may use antibiotics indiscriminately, prescribing for clinical conditions for which they are ineffective. This may be because practitioners are unaware of the action of antibiotics and their potential problems. It is important that the prescribing of antibiotics is effective, safe and appropriate in dental practice.

Previous studies have looked at specific areas of prescribing such as acute dentoalveolar infections or prophylaxis for endocarditis. The aim of this study is to investigate the general use of antibiotics in dental practice and to assess the need for educational initiatives.

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Method

All 104 general dental practitioners on the health authority list in a district of Merseyside were circulated with an anonymised written questionnaire following piloting of the questionnaire to a small group of dentists outside the area of investigation. The areas of questioning are listed in *Table 1*.

The questionnaires were returned over a two month period. No follow up of outstanding questionnaires

Table 1: Subject areas in questionnaire

1.	Prescribing therapeutically in various clinical situations.
2.	Prescribing prophylactically in non-medically compromised patients.
3.	Medical conditions and clinical procedures requiring prophylaxis in the medically compromised patient.
4.	The antibiotics prescribed.
5.	Year of qualification.
6.	Attendance at postgraduate courses on the use of antibiotics in general practice within previous two years.

Results

Legibility. Patient Details, Antibiotic and Frequency

The legibility of the prescriptions examined was rated very good for 88 (44%) prescriptions, good for 99 (45.5%); only 13 (6.5%) were rated poor. Only nine of the 200 prescriptions contained incorrect patient details.

The names of the antibiotics were written in full on 186 prescriptions (93%) and generic names were used on 177 prescriptions (83.5%). Latin abbreviations were used on 142 (73.5%) of prescriptions to denote frequency.

Antibiotic Prescribed, Dose and Duration

Table 1 shows the antibiotics prescribed in the 200 prescriptions. Amoxycillin and metronidazole accounted for the majority of the antibiotics prescribed. There were large variations in the frequency, dose and duration of the prescriptions for the 129 amoxycillin prescriptions (*Table 2*). Metronidazole was the next most prescribed antimicrobial accounting for 43 prescriptions with wide variations in doses, frequency and dosage (*Table 3*).

Erythromycin and penicillin accounted for only 21 prescriptions and there was also a variety of dosages, frequency and duration in the prescriptions (*Tables 4 and 5*).

Clindamycin was only prescribed four times in single doses of 600 mg (two prescriptions), and twice for five days, four times daily, at the dose of 150 mg.

There was one prescription for tetracycline (six days, four times daily, 250 mg) and one for cephradine (500 mg, 90 minutes pre-operatively).

Table 1: Antibiotics and frequency of prescription

Antibiotic prescribed	No. prescriptions
Amoxycillin	129
Metronidazole	43
Erythromycin	11
Penicillin	11
Clindamycin	4
Tetracycline	1
Cephradine	1
Total	200

Year of Qualification

The prescriptions analysed were from general dental practitioners showing an even distribution over the full range of years since qualification (0-30+ years).

Discussion

This study shows that the legibility of the scripts was of a high standard (93.5%), being satisfactory or better. The majority of dentists conformed to the guidelines laid down in the *BNF* (*British National Formulary*) in recording the correct patient details (95.5%) and writing the drug in full (93%). The *BNF* does suggest that in order to avoid confusion the frequency with which the antibiotic should be taken ought be written out in full; preferably in English and without abbreviation. The majority in this sample favoured Latin abbrevia-

Table 2: Doses, frequency and duration of the prescriptions for amoxycillin

Number of prescriptions	Dose	Frequency	Duration (days)
7	3 g	-	-
3	3 g	twice	-
1	3 g	three times	
2	250 mg	three times daily	3/4
34	250 mg	three times daily	5
9	500 mg	three or four times daily	5
21	250 mg	four times daily	5
12	125 mg	three or four times daily	5
22	250 mg	three times daily	6/7
5	250 mg	four times daily	6/7
2	500 mg	three times daily	7
7	125 mg	three or four times daily	7
1	250 mg	four times daily	14
3	not specified	not specified	not specified

Table 3: Doses, frequency and duration of prescriptions of metronidazole

Number of prescriptions	Dose	Frequency	Duration (days)
21	200 mg	three times daily	3
1	200 mg	three times daily	4
1	200 mg	twice daily	5
10	200 mg	three times daily	5
2	200 mg	four times daily	5
3	200 mg	three times daily	7
2	400 mg	three times daily	3
3	400 mg	three times daily	7

Table 4: Doses, frequency and duration of prescriptions of erythromycin

Number of prescriptions	Dose	Frequency	Duration (days)
7	250 mg	four times daily	5
1	250 mg	four times daily	6
1	125 mg	three times daily	7
1	500 mg	four times daily	5
1	500 mg	three times daily	7

Table 5: Frequency and duration of prescriptions of penicillin

Number of prescriptions	Dose	Frequency	Duration (days)
5	250 mg	four times daily	5
3	250 mg	three times daily	5
2	500 mg	four times daily	7
1	125 mg	three times daily	7

tions to record the frequency (71%) although English is to be preferred. Most of the antibiotics were prescribed using generic (88.5%) rather than proprietary names.

Seven different antibiotics were used and the two most popular were amoxycillin (64.5%) and metronidazole (21.5%). The use of amoxycillin and metronidazole is in accordance with the sensitivity of microorganisms found in oral and dental infections. This does not accord with the results of the Torbay study where erythromycin and penicillin were widely used.[1] The use of erythromycin (base) in the treatment of dental infections has been shown to be ineffective as the first choice due to poor absorption and rapid emergence of microbial resistance.[3] Penicillin is an effective treatment against dental infections although several oral microorganisms are resistant to it.[4] Very little cephradine was prescribed in this study although it has been shown to be effective in the management of acute infections.[5]

The most worrying aspect of the study was the variation in the duration of the antibiotic treatment. Amoxycillin was prescribed for periods which did not conform in many cases to that recommended within the *BNF*[6] and was contrary to current views on shorter periods of prescribing.[7-9] There also was considerable variation from recommended frequencies and doses.

This was a small pilot study which would require a multicentre investigation for definitive conclusions to be drawn. Despite these limitations there were considerable inconsistencies in the prescribing of antimicrobial agents. It is important that antibiotics are taken in the correct frequency so that minimum inhibitory concentration is exceeded and the antimicrobial is cidal. One reason for these inconsistencies is that the recommendations as to the indications for antimicrobials, their duration and frequency are not available to practitioners. A 'standards' document with up-to-date views could help practitioners prescribe more appropriately.

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A study of therapeutic antibiotic prescribing in National Health Service general dental practice in England

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Objective To study the therapeutic prescribing of antibiotics by general dental practitioners.

Design A postal questionnaire of National Health Service general dental practitioners in ten English Health Authorities.

Subjects General dental practitioners (1,544) contracted to provide NHS treatment in the Health Authorities of Liverpool, Wirral, Oxfordshire, Buckinghamshire, Nottingham, North Nottinghamshire, Sheffield, Newcastle, Northumberland and North Tyneside.

Main outcome measures The questionnaires were analysed and the responses to each question expressed as absolute frequencies.

Results Responses to the questionnaire were received from 929 (60.1%) practitioners. More than 95% of practitioners recognised the need for prescribing antibiotics where there was evidence of spreading infection. Some practitioners (12.5 %) prescribed antibiotics for acute pulpitis and (3.3 %) for chronic marginal gingivitis. Antibiotics were prescribed by practitioners before drainage of acute abscesses (69%) and by 23% after drainage. Practitioners were generally not influenced by patient's expectations of receiving antibiotics (92%), but would prescribe when under pressure of time (30.3%), if they were unable to make a definitive diagnosis (47.3%), or if treatment had to be delayed (72.5 %). Amoxicillin was the most frequently prescribed antibiotic used for most clinical conditions apart from pericoronitis, acute ulcerative gingivitis and dry sockets where metronidazole was the drug of choice. There was a wide variety of dosage, frequency and duration for all the antibiotics used in the treatment of acute dental infections.

Conclusions The results obtained from this questionnaire support the conclusion that the therapeutic prescribing of antibiotics in general dental practice varies widely and is suboptimal. There is a clear need for the development of prescribing guidelines and educational initiatives to encourage the rational and appropriate use of the antibiotics in National Health Service general dental practice.

There is widespread concern about the overuse of antibiotics and the emergence of resistant bacterial strains.[1–3] Overprescribing of antibiotics by general dental practitioners (GDPs) is not generally perceived as a problem, although in 1997 more than 3.5 million prescriptions for antibiotics were dispensed by GDPs at a net ingredient cost of £5.2 million.[4] Antibiotic prescribing by dentists could therefore, play a significant part in the emergence of resistant bacterial strains, particularly if there was evidence that there was significant misuse.

There have been some limited studies of antibiotic prescribing by dental practitioners and these have shown wide variation in what is prescribed and the dosages employed.[5–7] Only two pilot studies have investigated how practitioners prescribe and in what clinical situations.[8,9] The aims of this study were to investigate when, why and what antibiotics were prescribed by a large population of National Health Service (NHS) GDPs.

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Materials and methods

Questionnaire

A questionnaire was devised to examine general dental practitioner's prescribing patterns. This questionnaire was a modification of that described by Palmer *et al.*[9] The questionnaire was anonymous but investigated the place and year of qualification, age (banded in decades from 21 to 61 years), sex and whether any postgraduate courses had been attended on antibiotics in the previous 2 years.

The questionnaire investigated for which clinical signs the practitioner would prescribe antibiotics for patients presenting with a dental infection. The clinical signs chosen were elevated temperature, evidence of systemic spread, localised fluctuant swelling, gross diffuse swelling, restricted mouth opening, difficulty in swallowing and closure of the eye because of swelling.

Information was sought on the antibiotic dose, frequency and number of days that the practitioner would prescribe for patients with an acute dental infection, who were not allergic to penicillin. They were also asked to select their preferred choice of antibiotic for a dental infection for patients allergic to penicillin. Information was also sought on a number of non-clinical factors to determine if they affected practitioners' prescribing. Specifically, questions were asked whether or not the patient's expectation of an antibiotic prescription, pressure of time and workload, the patient's social history, uncertainty of diagnosis, or if treatment had to be delayed would cause an antibiotic to be prescribed.

Information was sought on the use of antibiotics for common clinical conditions, if a positive response was made then the practitioners were asked to state what antibiotic would be prescribed. The clinical conditions were acute pulpitis, acute periapical infection (before, with or after drainage), chronic apical infection, pericoronitis, cellulitis, periodontal abscesses, acute ulcerative gingivitis, chronic marginal gingivitis, sinusitis, chronic periodontitis, dry socket, trismus and reimplantation of teeth.

Sample and data handling

Ten health authorities were chosen for sampling, these were Liverpool, Wirral, Oxfordshire, Buckinghamshire, North Tyneside, Northumberland, Newcastle, Nottingham, North Nottinghamshire and Sheffield. All the general dental practitioners contracted to provide NHS General Dental Services were included from the health authority lists; specialist practitioners (eg orthodontists) were excluded. Questionnaires were sent out at the beginning of February 1999 with a freepost envelope which was coded with an area code, so that the response rate from any locality could be assessed. The respondent dentists could not be identified from the completed questionnaire.

The questionnaires received were entered into a *Statistical Package for Social Science* (SPSS) database.[10] From this database the overall response rate was calculated, together with the percentage responses for each question.

Results

A total of 929 replies were received giving a response rate of 60.1%; 38 of the returned questionnaires were incomplete resulting in 891 useable replies. All the dental schools in the UK were represented, 71.5% males and 28.5% females responded and there was a normal distribution of age groups. Only 21.5% of the respondents had attended postgraduate courses on antibiotics in the previous 2 years.

Table 1 shows the clinical signs for which practitioners would prescribe antibiotics. Elevated temperatures, gross diffuse swelling, difficulty in swallowing and closure of the eye, were the principal clinical indications for antibiotic prescribing.

Table 2 shows the antibiotics prescribed for adults with an acute dentoalveolar infection, the frequencies, dosages and length of the course. Amoxicillin was the principal antibiotic prescribed with 70.5% choosing this antibiotic as their first choice. The principal dosage of amoxicillin was 250 mg three times daily for 5 days, but 3 g, 200 mg and 500 mg were also used, the latter two doses for periods of 3 to 10 days, and three to four times daily. Penicillin V was the next most popular first choice of antibiotic with 20.5% using it; the dosages and frequency were mainly 250 mg and four times daily for 5 days. Metronidazole was used by 7% of the respondents at dosages of 200, 250 and 400mg for 3 to 7 days. Both ampicillin and cephalexin were prescribed by only 0.5% of respondents. The main choice of therapeutic antibiotic for patients allergic to penicillin was either erythromycin 46.7%, or metronidazole 48%: the other choices were tetracycline (0.9 %) or cephalosporins (1.3%).

Table 1 The clinical signs for which GDPs (*n* = 891) would prescribe antibiotics in conjunction with appropriate treatment

Clinical signs	%
Elevated temperature and evidence of systemic spread	97.5
Localised fluctuant swelling	34.5
Gross diffuse swelling	96.6
Restricted mouth opening	88.3
Difficulty in swallowing	80.5
Closure of eye because of swelling	96.2

The non-clinical factors influencing antibiotic prescribing are shown in Table 3. Almost half the practitioners surveyed used antibiotics when they were uncertain about the diagnosis or when under pressure of time (30%). Circumstances where treatment had to be delayed accounted for 72.5% of prescribing.

The percentage of practitioners prescribing for specific conditions is shown in Figure 1. The majority prescribed for acute periapical lesions before drainage, pericoronitis, acute ulcerative gingivitis, dry sockets, periodontal abscesses and the reimplantation of teeth. More than 10% prescribed for acute pulpitis and chronic periodontitis. The GDPs' choice of antibiotics for specific conditions, assuming no allergy to penicillin, are shown in Table 4. Amoxicillin or metronidazole were the most used antibiotics for all the conditions surveyed.

Discussion

There are about 15,800 dentists practising (excluding assistants and vocational trainees) within the NHS General Dental Services in England, 72% are male and 28% female.[11] This study aimed to sample around 10% of GDPs. The geographical areas chosen for the study included rural and inner city areas and 1,544 dentists were surveyed. When the sample was analysed the 60.1% response rate had a male to female split of 71.5% male and 28.5% female; graduates representing all the English dental schools and a normal distribution of age groups. Although it was hoped to achieve a higher response rate, research in general medical practice has suggested that the primary reason for non-response to postal surveys is that questionnaires get lost in other paperwork, that practitioners are too busy or that the questionnaires are routinely binned.[12]

The indications for antibiotics in acute dentoalveolar infections are well defined as signs of spreading infection, patient

Table 2 Antibiotic prescribed by GDPs (*n* = 891) for acute dentoalveolar infection showing dosage, frequency of dose and number of days prescribed

Antibiotic	% of GDPs	dosage	Frequency: 1 dose	3xdaily	4xdaily	1+1, 8 hrs later	No days: 0	1	2	3	4	5	6	7	8	10	Total
Amoxicillin	70.5	3 g	2	4	1	22		22	5	1		1					29
		200 mg		4	2							4		2			6
		250 mg		346	110	2	1			20	4	356	6	69	1		459
		500 mg		112	10	2	1			10	2	88		22		1	125
		Total	2	466	123	26	2	22	5	31	6	449	6	93	1	1	622
Pen V	20.5	200 mg			1							1					1
		250 mg		4	150					6		119	4	25			154
		500 mg		2	24				1	1		23		1			26
		Total	0	6	175	0	0	0	1	7	0	143	4	26			181
Metronidazole	7	200 mg		42	2					12		27		5			44
		250 mg		2						1		1					2
		400 mg		12	3	1				4	1	11					16
		Total	0	56	5	1	0	0	0	17	1	39	0	5	0	0	62

Table 3 Non clinical factors that cause GDPs (n = 891) to prescribe antibiotics

Non clinical factor	%
Patient expectation of a prescription	8.0
Pressure of time and workload	30.3
Patient's social history	8.2
Uncertainty of diagnosis	47.3
Where treatment has to be delayed	72.5

malaise, temperature elevation and lymphadenitis.[13,14] Generally this survey showed that GDPs are aware of these indications and mostly used antibiotics judiciously for acute infections (Table 1). However, more than one third would prescribe antibiotics for a localised fluctuant swelling and where there was no evidence of trismus. This study suggests therefore that a significant proportion of practitioners prescribed antibiotics for all swellings where local treatment would have sufficed.

Amoxicillin was the most frequently prescribed antibiotic for acute dentoalveolar infections requiring antibiotics, followed by phenoxymethylpenicillin (penicillin V). The antibiotic of choice for acute dentoalveolar infections has traditionally been phenoxymethylpenicillin and this antibiotic, at a dose of 500 mg, is currently recommended by the *Dental Practitioners Formulary* (DPF).[15] The use of phenoxymethylpenicillin was based on old studies that had isolated mainly streptococci and staphylococci as the main bacteria from dental abscesses.[5,16,17] More recent studies have shown that the main isolates from dental abscesses are complex mixtures of facultative and anaerobic bacteria, some of which are penicillin resistant.[18,19] The main choices of antibiotics by the practitioners in the survey for dental abscesses were amoxicillin and metronidazole. The use of amoxicillin and metronidazole is supported by some microbiological and clinical findings,[20–22] but the DPF still recommends phenoxymethylpenicillin as the first choice for most dentoalveolar infections.[15] Erythromycin and metronidazole were used by the dentists surveyed for dental abscesses in patients allergic to penicillin, concurring with the advice in the DPF.[15]

The wide range of doses and duration of antibiotics prescribed for dentoalveolar infections was alarming. There is increasing evidence that short courses of antibiotics, together with local surgical measures, are adequate for the resolution of dentoalveolar infections.[23] Prolonged courses of antibiotics, which were recommended by some of the practitioners in the survey, for periods up to 10 days, could be harmful by selecting resistant bacteria and abolishing colonisation resistance.[24] Large doses of amoxicillin (500 mg) are not indicated in acute dentoalveolar infections as the absorption of this antibiotic in standard 250 mg amounts is good enough to be therapeutically effective.[19] A minority of practitioners used the two-dose 3 g amoxicillin regime which has been shown to be effective for dental abscesses in some specific situations.[21]

Although most of the practitioners in the survey (90%) would not be influenced to prescribe antibiotics because of patient expectation, 30% would prescribe because of shortage of time and 47% if they were unable to make a definitive diagnosis. The decision to prescribe antibiotics must be based on a thorough medical history, clinical examination and accurate diagnosis. The use of antibiotics

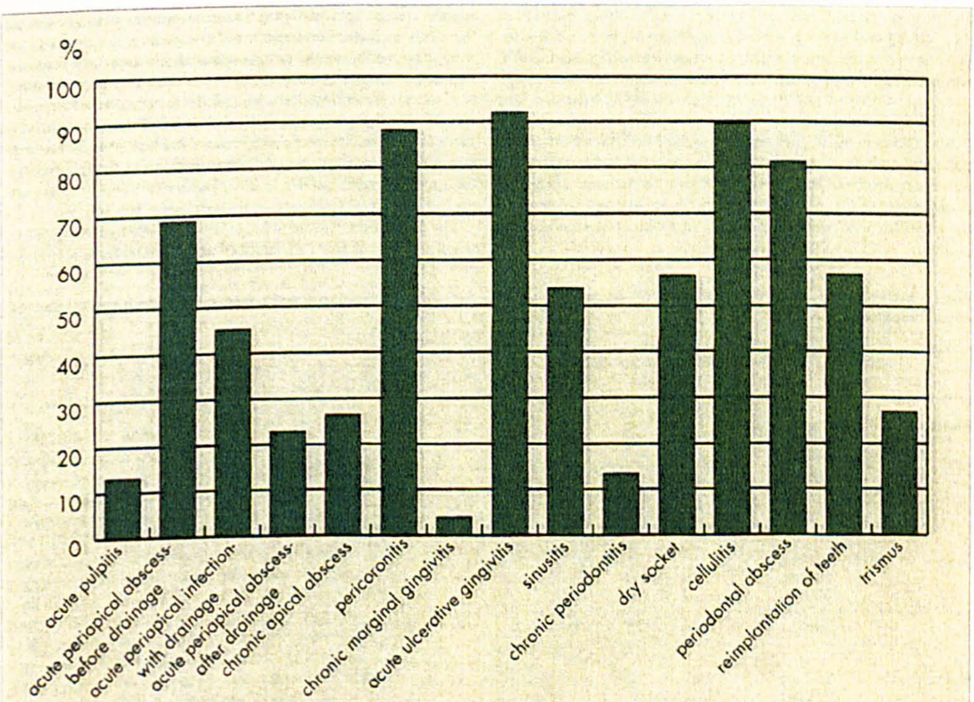

Fig. 1 Percentage of GDPs prescribing for specific clinical conditions (n = 891)

Table 4 Antibiotic choices for specific clinical conditions

Clinical condition	Number of GDPs	Antibiotic choice							
Acute pulpitis	116	Amoxicillin	(74%)	Penicillin	(21%)	Metronidazole	(5%)		
Acute periapical infection– (a) before drainage	609	Amoxicillin	(72%)	Penicillin	(20%)	Metronidazole	(19%)		
Acute periapical infection– (b)with drainage	400	Amoxicillin	(76%)	Penicillin	(18%)	Metronidazole	(15%)		
Acute periapical infection– (c) after drainage	201	Amoxicillin	(70%)	Metronidazole	(19%)	Penicillin	(17%)		
Chronic apical infection	233	Amoxicillin	(67%)	Metronidazole	(20%)	Penicillin	(18%)		
Pericoronitis	780	Metronidazole	(67%)	Amoxicillin	(30%)	Penicillin	(10%)		
Cellulitis	792	Amoxicillin	(77%)	Metronidazole	(22%)	Penicillin	(15%)		
Periodontal abscess	720	Metronidazole	(58%)	Amoxicillin	34%)	Penicillin	(9%)		
Acute ulcerative gingivitis	814	Metronidazole	(92%)	Amoxicillin	(3%)	Tetracycline	(3%)	Penicillin	(2%)
Chronic marginal gingivitis	31	Metronidazole	(48%)	Tetracycline	(22%)	Amoxicillin	(11%)	Penicillin	(10%)
Sinusitis	477	Amoxicillin	(65%)	Erythromycin	(10%)	Penicillin Metronidazole	(7%) (5%)	Doxycycline	(6%)
Chronic periodontitis	119	Metronidazole	(44%)	Tetracycline	(39%)	Amoxicillin	(15%)	Penicillin	(6%)
Dry socket	501	Metronidazole	(47%)	Amoxicillin	(44%)	Penicillin	(11%)		
Trismus	237	Amoxicillin	(67%)	Metronidazole	(23%)	Penicillin	(15%)		
Reimplantation of teeth	502	Amoxicillin	(78%)	Penicillin	(17%)	Metronidazole	(7%)		

for the eradication of the cause of an acute dentoalveolar infection is difficult to support on clinical or medico-legal criteria. There are some clinical situations where antibiotics can be used where treatment has to be delayed eg where drainage cannot be established, 72% of practitioners used them for this purpose. However, evidence from other studies showed that antibiotics were used in 50% of out-of-hours emergency consultations in which there was evidence of infection in only 25% of cases.[25]

There is no indication for prescribing antibiotics for acute pulpitis,[26] yet 13% of practitioners used them for this condition. Similarly, more than 3% of the survey prescribed antibiotics for chronic marginal gingivitis: antibiotics are not indicated for this purpose. There was similar confusion over the use of antibiotics in the presence of purulent infection. In this study 69% used antibiotics prior to drainage and 45% when it was established. Drainage of an infection is the only treatment necessary in the majority of uncomplicated infected swellings. Chronic apical infections rarely need antibiotics unless there is evidence of gross local spread; extraction or root canal therapy are the definitive treatment options. In this survey more than a quarter of those surveyed would prescribe antibiotics for chronic apical infections.

Pericoronitis, periodontal abscesses and dry sockets can be effectively treated by local measures and antibiotics are only indicated for large spreading infections, or systemic involvement. The majority of practitioners routinely prescribe antibiotics for these conditions. Most of those surveyed would correctly prescribe antibiotics for cellulitis, trismus and acute ulcerative gingivitis, with amoxicillin and metronidazole being the antibiotics of choice. The majority of those surveyed prescribed prophylactically for reimplanting avulsed teeth as recommended.[27] The prescribing of antibiotics for sinusitis is controversial. Recent research has shown that antibiotics do not affect the clinical course of the disease.[28] From this survey 54% of dentists would prescribe antibiotics for sinusitis when it is unlikely to have any effect.

The results of this survey have shown that the prescribing of antibiotics by dentists is often not based on sound clinical principles. Most of those surveyed used antibiotics routinely for conditions where local treatment would suffice. This survey supports the conclusion that there is overprescribing of antibiotics within NHS general dental practice in England. Part of the problem is that the DPF, which is designed for all grades of dental personnel within the NHS, gives only general guidelines on prescribing rather than definitive regimes. GDPs need clear, simple and practical advice on when to prescribe, what to prescribe, for how long and in what dose. The Faculty of General Dental Practitioners of the Royal College of Surgeons is shortly to publish recommended standards for antimicrobial prescribing for dental practitioners which may help to combat overprescribing.[29] There is also an urgent need for consistent antimicrobial policies to be taught to dental undergraduates within schools. A small survey of antibiotic teaching within dental schools (results not shown) revealed a wide disparity in the teaching of antibiotic usage. Finally, there is a clear need for research in the efficacy and indications for antibiotic use, to provide evidence-based regimens for general dental practitioners.

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A study of prophylactic antibiotic prescribing in National Health Service general dental practice in England

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Objective To study the use of prophylactic antibiotics by general dental practitioners.

Design A postal questionnaire of National Health Service (NHS) general dental practitioners in ten English Health Authorities.

Subjects General dental practitioners (GDPs) (1544) contracted to provide NHS treatment in the Health Authorities of Liverpool, Wirral, Oxfordshire, Buckinghamshire, Nottingham, North Nottinghamshire, Sheffield, Newcastle, Northumberland and North Tyneside.

Main outcome measures The questionnaires were analysed and the responses to each question expressed as absolute frequencies.

Results Responses to the questionnaires were received from 929 (60.1%) practitioners. Over 40% of general dental practitioners would prescribe prophylactic antibiotics for patients with no relevant medical history for minor oral surgery to prevent postoperative infection. Amoxicillin was the predominant choice of antibiotic in this situation. Between 15–67% of GDPs failed to prescribe prophylactic antibiotics for at risk medically compromised patients. GDPs also prescribed for patients with a medical history not known to be at risk from dental procedures. Over 50% of GDPs however, would seek specialist advice about prophylaxis if they were unsure of the indications and over 90% of GDPs indicated they would use the current recommended regime for antibiotic prophylaxis for patients at risk of infective endocarditis.

Conclusions The evidence from this study suggests that a significant number of the practitioners surveyed prescribe prophylactic antibiotics inappropriately, both for surgical procedures and for patients at risk from endocarditis. There is also evidence that practitioners prescribe antibiotic prophylaxis for clinical procedures and medical conditions for which there is little evidence. The results suggest that there is a need for the development of guidelines for practitioners on the appropriate prophylactic use of antibiotics.

Approximately one third of all antibiotics used in medicine are prescribed for prophylactic purposes.[1] In dentistry prophylactic antibiotics are prescribed to either prevent serious life threatening complications (e.g. infective endocarditis), or to prevent infection following surgical treatment. Antibiotic prophylaxis in non-medically compromised patients remains a contentious area of clinical practice[2] but is an important area medico-legally for medically compromised patients.[3] The benefits of antibiotic prophylaxis need to be balanced against the risks of allergic reactions, toxicity, side effects and the increasing problem of antimicrobial resistance.[4–5]

Previous studies in general dental practice have centred on how practitioners prescribe prophylactically to prevent endocarditis.[6–7] There is however some evidence that prophylactic antibiotics are being prescribed in dentistry when there is little evidence that they would have any beneficial effect.[8] The purpose of this study was to investigate when and for which clinical procedures prophylactic antibiotics were being prescribed by National Health Service GDPs in England.

Method

Questionnaire

A questionnaire was devised to investigate when GDPs would prescribe prophylactic antibiotics and the regime used. The questions used were first evaluated in a pilot study and after modification, the questionnaire was sent to a sample of GDPs in England.

The first part of the questionnaire sought to determine for which specific dental procedures practitioners would prescribe antibiotics for patients who were not medically compromised. The specific dental procedures were surgical extractions, apicectomy and before or after root canal therapy. The practitioners who prescribed for any of the procedures listed were asked to state their preferred choice of antibiotic.

The next part of the questionnaire asked which specific antibiotic and regime practitioners would use for medically compromised patients requiring prophylaxis, who were not allergic to penicillin. A further question asked what antibiotic regime would be used for medically compromised patients, allergic to penicillin, requiring prophylaxis.

The final part of the questionnaire sought information on the medical conditions and dental procedures for which practitioners might prescribe prophylactic antibiotics. The dental procedures were scaling and polishing, class II and V subgingival restorations, root canal therapy, extractions and impressions. The medical conditions are listed in Table II and included patients with cardiac and immunological problems, renal pathology and transplantation, prosthetic joints and radiotherapy treated head and neck cancer together with diabetes, Hodgkin's disease and AIDS. GDPs were also asked whether they would seek specialist advice on the need to provide prophylactic antibiotics before treatment for each of the medical conditions.

Sample and data handling

Ten health authorities were chosen for sampling and these were Liverpool, Wirral, Oxfordshire, Buckinghamshire, North Tyneside, Northumberland, Newcastle, Nottingham, North Nottinghamshire and Sheffield. All GDPs contracted to provide NHS General Dental Services (GDS) were included apart from specialist

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Table 1 Clinical procedures for which GDPs (n=891) prescribe antibiotics and the antibiotics used for patients with no relevant medical history and no allergy to penicillin

Procedure	% of GDPs	Antibiotic choice
Apicectomy	43.5	Amoxicillin 28.5% Penicillin 9% Metronidazole 6%
Surgical extractions	38.9	Amoxicillin 26.5% Penicillin 7.5% Metronidazole 4.9%
Before root canal treatment	5.4	Amoxicillin 3.6% Penicillin 1.1% Metronidazole 0.9%
After root canal treatment	2.8	Amoxicillin 1.7% Penicillin 0.6% Metronidazole 0.3%

NB Some practitioners indicated more than one antibiotic

orthodontic practitioners. The questionnaire was distributed so that no respondent could be identified. The responses were entered into a Statistical Package for Social Science (SPSS) database[9] and the overall response rate and percentage responses for each question were calculated.

Results

A total of 929 replies were received giving a response rate of 60.1%. Some of the responses were returned incomplete (38) and were not used so 891 were analysed.

Prophylactic antibiotics for specific dental procedures for non-medically compromised patients

Table I shows the antibiotics used for specific clinical procedures in non-medically compromised patients who were not allergic to penicillin. Practitioners prescribed antibiotics for surgical extractions (38.9%) and apicectomies (43.5%) with amoxicillin, penicillin and metronidazole being the antimicrobials most frequently prescribed. Some practitioners indicated more than one choice of antibiotic.

Prophylactic regimes for medically compromised patients

Table II shows the medical conditions and procedures for which GDPs might consider prescribing prophylactic antibiotics. Only a minority of dental practitioners considered that a history of diabetes, haemodialysis, Hodgkin's disease and AIDS, immmunosuppressive therapy, autoimmune disorders and renal transplant were an indication for prophylactic antibiotics. With the exception of diabetes the majority of respondents felt they would seek specialist advice for the other conditions. The response to cardiac conditions, apart from patients with aortic stenosis and ventricular septal defects, was that the majority of practitioners would give antibiotics for extractions, restorations involving the gingival margin, scaling and polishing but not impressions. Coronary heart disease and bypasses, pacemakers and physiological murmurs were not generally seen as an indication for prophylactic antibiotic cover. Approximately 25% felt that a history of prosthetic joints was an indication for prophylactic cover, with approximately 40% of GDPs providing cover for patients with a history of rheumatic fever with no valvular dysfunction when carrying out scaling and polishing and extractions. Only 21.8% felt there was a need to provide antibiotic prophylaxis for extractions on patients who had undergone radiotherapy to the head and neck.

Table 2 Medical conditions and procedures for which GDPs provide antibiotic prophylaxis (n=891)

Medical History	% of dentists providing prophylaxis for procedures listed						
	Scaling & polishing	Fillings Class II subgingival	Fillings Class V subgingival	Root canal therapy	Extractions	Impressions	Seek specialist advice
Diabetes mellitus	1.1	0.7	0.7	3.6	15.8	0.1	3.5
Haemodialysis patients	5.1	3.4	3.2	5.0	8.4	0.2	48.9
Hodgkins disease	2.5	1.1	1.1	1.9	4.4	0.2	43.8
Aids	6.7	4.2	4.1	5.9	11.3	0.5	58.0
Patients on immunosuppressives	10.7	6.7	6.6	10.0	19.9	0.8	56.0
Patients with autoimmune disease	3.6	1.9	2.0	3.3	6.8	0.3	47.6
Renal transplant patients	13.5	8.6	8.0	10.6	17.4	1.0	51.2
Radiotherapy to head and neck	6.0	3.6	3.5	6.2	21.8	0.8	42.3
Patients with prosthetic joints	21.8	13.8	13.5	17.2	25.2	0.8	16.0
History of infective endocarditis	86.2	64.4	63.7	71.8	88.3	7.6	17.0
Cardiac valve prosthesis	84.4	60.2	59.8	67.9	87.0	5.7	11.0
Rheumatic heart disease	89.4	63.1	63.5	72.1	92.0	5.5	7.8
Aortic stenosis	33.9	23.5	23.0	25.6	33.9	1.9	29.5
Ventricular septal defect	55.1	38.0	38.0	43.0	56.0	3.2	29.0
Coronary by-pass surgery	12.8	9.2	9.0	10.5	14.4	1.1	17.0
Rheumatic fever- no valvular dysfunction	38.8	24.0	24.3	30.1	40.2	2.4	22.5
Coronary heart disease	2.7	1.7	1.8	2.3	3.5	0.2	9.5
Pacemakers	6.8	5.1	5.3	5.9	7.9	1.0	10.1
Physiological/innocent murmurs	8.3	4.9	5.0	6.2	9.6	0.6	23.4

Table 3 GDPs' choice of antibiotic regime for medically compromised patients not allergic to penicillin (n=891)

Antibiotic regime	% of dentists
Amoxicillin 3g 1 hour preop	90.6
Clindamycin 600mg 1 hour preop	14.9
Amoxicillin 3g 1 hour preop +500mg 6 hours later	9.2
Erythromycin stearate 1g 1hour preop + 500mg 6 hours later	3.1
Metronidazole 200mg 3x daily for 3 days	2.8
Penicillin V 2g 1 hour preop + 1g 6 hours later	0.6
Tetracycline 1g preop +500mg 6 hours later	0.1

NB Some dentists use more than one regime for prophylaxis

Table 4 Antibiotic prophylactic regime used by GDPs (n=891) for medically compromised patients allergic to penicillin

Antibiotic	Dose	% of GDPs
Clindamycin	600mg 1 hour preop	77.1%
Erythromycin stearate	1g 1 hour preop +500mg 6 hours later	18.6%
Metronidazole	200mg 3 times daily for three days	3.3%
Tetracycline	1g 1 hour preop 500mg 6 hours later	2.2%

NB Some GDPs indicated more than one regime.

Antibiotics for medically compromised patients

The prophylactic antibiotics used by GDPs for medically compromised patients not allergic to penicillin are shown in Table III. A single 3g dose of amoxicillin was the choice of prophylactic antibiotic cover provided by 90.6% of the respondent GDPs; a two dose regime of amoxicillin was used by 9.2% of respondents. Other regimes included clindamycin (11.9%), metronidazole (2.8%), penicillin (0.6%) and tetracycline (0.1%). Some GDPs indicated more than one regime. The antibiotics used for patients allergic to penicillin, shown in Table IV, were mainly clindamycin (77.1%), erythromycin stearate (18.6%) with a small percentage prescribing metronidazole or tetracycline.

Discussion

This study investigated the use of prophylatic antibiotics by general dental practitioners. It was the second part of a questionnaire which also investigated the therapeutic use of antibiotics. The details of the rationale, choice and analysis of the sample have been discussed previously.[10] Responses to the questionnaire were received from 929 GDPs, which is 5.9% of those dentists practising within the NHS General Dental Services in England. This is the largest study reported concerning the prophylactic antibiotic prescribing practices of GDPs in the UK.

A large proportion of the respondents to the questionnaire prescribed prophylactic antibiotics for apicectomies (43%) and surgical extractions (39%). This is a high proportion considering that the rate of post-operative infection from both procedures is low and there is some evidence that antibiotics have little or no effect.[11–12] Antibiotics should never be used as a substitute for good surgical and aseptic operating techniques.[2] Amoxicillin was the most prescribed antimicrobial for these procedures. This is a logical choice as it attains high serum concentrations and is effective against facultative and some anaerobic flora that may cause post-operative infection.[13–14] Penicillin was the next most popular prophylactic antibiotic but resistance by both the oral facultative and anerobic bacteria lessens its usefulness. The choice of prophylactic metronidazole is also appropriate as anaerobes are usually involved in post–operative infection.[16]

Encouragingly, only a small proportion (<6%) of the respondent practitioners used antibiotics before or after root canal therapy. The use of antimicrobials before or after root canal therapy is controversial so the indiscriminate use of antibiotics during root canal therapy should be discouraged.[17–18] The use of antimicrobials during root canal therapy has been shown to prevent flare-ups during multi-visit treatments and to reduce postoperative pain and swelling when root filling asymptomatic teeth with pulpal necrosis and with associated periapical lesions.[19–20] There is, however, little indication for this if good technique is employed in canal preparation and obturation.[18]

Knowledge of the interaction of restorative treatment with patients who had a history of AIDS, Hodgkin's and autoimmune disease, diabetes or haemodialysis was good, with the majority of practitioners not prescribing any prophylactic antibiotics. However, between 4% and 19.9% would prescribe prophylactic antibiotics for extractions with these medical conditions. The value of prophylactic antibiotics in all of these conditions for prevention of post-operative complications is questionable or unproven, with the Working Party of the British Society for Antimicrobial Chemotherapy (BSAC) stating that there is no need for antibiotic prophylaxis for dental treatment.[21] In contrast, radiotherapy to the head and neck is known to affect the blood supply and prophylactic antibiotics are essential for extractions to prevent post-operative infection:[22] only 21.8% of respondents in this study indicated they would prescribe them.

The use of antibiotics for patients with prosthetic joints has been reviewed by a number of workers and it is generally agreed that they are not indicated.[23,24,25] In this study a quarter of respondents (25.2%) would prescribe prophylactic antibiotics for patients with prosthetic joints for extractions and between 13.5–21.8% would use them for restorative procedures and scaling and polishing. The prophylactic use of antibiotics for this group of patients undergoing dental treatment has been investigated following concerns that there is a transient bacteraemia produced which could localise on prostheses leading to infection. The bacteria associated with late infections of joint replacements are mainly staphylococci and beta haemolytic streptococci which do not form part of the normal oral flora and are rarely isolated from dentally related bacteraemias.[23,24] There is little justification for prophylaxis for these patients. The BSAC Working Party does not support the routine use of prophylaxis for dental procedures carried out on patients with prosthetic joints.[25] The relatively high number of GDPs who would prescribe in this study may reflect ignorance of recommendations or advice from overprotective orthopaedic surgeons.

A high proportion of the GDPs followed current guidelines on antibiotic prophylaxis for patients with cardiac problems that could predispose to infective endocarditis, except in the case of aortic stenosis and ventricular septal defects.[26]

The use of prophylactic antibiotics for restorative procedures is contentious and must be based on the likelihood of inducing a bacteraemia. The consensus of opinion is that the placement of restorations subgingivally does not require prophylaxis.[27] Within this study there was however, a large number that associated any involvement of the gingival margin during dental procedures with a significant risk of bacteraemia and would therefore prescribe prophylactic antibiotics. In addition, a high proportion of practitioners associated any history of rheumatic fever, even those with no valvular pathology, with a risk of infective endocarditis and would prescribe prophylactic antibiotics. In contrast, the majority of practitioners in this survey understood that pacemakers, coronary heart disease and innocent murmurs did not need prophylactic antibiotics.[22,28]

In this study, the choice of prophylactic antibiotic regime, by most GDPs (99%), for medically compromised patients not allergic to penicillin fell within the BSAC recommended guidelines.[21] A small number of practitioners used regimes known to be ineffective against some oral bacteria. For patients who were allergic to penicillin, clindamycin or erythromycin was the most used prophylactic antibiotic, which follows recommended guidelines.[21]

Conclusions

There was evidence from this study that general dental practitioners are overusing prophylactic antibiotics particularly for surgical procedures. GDPs err on the side of caution with regard to medically compromised patients, prescribing when there is no indication, and yet failing to prescribe when there is an overwhelming need to do so.

Although a thorough medical history and dialogue with the patient's medical practitioner and specialist is imperative, there remains a need for clear evidence based guidelines for practitioners on the prophylactic prescribing of antibiotics in order to reduce inappropriate prescribing.

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An analysis of antibiotic prescriptions from general dental practitioners in England

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The aim of this study was to determine the antibiotics prescribed by general dental practitioners (GDPs). Adult antibiotic prescriptions issued by GDPs from 10 Health Authorities (HAs) in England were analysed. The type of antibiotic prescribed, dose, frequency and duration were investigated. Most of the 17 007 prescriptions were for generic antibiotics; nine different antibiotics were prescribed. Many practitioners prescribed antibiotics inappropriately with inconsistent frequency and dose, and for prolonged periods.

Introduction

General dental practitioners (GDPs) prescribe antibiotics therapeutically and prophylactically to manage oral and dental infections. The emergence of resistant bacterial strains due to overuse of antibiotics is a cause for worldwide concern.[1] How and what GDPs prescribe is limited by the Dental Practitioners Formulary (DPF).[2] In 1997, GDPs issued >3.5 million antibiotic prescriptions, which represent 7% of all the antibiotics prescribed in the community.[3] Inappropriate prescribing by dentists could therefore play a significant part in the emergence of resistant strains. Our study investigated the prescribing of antibiotics, by analysis of prescriptions, issued by a large population of National Health Service (NHS) GDPs in England.

Materials and methods

All adult dental prescriptions for antibiotics issued by GDPs from 10 Health Authorities (HAs) in February 1999 were included in the study. Liverpool, Wirral, Oxfordshire, Buckinghamshire, North Tyneside, Northumberland, Newcastle, Nottingham, North Nottinghamshire and Sheffield HAs were selected to provide a geographical spread of rural and urban areas and covering 10% of the total number of dentists working in the General Dental Services in England. The data collected from each prescription were the antibiotic prescribed, dose, frequency and duration in days.

Results

A total of 17 007 prescriptions were analysed. The antibiotics prescribed are shown in Table I. The majority of prescriptions (90.9%) were for generic antibiotics, with amoxycillin and metronidazole the most commonly prescribed (78%). Combinations of two or three antibiotics were prescribed in 5.6% of prescriptions, with 4% being for a combination of amoxycillin and metronidazole. Other combinations included penicillin and metronidazole, metronidazole and clindamycin, amoxycillin with metronidazole and penicillin, amoxycillin with clindamycin, and amoxycillin with penicillin.

Detailed analysis of the most commonly prescribed antibiotics, shown in Table II, demonstrated a wide variation in the doses employed, frequencies of prescription and duration of the course. Many of the prescriptions fell outside the recommendations of the DPF in terms of dose and frequency for the antibiotic prescribed: 44% of prescriptions for amoxycillin, 33% for metronidazole, 87% for penicillin and 42% for erythromycin.

Discussion

The majority of prescriptions (78%) issued were for amoxycillin or metronidazole. The recommendation of the DPF for most dental infections is phenoxymethylpenicillin four times daily, at a dose of 500 mg increased to 750 mg for severe infections.[2] Only 1.2% of the prescriptions in this study were for penicillin at these doses and frequency.

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Table I. The number and percentage of the total number of prescriptions (n = 17007) for each of the antibiotics prescribed by GDPs in 10 English health authorities in February 1999

Antibiotic prescribed	Number of prescriptions	Percentage of total prescriptions
Amoxycillin	9494	55.8
Metronidazole	3773	22.2
Penicillin	1395	8.2
Erythromycin	839	4.9
Amoxycillin + metronidazole	683	4.0
Clindamycin	236	1.4
Cephalexin	158	0.9
Tetracycline	156	0.9
Ampicillin	113	0.7
Cephradine	51	0.3
Metronidazole + erythromycin	52	0.3
Other combinations of antibiotics	57	0.4

Table II. Details of the prescriptions for the most commonly prescribed antibiotics by GDPs in 10 English health authorities in February 1999

Antibiotic prescribed	No. of prescriptions	Dose	Frequency	Duration in days
Amoxycillin	1322	3 g	1 dose, 1 dose + 1 dose 8 h later, 1 dose + 1 48 h later, 3× daily, 2× daily	1–3
	66	3 g + 250 mg	1 dose + 1 tablet 3× daily, 1 dose + 1 tablet 4× daily, 1 dose + 1 dose 8 h later + 1 tablet 3× daily	3–15
	88	3 g + 500 mg	1 dose + 1 tablet 3× daily, 1 dose + 1 tablet 4× daily, 1 dose + 1 dose 8 h later + 1 tablet 3× daily	1–8
	46	200 mg	2× daily, 3× daily, 4× daily	3–14
	5115	250 mg	2× daily, 3× daily, 4× daily, 6× daily	2–15
	1	300 mg	3× daily	7
	3	400 mg	3× daily, 4× daily	5–6
	2741	500 mg	1 dose, 2× daily, 3× daily, 4× daily, 6× daily	1–21
	1	750 mg	1 dose	1
Metronidazole	2746	200 mg	2× daily, 3× daily, 4× daily, 6× daily	2–21
	28	250 mg	3× daily, 4× daily	5–7
	966	400 mg	2× daily, 3× daily, 4× daily, 6× daily	3–15
	6	500 mg	3× daily	3–7
	1	600 mg	3× daily	5
	18	400 + 200 mg	1 tablet + 1 tablet 3× daily, 1 tablet + 1 tablet 4× daily	5–7
	1	500 + 200 mg	3× daily	7
Penicillin	8	200 mg	4× daily	5–7
	1123	250 mg	3× daily, 4× daily, 6× daily	3–15
	236	500 mg	3× daily, 4× daily	4–10
	1	750 mg	4× daily	5
	1	1000 mg	3× daily	7
	20	500 + 250 mg	1 dose + 1 tablet 3× daily, 1 dose + 1 tablet 4× daily	2–10
Erythromycin	1	1.5 g	1 dose + 1 dose 8 h later	1
	5	200 mg	3× daily, 4× daily	5–7
	669	250 mg	3× daily, 4× daily, 6× daily	3–17
	1	400 mg	3× daily	7
	149	500 mg	2× daily, 3× daily, 4× daily	1–8
	1	3 g + 500 mg	1 dose + 1 tablet 8 h later	1
	7	500 + 250 mg	1 dose + 1 tablet 4× daily	5–7

Recent studies showed, however, that the main isolates from dental abscesses are a complex mixture of facultative and anaerobic bacteria, often resistant to penicillin, justifying the use of amoxycillin or metronidazole.[4]

Erythromycin (base) in the treatment of dental infections is ineffective due to poor absorption and rapid emergence of resistant strains.[5] It is only recommended for patients allergic to penicillin.[2]

Combinations of antibiotics are only indicated in the treatment of severe infections, with the DPF recommending phenoxymethylpenicillin (or erythromycin) with metronidazole.[2] Within this study, most were combinations of amoxycillin and metronidazole.

The wide range of doses, frequencies and duration of all the antibiotics prescribed, many outside the recommendations of the DPF, was a major cause for concern. Antibiotics should be prescribed at the correct frequency, dose and duration so that the MIC is exceeded, and side effects and the selection of resistant bacteria are prevented. Although recommendations are given in the DPF on doses and frequencies, practitioners are only advised, with most antibiotics, to refrain from unduly prolonged courses.[2] There is evidence that short courses of antibiotics, with appropriate clinical treatment, are adequate for the resolution of dental infections.[6] Prolonged courses of antibiotics evident in this study, for periods up to 21 days, could be harmful by selecting resistant bacteria and abolishing colonization resistance.[7] Large doses of amoxycillin (500 mg, 750 mg) and metronidazole (400 mg, 600 mg) in this study are contraindicated because absorption using the standard doses is therapeutically effective.[4] However, the two-dose 3 g regimen for amoxycillin has been shown to be effective in specific situations.[8]

Our investigation showed that there is inappropriate prescribing of antibiotics within NHS general dental practice. To prevent the further development of antibiotic resistance, GDPs need clear guidelines and educational initiatives on prescribing of antibiotics. Recently published guidelines give advice on the recommended antibiotic, the dose, frequency and duration for specific clinical situations.[9] This, with a possible revision of the DPF, may improve antibiotic prescribing in general dental practice.

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Antimicrobial practice

Antibiotic prescribing knowledge of National Health Service general dental practitioners in England and Scotland

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The inappropriate use of antibiotics has contributed to the worldwide problem of antimicrobial resistance. Information on the knowledge, understanding and training of dental practitioners in the use of antibiotics in clinical practice is scarce. This study assessed the level of knowledge of general dental practitioners and the need for educational initiatives. An anonymous postal questionnaire was sent to National Health Service dental practitioners working in 10 Health Authorities in England (1544) and four Health Boards in Scotland (672). Each correct answer to the questionnaire was given a score of one mark; there were 84 questions. The scores for each section of the questionnaire were compared. Responses were received from 1338 (60.4%) of practitioners, of whom 22.1% had attended postgraduate courses in the previous 2 years on antibiotic prescribing. Practitioners who had attended courses had a significantly greater knowledge of antibiotic use ($P < 0.05$) than those who had not. There was no significant difference in knowledge between all age groups under 60 years of age. There were significant differences in knowledge between dentists practising in English Health Authorities and Scottish Health Boards ($P < 0.01$). Knowledge was good for clinical signs that are indicators for prescribing antibiotics and for a number of non-clinical factors, e.g. patient expectation. Knowledge of therapeutic prescribing for commonly presenting clinical conditions and prophylactic prescribing for medically compromised patients, however, was generally poor. This study has shown that an urgent review of dental undergraduate and postgraduate education in antibiotic prescribing is required. Provision of prescribing guidelines may improve knowledge and encourage the appropriate use of antibiotics in clinical dental practice.

Introduction

The increasing problem of antimicrobial resistance has emphasized the need for rationalization of antibiotic use in the treatment of infections.[1,2] Very little information is available on the knowledge and understanding of general dental practitioners concerning the use of antibiotics in everyday clinical practice. Previous studies have investigated the prescribing of antibiotics in acute dentoalveolar infections[3,4] and for prophylaxis for endocarditis.[5] More recent studies have shown that general dental practitioners prescribe inappropriately both therapeutically and prophylactically, and that a number of non-clinical factors can affect prescribing.[6,7] The aim of this study was to assess the level of knowledge of the use of antibiotics by a large population of general dental practitioners from England and Scotland, and to assess whether there is a need to investigate current undergraduate and postgraduate teaching.

Materials and methods

A questionnaire was designed to investigate general practitioners' knowledge of prescribing of antibiotics, both therapeutically and prophylactically. The questionnaire was first evaluated in a pilot study, and following modifications was sent to a sample of general dental practitioners (GDPs) in England and Scotland.[8]

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The questionnaire first sought information on the place and year of qualification, gender, age (banded in decades from 21–61 + years) and whether any postgraduate courses had been attended on antibiotics in the previous 2 years.

The questionnaire investigated practitioners' knowledge of the indications for prescribing antibiotics for a number of clinical signs that may be associated with a dental infection. The clinical signs chosen were elevated temperature, evidence of systemic spread, localized fluctuant swelling, gross diffuse swelling, difficulty in swallowing and closure of the eye due to infection. GDPs were asked to indicate their chosen antibiotic regimen for an acute infection in a patient not allergic to penicillin and for patients allergic to penicillin.

GDPs were also asked whether a number of clinically presenting conditions required antibiotics and, if so, their choice of agent. The clinical conditions were acute pulpitis, acute periapical infection (before, with and after drainage), chronic apical infection, pericoronitis, cellulitis, periodontal abscess, acute ulcerative gingivitis, chronic marginal gingivitis, sinusitis, chronic periodontitis, dry socket, trismus and re-implantation of teeth. A number of non-clinical factors that can influence prescribing were investigated. The questionnaire asked whether patient expectation of a prescription, pressure of time or workload in the surgery, the patient's social history, uncertainty of diagnosis or where treatment had to be delayed might be a reason for prescribing antibiotics.

GDPs were asked if prophylactic antibiotics were required for dental treatment or oral surgery in non-medically compromised patients. They were asked specifically whether antibiotics were required for surgical extractions, apicectomies and before or after root-canal treatment. If antibiotics were indicated, practitioners were asked to state their choice of antibiotic.

The next part of the questionnaire sought knowledge on the medical conditions and dental procedures that may require prophylactic antibiotics. The dental procedures were scaling and polishing, subgingival restorations, root-canal therapy, extractions and impressions. The medical conditions included patients with cardiac and immunological problems, renal pathology and transplantation, prosthetic joints and radiotherapy-treated head and neck cancer together with diabetes, Hodgkin's disease and AIDS. A copy of the questionnaire can be obtained from the corresponding author.

Subjects and data handling

Ten Health Authorities in England and four Health Boards in Scotland were chosen for sampling. These were Liverpool, Wirral, Oxfordshire, Buckinghamshire, North Tyneside, Northumberland, Newcastle, Nottingham, North Nottinghamshire, Sheffield, Lothian, Argyle and Clyde, Grampian, and Dumfries and Galloway. All GDPs contracted to provide National Health Service (NHS) general dental services were included with the exception of specialist orthodontic practitioners. A total of 1544 questionnaires were sent in England and 672 in Scotland. The questionnaires contained a Health Authority/Health Board identifier, but no individual respondent could be identified. The responses were analysed using a Statistical Package for Social Science (SPSS) database. The total response rate and scores for each question were calculated, correct answers were given a score of 1, with a maximum correct score for the questionnaire of 84. The correct answers were based on a review of the clinical literature, expert opinion where there is a lack of good evidence and the recommendations of specialist societies, e.g. the British Society for Antimicrobial Chemotherapy. The knowledge of GDPs was equated to their total score for the questionnaire. Mean scores were compared using gender, age band, attendance at postgraduate courses, Health Authority/Board and University of qualification as grouping variables.

Results

A total of 1338 replies were received, giving a response rate of 60.4%; 63 questionnaires were returned incomplete, resulting in 1275 useable replies (891 from England and 384 from Scotland). Only 22.1% of respondents had attended postgraduate courses on antibiotic usage in the previous 2 years. Table I shows the breakdown of responses and postgraduate attendance of courses on antibiotic prescribing in the previous 2 years. All dental schools within the UK were represented, alongside a number of overseas graduates. There was a normal distribution of age groups, of which 70% were males and 30% were females, as shown in the Figure.

The maximum possible score for the questionnaire was 84, with respondents achieving a range of 25–84 (mean 57.28, s.d. 6.73). Table II shows the range of scores, means

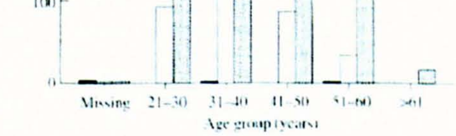

Figure. Questionnaire responses by age group and gender. ■, information missing; □, female; ▒, male.

and standard deviations for the subject areas. The total mean scores for gender, age groups and attendance at postgraduate courses were compared. t-Tests showed no significant difference between genders (t = 1.906; P > 0.05), with a female mean score of 57.03 (S.D. 7.15) and male mean score of 56.21 (S.D. 6.98). A separate t-test, however, showed a small but significant difference between those who had attended a postgraduate course on antibiotic prescribing in the last 2 years and those who had not (t = −4.68; P < 0.05), with a mean score of 55.94 (S.D. 7.09) for non-attenders and 58.17 (S.D. 6.88) for attenders.

A one-way analysis of variance (ANOVA) using age bands as the grouping variable showed there were significant differences [$F(4,1269)$ = 5.305; P < 0.01] between age bands and knowledge. A Tukey honestly significant difference (HSD) *post hoc* statistical test revealed that the significant differences (P < 0.05) were between age bands over 61 years of age (mean total score 49.2) and those under 61 years (mean total score 56.53), with no significant differences between the four age groupings under 61 years of age.

A t-test (t = 6.582; P < 0.01) showed that there was a significant difference in total scores between English Health Authorities (mean total score 57.28, S.D. 6.73) and Scottish Health Boards (mean total score 54.47, S.D. 7.56). When comparisons were made between individual Health Authorities/Boards of mean total scores (shown in Table III) using a one-way ANOVA, significant differences in scores were evident [$F(13,1273)$ = 4.527; P < 0.01]. Table IV shows small but non-significant differences between the mean total scores for the respondents' university of qualification.

Table I. Number of GDPs by Health Authority/Board who had attended a postgraduate course on antibiotics in the previous 2 years

	Postgraduate course attendance	
Health Authority	no	yes
Liverpool	63	22
Wirral	52	27
Oxfordshire	96	27
Buckinghamshire	136	31
North Tyneside	25	14
Northumberland	45	6
Newcastle	57	11
Nottingham	82	19
North Notts	44	11
Sheffield	101	22
Grampian	75	29
Lothian	141	33
Argyle and Clyde	60	24
Dumfries and Galloway	16	6
Total	993	282

Discussion

There are approximately 15 800 dentists practising (excluding assistants and vocational trainees) within the NHS General Dental Services in England, of whom 72% are male and 28% female.[19] Approximately 1912 dentists practise in Scotland, of whom 69% are male and 31% female. This study sampled c. 10% of GDPs in England and 30% in Scotland. The geographical areas covered included inner city and rural areas, and 2216 dentists were surveyed in total. This study represents one of the largest studies reported on antibiotic prescribing in the UK. When the sample was analysed, the 60.4% response rate had a gender distribution of 72% male and 28% female, reflecting the distribution in NHS practice in England and Scotland.

Table II. Maximum score, range of scores, means and standard deviations for subject areas

Subject area	Maximum possible score	Range of scores: minimum	Range of scores: maximum	mean	Standard deviation
Clinical signs	6	2	6	5.27	0.82
Antibiotic for acute infections	4	0	4	2.56	1.27
Non-clinical factors	5	0	5	3.22	1.17
Antibiotic for pt allergic to Pen	1	0	1	0.44	0.49
Clinical conditions	15	0	15	8.06	2.24
Prophylactic use in non-medically compromised patients	7	0	7	5.88	1.24
Medical conditions	30	0	30	16.67	4.48
Prophylactic regimen	8	0	8	6.85	0.79
Regimen for patients allergic to penicillin	8	0	8	7.44	0.95

Table III. Mean scores of GDPs by Health Authority/Board

Health Authority/Board	*n*	Mean score	Standard deviation
Liverpool	85	57.67	7.33
Wirral	79	58.70	6.80
Oxfordshire	122	57.13	7.06
Buckinghamshire	167	57.00	6.63
North Tyneside	39	57.56	8.85
Northumberland	51	55.82	6.32
Newcastle	68	57.44	6.75
Nottingham	101	56.54	6.67
North Notts	55	57.05	5.61
Sheffield	123	57.75	5.89
Grampian	104	54.94	7.98
Lothian	174	53.46	7.63
Argyle and Clyde	84	55.46	7.30
Dumfries and Galloway	22	56.40	4.77

Table IV. Mean scores of GDPs by university of qualification

Dental school	*n*	Mean score	Standard deviation
Belfast/Cork/Dublin	27	56.29	4.45
Birmingham	53	59.77	5.80
Bristol	30	58.76	5.64
London	178	56.77	7.08
Overseas	35	54.48	6.69
Cardiff	19	57.31	3.95
Dundee	105	54.87	8.48
Edinburgh	154	53.83	7.38
Glasgow	152	55.21	6.83
Leeds	38	56.89	7.03
Liverpool	129	58.51	6.70
Manchester	44	58.65	5.83
Sheffield	142	57.62	6.09
Newcastle	161	56.27	7.27

There was a normal distribution of age groups and graduates representing all the English and Scottish dental schools. It had been hoped to achieve a higher response rate, but research in medical practice has suggested that the reasons for non-response to postal surveys is that questionnaires are lost in other paperwork or are routinely thrown away, or practitioners are too busy.[11]

There was a significant difference in knowledge of the use of antibiotics amongst those who had attended postgraduate courses in the previous 2 years, although only 22% of all respondents had received education in this area. This may be because very few courses had been organized, or that the majority of practitioners felt that they were up to date with current opinion. Most practitioners scored well on the clinical signs indicating the need for prescribing antibiotics (spreading infection, patient malaise, temperature elevation, lymphadentitis),[12] but about a third felt that there was a need for antibiotics where there was only localized swelling. Generally, practitioners scored well on the non-clinical factors that should not influence prescribing. A number did feel, however, that it was acceptable to prescribe when short of time, if a definitive diagnosis could not be made or if treatment had to be delayed.

As can be seen from Table II, there were low scores for the questions on the common clinical conditions presenting in everyday practice. This may be due to practitioners thinking that antibiotics are required for conditions that are easily dealt with by routine operative dental treatment. Low scores were also evident for questions on prophylactic prescribing for medical conditions. The total mean score of 56 out of a possible 84 indicates a poor understanding of the use of antibiotics in dental practice.

There was no significant difference in scores relating to age bands, with the recently qualified scoring little better than those who had been qualified for 30 years. This perhaps calls into question the efficacy of present undergraduate teaching and the retention of knowledge. Graduates of some dental schools scored more poorly than others, although this was not statistically significant. The Standing Medical Advisory Committee (SMAC) recommended that greater emphasis should be placed on education of clinical students and qualified clinicians about antimicrobial prescribing.

The SMAC also recommended that teaching about antimicrobials should be better integrated with teaching about the infections against which they are used.[7] There is a clear need to re-evaluate the teaching of antibiotic usage to undergraduates to see if these recommendations have been put into practice. Practitioners working in some Health Authorities/Boards showed less knowledge than others, though this may be linked to the place of qualification. There is therefore a need to standardize the teaching of antibiotics to all undergraduates.

It would appear from this study that dental practitioners' knowledge about the use of antibiotics in general practice is far from ideal. This mirrors general medical practice, where studies have shown that decision making in antibiotic therapy requires improvement.[13] Rational prescribing based on a thorough knowledge is an important objective. Effective communication between microbiologists and practitioners, and the publication of prescribing guidelines and protocols could help to achieve this.[13]

A study in medical practice has shown the effectiveness of educational intervention, using guidelines, in attaining the appropriate prescribing of antibiotics within a specific clinical situation.[14] An audit of antibiotic prescribing in dental practice showed that there was a reduction in the number of prescriptions following the introduction of guidelines.[15] The use of clinical audit as a tool to increase knowledge of antibiotic prescribing and improve patient care should not be underestimated. Computers as a tool for education and behaviour change, along with direct mail interventions have been shown to be effective in medical prescribing.[16,17]

This study supports the conclusion that there is a lack of knowledge of the use of antibiotics in practice and that GDPs need clear advice on when and what to prescribe, for how long and in what dosage. The Faculty of General Dental Practitioners of the Royal College of Surgeons of England has recently published recommended standards for antimicrobial prescribing for dental practitioners, which may improve knowledge.[18] There is also a need to improve undergraduate education and to increase the provision of postgraduate courses and other educational initiatives on antibiotic prescribing.

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Paediatric antibiotic prescribing by general dental practitioners in England

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Key words: Antibiotics, prescriptions, children, therapeutic, prophylaxis

Running head: Paediatric antibiotic prescribing

Abstract

Objectives

The inappropriate use of antibiotics is known to be a major contributory factor to the problem of antimicrobial resistance. No information is available on how practitioners prescribe antibiotics for children. This study investigated the prescribing of liquid-based antibiotics for children by general dental practitioners in England.

Design

Analysis of National Health Service liquid-based prescriptions issued by general dental practitioners in England .

Sample and method

All prescriptions issued by practitioners in ten Health Authorities in England for February 1999 were collected. All the liquid- based antibiotic prescriptions for children were selected and the type of antibiotic prescribed, whether sugar free, the dose, frequency, and duration was investigated.

Results

A total of 18614 prescriptions were issued for antibiotics. Of the 1609 liquid-based paediatric prescriptions 88.3% were for generic and 11.7% for proprietary antibiotics. of which 75.5% were for amoxicillin, 15.2% for phenoxymethylpenicillin, 6.6% for erythromycin, 1.7% for metronidazole. Cephalexin, ampicillin, cephadrine and combinations of two antibiotics were also prescribed. There was a wide variation in dosages for all the antibiotics prescribed. A significant proportion of practitioners prescribed at frequencies inconsistent with manufacturers' recommendations and for prolonged periods, with some practitioners prescribing for periods up to ten days. Only 29.1% of all the prescriptions issued were sugar free.

Conclusions

The results of this study show that some practitioners prescribe liquid-based antibiotics inappropriately for children. This may contribute to the problem of antimicrobial resistance. Clear guidelines on the choice of antibiotic, dose, frequency and duration along with educational initiatives for GDPS might reverse this trend.

Introduction

General dental practitioners (GDPs) prescribe antibiotics for children, both therapeutically and prophylactically, to manage oral and dental infections. The benefits of prescribing antibiotics are limited by a number of problems associated with their use e.g. side effects, allergic reactions, toxicity and the development of resistant strains of microbes.

The emergence of resistant bacterial strains due to the inappropriate use of antibiotics is a cause for worldwide concern(1-3). The Dental Practitioners Formulary (DPF), a section of the British National Formulary (BNF) gives advice on how and what should be prescribed for dental infections and prophylaxis(4). However, it only provides non-specific recommendations on therapeutic dose and frequency of antibiotics for children, stating that age and weight should be considered when prescribing, with no recommendations for the treatment duration. The management of abscessed teeth is influenced by the severity of the infection. The important principle should be to establish and maintain drainage by incision of the soft tissue abscess, by opening up the pulp chamber or extracting the tooth(5). Inappropriate prescribing of antibiotics by GDPs has not been perceived as a problem but in 1998, GDPs issued 3.56 million antibiotic prescriptions, equating to 7.5% of all antibiotics prescribed by general medical and dental practitioners in the community (6). There is evidence in general dental practice of overuse of antibiotics (7-9) but there is no information on dental practitioner paediatric prescribing apart from a survey of paedodontists(10) and an examination of children attending a casualty department with dental pain (11).

Both these investigations showed antibiotics were prescribed in some cases inappropriately, with antibiotics prescribed for pain where there was no swelling and for infection and trauma with no swelling. Other limited studies have shown a wide variation in what is prescribed therapeutically and dosages employed (12-14). The aim of the present study was to investigate the prescribing of antibiotics for children, by analysis of prescriptions issued by a large population of GDPs in England.

Method

The Regional Prescription Pricing Authorities (RPPAs), for the nine Health Authorities selected, collected all dental prescriptions for the month of February 1999. The nine Health Authorities were Liverpool, Wirral, Oxfordshire, Buckinghamshire, North Tyneside and Newcastle, Northumberland, Nottingham, North Nottinghamshire and Sheffield. The RPPAs photocopied the prescriptions with the patient and dentist information removed in order to maintain confidentiality. Paediatric prescriptions for antibiotics were then selected from those received from the RPPAs. The selection was based on whether a liquid preparation was prescribed. The prescriptions were given an individual identification number and were grouped into Health Authority areas. The information collected from the prescriptions was the antibiotic prescribed, dose, frequency and duration in days and whether the preparation was dispensed sugar free. This information was numerically coded and entered into a Statistical Package for Social Science (SPSS) database(15). From this database frequencies were used to describe the sample and examine the distribution of variables.

Results

A total of 18614 prescriptions were issued for antibiotics. Of these 1609 paediatric prescriptions were analysed and the antibiotics prescribed are shown in Table 1.The majority (88.3%) of these were generic prescriptions but 11.7% were for proprietary antibiotics. The most prescribed antibiotic was amoxicillin (75.5%) followed by phenoxymethylpenicillin (15.2%) and erythromycin (6.6%). No prescriptions were written for clindamycin. Only 29.1% of the prescriptions were in sugar free form, with the dispensing pharmacist changing a further 3.8% of the prescriptions to sugar free form. Detailed analysis of the commonest antibiotics prescribed, shown in Table II, III, IV and V demonstrated a wide variation in the doses employed, frequency and duration of the course. A significant number of practitioners prescribed at frequencies inconsistent with manufacturers' recommendations and for prolonged duration of treatment with some prescribing for up to ten days. Table VI shows the distribution of prescriptions for each Health Authority area, the number of GDPs practising in each of the areas and the number of prescriptions for each GDP

Discussion

There are approximately 15800 dentists (excluding assistants and vocational trainees practising within the NHS General Dental Services in England, 72% are male and 28% are female (16). The geographically distributed areas chosen for this study included rural and urban areas with approximately 10% of all dentists practising in the GDS in England. In order to preserve confidentiality the patient and dentist details, along with the age of the patient, were removed from the prescriptions. The prescriptions were taken for one month (February), as there is little seasonal, or monthly variation in the number of antibiotic prescriptions issued (Prescription Pricing Authority, data on file) Only prescriptions containing antibiotics prescribed in liquid form were included in this study. It was assumed that these would be mainly for younger children, although it is acknowledged that some children may have been prescribed tablets and some liquid prescription may have been for elderly adults.

The majority of prescriptions issued were for amoxicillin (75.5%), followed by phenoxymethylpenicillin (15.2%) and erythromycin (6.6%). The majority of prescriptions were generic, which are known to be as efficacious as brand name equivalents but also produce cost savings (17). For most therapeutic prescribing the antibiotic of choice recommended by the DPF is phenoxymethylpenicillin at a dose for children below 5years of age of 125mg every six hours. This is increased to 250mg for children aged 6-12years. The BNF section is more specific and it suggests that children's doses should be calculated from adult doses by using age (in age ranges), body weight, or body surface area (4). There was a wide variation in doses in this study perhaps mirroring these recommendations. As the age of the patient for whom the antibiotic was prescribed was unavailable, it was not possible to see if there was a relationship between the age of the patient and the dosage prescribed. Further investigations of this aspect would be of benefit.

The recommended use of phenoxymethylpenicillin is based on studies that had isolated mainly streptococci and staphylococci from dental abscesses (18-20). More recent studies have shown that isolates from dental abscesses are a complex mixture of facultative and anaerobic bacteria, some of which are resistant to penicillin (21-

23). The use of amoxicillin by the majority of GDPs within this study can therefore be supported by some microbiological and clinical findings (24, 25).

The use of erythromycin in the treatment of dental infections has been shown to be ineffective as a first choice due to poor absorption and rapid emergence of resistant strains (26). It is however, recommended as the choice for patients allergic to penicillin, along with metronidazole(4). Within this study, 6.6% of GDPs prescribed erythromycin and 1.7% metronidazole. Table VI showed that although very few prescriptions for antibiotics were prescribed over the month there were wide variations in frequency of dosage with over 19% failing to prescribe the antibiotics used at the frequencies recommended in the DPF. No indication is given within the DPF or BNF on the duration of the course other than a recommendation that treatment should not be unduly prolonged(4). It has been shown that compliance by children to complete a conventional course of antibiotics is poor(27). Within this study there was evidence of prolonged duration of treatment with antibiotics prescribed up to 10 days. There is evidence that short courses of antibiotics, with appropriate treatment, are adequate for resolution of dental infections(24, 28, 29).

The British Society for Antimicrobial Chemotherapy recommends for prophylaxis a single dose of amoxicillin (750mg for children under 5years of age and 1.5g for children aged 5-10years) for patients not allergic to penicillin, and clindamycin (150mg for the under 5years and 300mg for children aged 5-10years) for patients allergic to penicillin. Clindamycin has replaced erythromycin as the choice for patients allergic to penicillin for prophylaxis (4,30, 31). It would appear from the analysis within this study that the antibiotics of choice for prophylaxis were amoxicillin and erythromycin

It was disappointing to note that only 29% of the prescriptions were specified as sugar free, with a further 3.8% prescriptions altered by pharmacists to be dispensed in this form. There is evidence that liquid medicines, many of which contain sugar, can cause decay and so sugar free preparations should be used whenever possible(32, 33). DPF products marked "sugar free" do not contain glucose, fructose or sucrose but may contain hydrogenated glucose syrup, mannitol or sorbitol which have all been shown not to be cariogenic(4). Pharamacists cannot dispense sugar-free generic prescriptions without contacting the prescriber and marking the prescription accordingly, so the proportion of antibiotics without fermentable carbohydrates was unlikely to have been higher than the 29% and 3.8% recorded in the study. There is obviously a need to educate practitioners to prescribe sugar- free liquid preparations of antibiotics whenever possible.

The number of paediatric liquid prescriptions in this study amounted to approximately 9% of all prescriptions issued (7,8), and there is anecdotal evidence, that antibiotic prescriptions for children are increasing. One reason for this increase in antibiotic prescribing may be the removal of general anaesthetics from general dental practice. There may be a delay in extracting abscessed teeth under general anaesthetic due to waiting lists and the need for patient pre anaesthetic assessment. Antibiotics may therefore be prescribed until definitive treatment can be provided. Recent research has shown that GDPs prescribe antibiotics when treatment has to be delayed (7). This is an area of prescribing that requires investigation.

It is accepted that antibiotics should only be used as an adjunct to surgical treatment in the management of acute or chronic infection, where there is evidence of spreading infections, for the definitive management of active infectious disease and for the prevention of metastatic infection such as infective endocarditis (34). In order to prevent the further development of antimicrobial resistance and to optimise the care to patients, general dental practitioners need clear guidelines on antibiotic prescribing for children.

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Table I

Antibiotics prescribed showing frequency and percentage

Antibiotic	**Frequency**	**Percentage**
Amoxicillin	1219	75.7
Metronidazole	28	1.7
Penicillin V	244	15.2
Erythromycin	106	6.6
Amoxicillin + Metronidazole	2	0.1
Cephalexin	5	0.3
Cephradine	1	0.1
Ampicillin	4	0.2
Total	1609	100

Table II

Distribution of prescriptions for amoxicillin showing dosage, frequency of dose and duration in days

Number of days	Dosage prescribed (mg)	Frequency of dose 1 dose	3x daily	4x daily	1 dose+1 8hrs later	2 doses followed by 1 dose 3x daily	2 x daily	1 dose + 1 dose 8 hrs later then 3x daily
1	1500	4						
	750	2			1			
3	125		10					
	250		2					
5	125		710	193		3	3	2
	250		104	38				
	500		1					
6	125		5					
7	75			1				
	125		87	8				
	250		35	2				
	500		1					
8	125		1					
10	125		2					

Table III

Distribution of prescriptions for Penicillin showing dosage, frequency of dose and duration in days

Number of days	Dosage prescribed (mg)	Frequency of dose 3 x daily	4 x daily
3	125		1
4	125		1
5	100		1
	125	29	129
	175		1
	250	8	54
	500		1
7	125		16
	250		2
8	125	1	

Table IV

Distribution of prescriptions for metronidazole showing dose, frequency of dose and duration in days

Number of days	Dosage prescribed (mg)	Frequency of dose		
		3 x daily	4 x daily	2 x daily
3	100	2		1
	200	2		
5	100	4		1
	125	1		
	200	13	1	1
7	100			1
	200			1

Table V

Distribution of prescriptions for erythromycin showing dose, frequency of dose and duration in days

Number of days	Dosage prescribed	Frequency of dose						
		3 x daily	4 x daily	1 dose + 1 8hrs later	2 doses + 3 x daily	1 dose + 3 x daily	2 x daily	1 dose + 2 x daily
0	2g +1g			1				
1	1.5g + 0.5g						1	
5	1g						1	
	125mg	7	40		2			
	250mg	6	35					1
	750mg+125mg					1		
7	125mg	3	5					
	250mg		2					
10	125mg						1	

Table VI

Distribution of liquid based prescriptions, number of GDPs for each Health Authority and the number of prescriptions issued for each GDP

Health Authority	Number of GDPs	Number of prescriptions	Number of prescriptions/ GDP
Liverpool	162	309	1.9
Wirral	122	125	1.0
Oxfordshire	219	147	0.7
Buckinghamshire	250	183	0.7
North Tyneside	55	57	1.0
Northumberland	86	111	1.3
Newcastle	124	96	0.8
North Notts	208	225	1.1
Nottingham	113	214	1.9
Sheffield	205	142	0.7
Total	1544	1609	1.0

Can audit improve antibiotic prescribing in general dental practice?

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Abstract

Objective

To investigate whether clinical audit can improve general dental practitioners' prescribing of antibiotics.

Design

An intervention study carried out in general dental practice in the North West of England.

Method

Information was collected over an initial six-week period from 175 general dental practitioners on their current antibiotic prescribing practices. The information collected was the antibiotic prescribed including dose, frequency and duration, the clinically presenting signs and conditions, the medical history (if for prophylaxis), and any other reasons for prescribing. This was compared to the practitioners' antibiotic prescribing for a further six-week period following an audit, which included an educational component and the issuing of guidelines.

Results

During the initial period practitioners issued 2316 prescriptions for antibiotics. This was reduced by 42.5% to 1330 during the audit. The

majority of the antibiotics (81%) for both periods were prescribed for therapeutic reasons. The most commonly prescribed antibiotics were amoxicillin (57.6%), metronidazole (23.8%), penicillin (9.3%), erythromycin (4.8%) and a combination of amoxicillin and metronidazole (1.7%). The antibiotic regimens used by practitioners were significantly changed by the audit (P<0.001) and there was a significant reduction in the number of prescriptions (P<0.05) which did not conform to national guidelines.

Conclusions

The results from this investigation support the conclusion that clinical audit, with the issuing of guidelines and an educational component, can change prescribing practices leading to a more rational and appropriate use of antibiotics in general dental practice.

Introduction

Clinical audit was introduced into general dental practice in 1995 and has been defined as the systematic, critical analysis of the quality of dental care, including the procedures and processes used for diagnosis, intervention and treatment, the use of resources and the resulting outcome and quality of life as assessed by both professionals and patients.[1] The suggested criteria for undertaking an audit are that the issue to be addressed should be a common, significant or serious problem; any changes following audit should benefit patients and lead to greater effectiveness; that the issue is relevant to professional practice and that there is a realistic potential for improvement.[2]

There is evidence that antibiotics are prescribed inappropriately in general dental practice.[3-5] With the increasing worldwide problem of antimicrobial resistance and the threat to public health there is a need to rationalise the prescribing of antibiotics.[6]

Antibiotic use has been the subject of many audits and educational activities within medical practice.[7-10] In contrast, very few audits on antibiotic prescribing in dental practice have been reported.[11, 12] It has been suggested that the production of guidelines for general dental practitioners (GDPs) along with educational initiatives and audit may encourage safe, effective, rational and economic use of antibiotics and at the same time reduce the likelihood of dentists contributing to the problem of antibiotic resistance.[5]

It has been noted that most audits have focussed on the process, rather than the structure or outcomes.[13] The aim of this study was to investigate whether clinical audit might change the prescribing of antibiotics by GDPs.

METHOD

Subjects

All 932 GDPs working within South Cheshire, North Cheshire, Liverpool, Wirral, Sefton, and St Helens and Knowsley Health Authorities in the North West of England were invited to participate in the study. The 175 dentists who took part were divided into groups of eight to ten and were assigned a trained audit facilitator to advise and oversee the investigation and audit.

Data collection

A *pro forma* was designed to collect information for each occasion a prescription for antibiotics was issued. The information noted on the *pro forma* included the antibiotic prescribed, dose, frequency, duration, the clinical signs and presenting condition, the medical history (if for prophylaxis), and any other reasons for prescribing the antimicrobial. No identification of the person completing the *pro forma* was made.

Procedure

The study consisted of an initial six-week period of data collection, following which the results were reviewed. Areas of inappropriate prescribing were noted and educational meetings were held for all participants to discuss the results of the data with experts in the field of oral microbiology and antimicrobial prescribing. During these meetings practitioners were made aware of the principles of appropriate prescribing, both therapeutically and prophylactically, based on the recently published guidelines of the Faculty of General Dental Practitioners, Royal College of Surgeons of England.[14] All the groups then met individually and set standards for antibiotic prescribing based on the guidelines and the educational component.

Practitioners then audited their antibiotic prescribing to patients for a further six- week period, collecting the information for each prescription issued as described above.

Statistical Analysis

The anonymous pre-audit and audit data were numerically coded and entered into a Statistical Package for Social Sciences (SPSS) database and analysed.[15] Frequencies were used to examine and describe the distribution of all the variables. Changes in prescribing practices between the pre-audit and audit periods were tested for significance using the chi-square test.

RESULTS

The total number of practitioners who took part in the study was 175. During the pre-audit period 2316 prescriptions for antibiotics were issued. This had reduced by 42.5% to 1330 following the issuing of prescribing guidelines, educational meetings, setting of standards and audit.

Antibiotics prescribed

The antibiotics prescribed before and after the educational component, issuing of guidelines and audit is shown in Fig 1. Amoxicillin was the most commonly prescribed antibiotic (57.6%) followed by metronidazole (23.8%), penicillin (9.3%), erythromycin (4.8%) with a combination of amoxicillin and metronidazole being used in 1.7% of prescriptions. Clindamycin (1.4%) was used primarily in prophylactic doses.

Reasons for prescribing

The majority of the prescriptions (81 %) over the two six week periods were issued for therapeutic reasons. Table I shows the clinical conditions recorded by GDPs for which antibiotics were prescribed, the number of prescriptions issued before and during audit and the percentage reduction between the two periods. Reductions in the number of prescriptions issued following guidelines and the educational component ranged from 17.3% to 100% for the clinical conditions recorded. Table II shows the medical conditions for which GDPs prescribed prophylactic antibiotics before and during the audit. The only medical condition which showed a marked reduction (51.7%) of prescriptions issued in the second data collection period related to murmurs. The other reasons for prescribing before and during the audit and the percentage reduction between the two data collection periods are shown in Table III. There was a reduction of 51% of prescriptions issued for localised swelling and 54% for pain following guidelines and the educational component.

Statistical analysis

Chi-square tests showed a significant change in the appropriateness of practitioners' prescribing practices between the two data collection periods when compared to national standards.[14] There was a reduction in the number of prescriptions issued for diagnostic purposes (X^2=16.70,df=1,P<0.001) and because of pressure of time (X^2=12.46,df=1,P<0.001), patient expectation (X^2=12.99,df=1,P<0.001) and pain (X^2=37.49,df=1,P<0.001), and patients presenting with localised swelling (X^2=8.75,df=1,P<0.001).

Antibiotic regimens

A significant improvement was seen between the two data collection periods. The prescribing of amoxicillin was significantly changed in the second data collection period and conformed more closely to national guidelines. Only 57.4% of prescriptions were at the recommended correct dose, frequency and duration before the guidelines were given. This increased to 70.5% following the audit (X^2 =36.79, df=1, P< 0.001).A significant change was also seen with the prescribing regimen for metronidazole, with an increase from 25% correct prescriptions to 41.6% during the audit (X^2 = 25.56,df=1, P<0.001).

DISCUSSION

The use of guidelines in audit to set standards is well recognised and it has been shown in medical practice that the publication of guidelines can improve prescribing.[16] Dental practitioners rely for antibiotic prescribing standards on information in the Dental Practitioners Formulary (DPF).[17] Unfortunately the information available does not provide specific information on when to prescribe and what to prescribe in specific clinical situations and therefore could not be used effectively to set standards for audit. The guidelines given to the practitioners in the audit described were based on a recently published guidelines document produced by the Faculty of General Dental Practitioners. These guidelines were based on a review of all the available literature, best practice and consultation with many specialist dental societies.[14] Even if a guideline is of high scientific quality, however, clinicians may still not follow it unless it is uncontroversial, specific, evidence based and requires no change to existing routine.[18] It has been shown that the publication of guidelines alone is seldom of value[19] but are more effective when linked with educational initiatives.[20] The effectiveness of innovation techniques in persuading practitioners to accept guidelines has shown that opinion leaders (100%) and audit with feedback (42%) are more effective than formal continuing education.[21]

This investigation showed that this innovative audit, using guidelines and an educational component with feedback, was effective in reducing inappropriate antimicrobial use by changing GDPs' prescribing practices. It was evident from the pre-audit data that GDPs prescribed inappropriately, at times using the wrong antibiotic at the incorrect dose and duration and in clinical situations where there was little benefit to the patient. This confirmed the results of a questionnaire study carried out in general dental practice in England.[4, 5] There was a significant reduction in the number of inappropriate reasons for prescribing during the audit with fewer practitioners prescribing due to uncertainty of diagnosis, pressure of time, patient expectation, pain and localised swelling. There was also a reduction in the number of prescriptions for periodontal and periapical abscesses, pulpitis, infected sockets, sinusitis, and after minor oral surgery. Whether these changes will be sustained requires further investigation after a suitable period of time. The importance of re-audit by GDPs cannot be overemphasized in order to continually improve patient care in this area of clinical practice.

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Fig 1

Number of prescriptions for each antibiotic issued pre-audit and post-audit

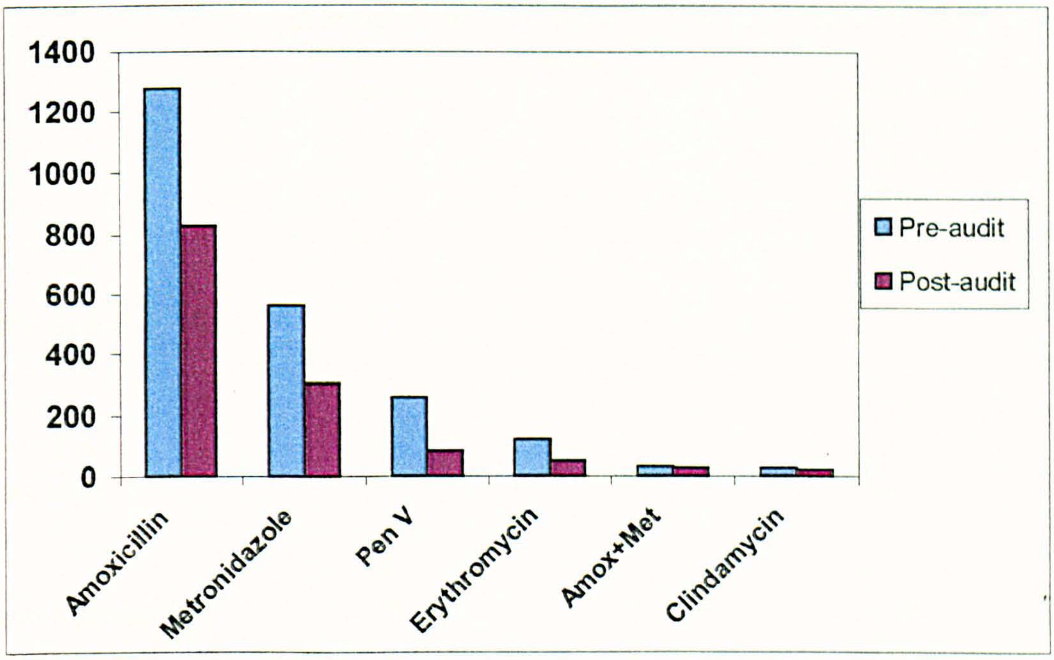

Table I

The clinical conditions and the number of antibiotic prescriptions issued by GDPs before and during the audit, showing the percentage reduction in the number of prescriptions between the two periods

Clinical condition	Number of prescriptions before the audit	Number of prescriptions during the audit	% reduction in the number of prescriptions between pre and post audit periods
Acute periapical infection	906	507	44.0
Acute periodontal abscess	237	94	60.3
Pericoronitis	187	124	33.6
Infected socket	69	57	17.3
Acute ulcerative gingivitis	98	68	30.6
Sinusitis	20	6	70.0
Post surgical procedure	140	86	38.0
During root canal therapy	2	1	50.0
After root canal therapy	12	15	25.0*
Periodontitis	51	45	16.6
Cellulitis	5	1	80.0
Pulpitis	46	13	71.7
Trismus	1	0	100.0
Gingivitis	16	7	56.0
Re-implantation of teeth	0	1	100.0*
Salivary gland infection	0	2	200.0*
Oral antral fistula	1	1	0
Others	8	2	75.0

* % Increase in the number of prescriptions between pre and post audit periods

Table II

The medical conditions and the number of prescriptions for which GDPs prescribed antibiotics before and during audit

Medical Condition	Number of prescriptions before the audit	Number of prescriptions during the audit
Rheumatic fever	81	70
Murmurs	58	28
Valvular disease	46	46
Congenital heart defects	11	6
Coronary heart disease	16	11
Prosthetic joints	8	1
Radiotherapy/chemotherapy	9	2
Immunocompromised	26	18

Table III

Reasons and the number of prescriptions for antibiotics prescribed by GDPs before and during the audit also showing the percentage reduction in the number of prescriptions between the two periods

Reasons for prescribing	Number of prescriptions issued before the audit	Number of prescriptions issued during the audit	% reduction in the number of prescriptions between the two periods
Localised fluctuant swelling	724	354	51.1
Gross diffuse swelling	365	319	12.6
Elevated temperature & evidence of systemic spread	179	177	1.1
Pain	1198	548	54.2
Prophylaxis due to medical history	255	182	28.6
Prophylaxis following surgical procedure	140	86	38.5
Patient expectation	121	36	70.2
Pressure of time & workload	86	22	74.4
Uncertainty of diagnosis	80	16	80.0
Treatment had to be delayed	209	151	27.7
Patient going on holiday/ in case of problems	39	7	82.0
Failed local anaesthesia/ un co-operative patient	26	14	46.1