The monetary value of oral health: willingness to pay for treatment and prevention

Christopher Robert Vernazza

Submitted for the degree of Doctor of Philosophy

School of Dental Sciences & Institute of Health and Society

December 2010

Abstract

Introduction

This thesis investigates two of the many dilemmas faced in oral health; whether policy makers and individuals should invest to reduce the risk of caries (decay) and whether an extensively decayed tooth should be saved or extracted (with or without a replacement).

An understanding of patient preferences, as defined in health economics (utility), is vital to addressing such dilemmas. Although health state utility is the most accepted form of utility in healthcare, monetary valuation, in the form of willingness to pay (WTP), is more appropriate for dentistry but there is little evidence for its use.

Method

Two studies were undertaken using WTP. The studies are outlined in Table 1.

Study name	Interventions	WTP elicitation	Sample size	Methodological experiments
Molar tooth	Treatment options for a non-vital molar tooth	Face to face/ shuffled payment card	503	1. Part-whole valuation 2. Influence of real price
Prevention	New varnish for root caries prevention	Questionnaire/ bidding card	167	1. Payment vehicles 2. Revealed & stated preference

Table 1 Outline of the two studies in the thesis

Results

The Molar Tooth Study showed that approximately half the sample wished to save a tooth with a mean WTP of £373 (standard deviation 991). Econometric analysis showed that choice was influenced by previous dental experience and that WTP was not strongly related to any factors.

The Prevention Study showed that mean stated preference for the intervention was £96 (standard deviation 55). Stated preference matched revealed preference in 55% of cases, with stated preference underestimating revealed preference in 30% of cases.

Discussion

Although some methodological issues remain, such as the discrepancy between stated and revealed preference, WTP is a useful measure of patient preference in oral health. The wide and apparently unpredictable range of values placed on oral health leave difficult questions for policy makers.

Acknowledgements

First and foremost, I would like to express my heartfelt thanks to my four supervisors who have guided me on the path to completing this thesis over the last five years: Dr John Wildman, Dr John Whitworth, Professor Cam Donaldson and Professor Jimmy Steele. They have given freely of their valuable time and their guidance, mentorship, knowledge, enthusiasm and ideas have been a constant source of interest, inspiration and motivation.

I would also like to thank the health economists and those from other disciplines working in the Institute of Health and Society who have taken a genuine interest in dentistry and oral health and have always been happy to answer any queries and share in any problems. Many from the School of Dental Sciences have offered help and advice, but in particular, I must express my gratitude to Dr Anne Maguire and Dr Paula Waterhouse in my "home" discipline of Child Dental Health who have been incredibly supportive in practical ways as well as through their advice and mentorship.

The research contained within this thesis would have been impossible without the help and time of the various dentists, practice managers, receptionists and patients of the many dental practices involved, as well as the staff of Denplan and CHX Technologies, all of whom I sincerely thank. Jill Smith of Newcastle University, who acted as Study Coordinator for the Prevention Study at very short notice, deserves a special mention. Some elements of the Prevention Study were funded by Denplan and CHX technologies and I am most grateful for the part they played in allowing these studies to happen.

Finally, it only remains for me to thank my friends and family who have always supported me, in so many different ways, in everything I have done. In particular, I extend my deepest thanks to Alison, Terry, Jon and most especially Tim.

Table of contents

List of tables

List of figures

Chapter 1. Introduction

1.1 Introduction

This thesis is concerned with illustrating how economic evaluation, and in particular preference-based measures, can help to address some difficult questions in two different areas of oral health care; the treatment of a non-vital molar tooth and caries (dental decay) prevention. Both are concerned with the most socially burdensome and resource intensive oral disease in the UK, caries. The work presented in this thesis contributes to knowledge in two main ways: by increasing understanding of the two dental areas explored and by investigating methodological issues in applying preference-based measures in oral health.

1.2 Outline of the thesis

In this introductory chapter, the two dental examples and some of the questions they raise will be outlined.

The second chapter will concentrate on the detailed background to the two dental scenarios, including the historical development that has led to the current situation, the current context and the policies that influence current resource allocation in the UK. This will be followed by a discussion of the research to date to address the questions raised, including the limited amount of health economics, leading to the case for using preference-based measures to address these questions.

The third chapter will then discuss preference-based measures in more detail, looking at both monetary and non-monetary measures and the benefits and limitations of each. The case will be made for monetary measures as being most appropriate to address the questions raised in the two areas previously described. One of the major monetary measures, willingness to pay (WTP), will be examined in depth, including a review of the challenges in using this measure both in the specific area of oral health and more generally, and how these challenges have (and have not) been addressed to date.

The first three chapters will therefore highlight a series of problems which will be addressed in the empirical section of the thesis which is divided into two studies; one to address each of the two oral health scenarios. The method, results and discussion for the first, Molar Tooth, study will be outlined in Chapters 4, 5 and 6 respectively, with Chapters 7, 8 and 9 addressing the second, Prevention, study. The overall themes will

be discussed in Chapter 10, leading to conclusions in Chapter 11 and finishing with a programme of future research emerging from the thesis in Chapter 12.

Based on the natural history of caries, the logical conceptual order of presentation of the two examples in this introduction, in the literature review and in the empirical section of the thesis, would be prevention first and molar tooth treatment second. However, the reverse order will be used. The reason for this is that the Molar Tooth Study is the more logical and more easily conceptualised extension of WTP into oral health, and so this is presented first. It is also the more substantial and conclusive of the two studies. The Prevention Study involves a more difficult valuation and is a step further in the application of WTP to oral health, and is therefore presented second. As will be made clear in the empirical section of the thesis, this second study was inconclusive in many respects but still presents several questions to be addressed in future programmes of research.

1.3 Dental examples used

In UK adults, the oral disease representing the major burden in terms of social welfare and resource implications is caries (Department of Health, 2005b). Two areas related to this disease process have been chosen for the studies around which this thesis is centred. The two examples represent clinical and resource allocation choices at different stages in the caries process.

Aside from this, the examples have also been chosen as there are difficult clinical and resource allocation choices related to them; they are encountered very frequently in dental practice and are topical internationally, nowhere more so than in the UK given the current policy context. The first is the decision about which treatment is appropriate for a non-vital (dead) molar tooth and the second is the delivery of prevention of caries in primary care (general dental practices).

1.3.1 Example 1: Treatment options for non-vital molar teeth

The first example is the treatment of non-vital molar teeth (i.e. teeth which have reached the end-point of the disease process of caries). When teeth become non-vital the choice in its simplest form is whether to preserve the tooth by undertaking endodontic (root canal) treatment or to extract the tooth with or without a prosthetic replacement of the tooth afterwards.

If a tooth has become non-vital then the live tissue (the pulp) inside the tooth has usually been killed by infection from the mouth. Untreated, this infection can spread beyond the tooth itself (often manifesting as an abscess). The aim of root canal treatment (RCT) is to remove the infected necrotic tissue, disinfect the space it occupied and then fill the space with an inert material that will prevent re-infection. The damaged tooth is then usually restored with a cap (crown).

However, faced with this clinical scenario, tooth preservation is not the only option. It is also possible to extract the tooth with or without a replacement prosthetic tooth being provided afterwards. Although this decision is complex and will depend in some circumstances on clinical factors, it could be argued that rather than embarking on a potentially unreliable RCT, it may be better to eliminate the infection more predictably with an extraction and then consider its prosthetic replacement. The advent of new technologies for prosthetic replacements (especially implants) with highly predictable outcomes, albeit at higher cost, has altered the way clinicians think about this particular decision (Pennington *et al.*, 2009; Zitzmann *et al.*, 2009). To put this argument another way, it is not clear if the extra benefit from saving a tooth outweighs the extra cost compared to an extraction, or that the extra cost of an implant provides any extra benefit compared to RCT.

This debate has become more important in the UK as evidence showing the poor technical quality of RCT performed in the National Health Service (NHS) has increased (Grieve and McAndrew, 1993; Saunders *et al.*, 1997; Dummer, 1998; McColl *et al.*, 1999; Lumley *et al.*, 2008). However, this issue is complicated by the fact that although the work may be technically poor and perhaps judged a failure in such terms, the failure rate, if defined in patient terms (a functional, pain free tooth), is much lower (Tickle *et al.*, 2008; Wu *et al.*, 2009). A vital input to this debate is patient preference which is often taken into account informally at an individual level, but has not been formally measured. Little is known about patient preference at a population level.

1.3.2 Example 2: Caries prevention

The second example is the application of a preventive intervention. Prevention should be the core of a good dental service for health and cost reasons (Steele, 2009). However, dentists, patients and policy makers have all been frustrated at the level of prevention

offered in NHS dentistry (House of Commons Health Committee, 2008). The reasons for this are complex but may include the need to realign patient expectations of having physical treatment when they pay to see a dentist, poor systems to reward dentists for prevention, and poor collection of data relating to prevention being carried out (Tomlinson and Treasure, 2006; Steele, 2009).

Again, little is known about patient preferences for prevention, but understanding this could help accelerate the uptake of prevention in dental primary care. The concept of valuing prevention may be of interest more widely in healthcare, both to those with commercial interests and policy makers, particularly given the potential long-term cost savings if there is less disease in the future.

One new intervention currently being marketed is a high concentration chlorhexidine varnish applied topically to teeth, which has been shown to be successful in preventing caries (Banting *et al.*, 2000). Its introduction provides a good opportunity to study patient preferences for prevention.

The next chapter will further develop the dental examples described in this chapter, looking at the historical and current context as well as the latest evidence surrounding these two scenarios. The resource allocation questions that the context and evidence for these two examples raise will be clarified alongside the potential for economics to answer these questions by measuring patient preferences.

Chapter 2. The dental issues in context

2.1 Introduction

In this chapter the two chosen dental scenarios will be explored in more detail, including a consideration of the developments and policy changes which have led to the current context. Contemporary research in these areas will be outlined along with the case for preference-based measures as a way of addressing some of the current resource allocation problems. Throughout this chapter and the remainder of the thesis, an understanding of caries is necessary and this will be dealt with in Section 2.2. Section 2.3 will cover the current policy context of dental services in the UK. Section 2.4 will address evidence based dentistry and then the specific policy context and evidence base for the two examples RCT and prevention will be dealt with in Sections 2.5 and 2.6 respectively. Section 2.7 will then outline the need for preference-based measures, before preference-based measures are discussed in detail in Chapter 3.

2.2 Caries

Figure 2.1 outlines a conceptual model of caries using an individual tooth as the unit of study. This model will be referred to throughout the thesis, and the individual steps and pathways will be described in detail in Section 2.2.1, which is concerned with the natural history of caries. However, a brief description of the model is presented here. Firstly, most teeth erupt into the mouth as sound teeth with intact mineralised hard tissues (enamel and dentine) covering the pulp. A combination of microbiota and fermentable carbohydrates create acid which demineralises this tissue. With appropriate preventive measures this process can be reversed. This equilibrium between demineralisation and remineralisation is shown moving between Level 1 and 2 of the diagram. Once demineralisation has begun, this process is known as caries, and once the caries has reached a certain level, tooth tissue will be lost, which can only be replaced by a filling (restoration) (Level 3). The size of restoration will depend on the amount of caries but once a restoration is placed, should a new restoration be required due to failure of the restoration or further demineralisation (moving left in Level 3), the new restoration will be larger. Without a restoration or where further demineralisation does occur, eventually the pulp of the tooth can become infected and inflamed, eventually leading to its necrosis (death) (moving to Level 4). At this stage the tooth can be preserved by undertaking RCT (moving right in Level 4) or extracted (moving to Level 5). The resulting gap can be replaced with a prosthesis (moving to Level 6). Of course,

RCT can also fail (moving left in Level 4) at which point re-treatment or extraction can be performed. These stages will be explained in further detail in the next section.

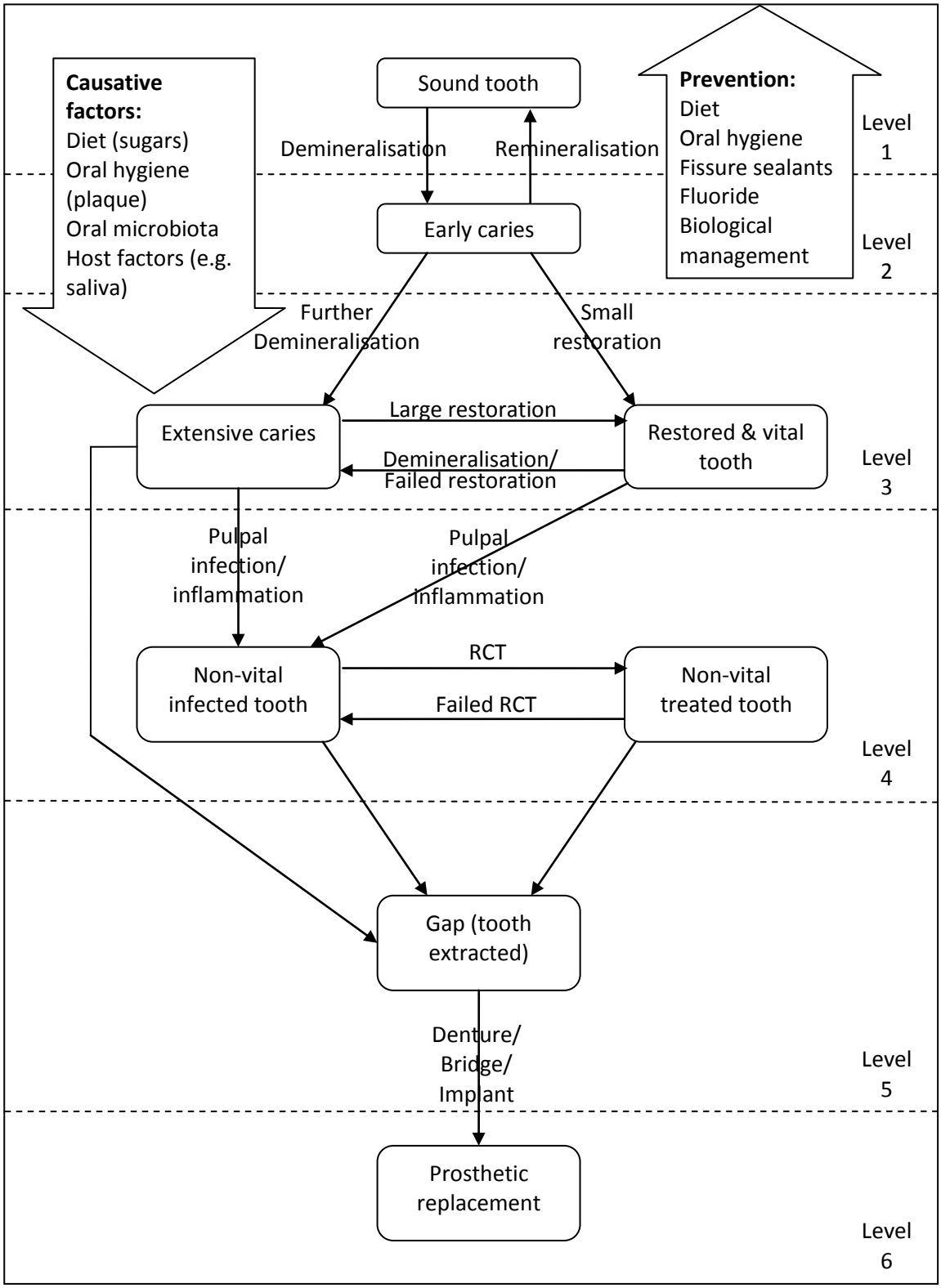

Figure 2. 1 Conceptual model of caries disease process and management on an individual tooth basis

2.2.1 Natural history of caries

Caries is the loss of tooth tissue following its demineralisation by acid produced by oral bacteria. These bacteria rely on specific local conditions created as part of a complex mature biofilm (plaque) attached to the surface of teeth, and a supply of fermentable carbohydrates, which the bacteria metabolise to produce tooth-damaging acid (Kidd, 2005). Any disruption to the plaque (e.g. through tooth brushing) means that the maturation of the biofilm cannot take place, thus preventing the carious process. The process of demineralisation can be accelerated where there are host factors affecting the process (Fejerskov, 1997), such as a lack of saliva, which has a protective function against the acid. The specific microbiota will also have a modifying effect on the process, with some species being more virulent than others (Aas *et al.*, 2008). These causative factors are illustrated in Figure 2.1 with the direction of the arrow clarifying that these factors move the tooth from being sound (Level 1), to early caries (Level 2) to more extensive caries (Level 3).

Once demineralisation of the hard tissues begins and the correct conditions are maintained for continued demineralisation, caries progresses through the tooth, getting closer to the pulp (containing the vascular and nervous tissues). When the carious process has reached this point, the pulp mounts an inflammatory response to the bacterial invasion. However, this is usually insufficient to prevent progress of the bacterial invasion and if left untreated, this eventually leads to necrosis of the vital tissue inside the tooth (moving from Level 3 to 4 in Figure 2.1) (Bergenholtz, 1990). This necrotic tissue becomes further infected and the result is often an abscess around the end of the root of the tooth. Without any intervention this can become chronic and can drain locally into the oral cavity, may be associated with repeated acute episodes with pain and infection, or may become systemic with spreading infection (Harty and Pitt Ford, 2004).

As shown in Figure 2.1, caries can be prevented (as well as the possibility of early caries being reversed) and four main methods have been identified (Murray *et al.*, 2003):

- Mechanical disruption of plaque through correct tooth-brushing and use of other oral hygiene aids

- Limitation of fermentable carbohydrate intakes in the diet
- The use of fluoride which has various effects on the carious process
- The removal or sealing off of plaque stagnation areas typically through the use of fissure sealants which are resins bonded to the tooth surfaces to occlude pits and fissures

An additional area, biological management, is now being recognised (Baelum, 2008), including the use of local or systemic antibacterials and immunisations. This is a rapidly developing area of prevention but as yet it has not been widely accepted as part of preventive practice.

Once caries has led to the loss of tooth tissue, treatment involves removal and replacement of demineralised, infected tooth tissue (a restoration). Where the amount of tissue lost is small in volume, a filling placed directly into the prepared cavity will often be sufficient, but if the volume to be replaced is larger, a crown (cap) may be placed to preserve the structure and function of the teeth (this is illustrated by moving from left to right within Level 3 in Figure 2.1). If the caries extends to the centre of the tooth and the pulp becomes infected and necrotic, a simple filling is not enough. To eliminate infection and the risks associated with it, the tooth may either be removed (moving from Level 4 to 5 in Figure 2.1) or the infected pulp space must be cleaned and filled (RCT), with a restoration placed to restore the structure, function and appearance of the tooth (shown by moving from left to right in Level 4 in Figure 2.1).

If a tooth is extracted following carious pulpal involvement (or other oral diseases, in particular periodontal (gum) disease) there are several treatment options including, leaving a gap (remaining at Level 4), permanently attaching artificial teeth to adjacent teeth (bridge), providing an artificial tooth on a removable plate (denture), or attaching an artificial tooth to an implant placed directly into the jaw bone (all of which are shown in Figure 2.1 as Level 6). The selection of option will both depend on local anatomical features (mainly the number of teeth lost in the mouth and their position, and how the teeth occlude (bite)), as well as the preferences of the patient and clinician (Graham *et al.*, 2006). This is the endpoint of the natural history process of caries.

2.2.2 Caries epidemiology

The changes in caries and its management in the UK over the last 40 years can be described using data from the UK Adult Dental Health Survey (ADHS) (Kelly *et al.*, 2000; The NHS Information Centre, 2010), a government organised survey carried out every 10 years on a representative national sample. At the time of writing this thesis, full results for 1998 were available, but only outline, initial results were available from the 2009 study.

The most important trend is that there has been a decrease in caries experience, shown by a decrease in the average number of teeth per individual with signs of disease or restoration (Nunn *et al.*, 2000; The NHS Information Centre, 2010). When this is analysed by different age groups, however, it can be seen that although there has been a decrease in the number of restored teeth in younger age groups, there has actually been an increase in restored teeth in older age groups. This reflects the fact that more decayed teeth are now treated and that, perhaps more importantly, more teeth are retained (in a restored state) rather than extracted. Although this is a positive step, it also brings a major concern, as more teeth are retained which are often heavily restored, requiring intensive maintenance and complex treatment planning in an ageing population, where the maintenance and treatment are often complicated by other social and medical factors (Department of Health, 2005a; Petersen and Yamamoto, 2005; Muller and Schimmel, 2007; Kleinman *et al.*, 2009).

The survey raises two additional areas of particular concern (The NHS Information Centre, 2010). Firstly, there is a high level of untreated caries in all age groups (29% have some untreated caries), particularly the 25-34 year old group, with 36% of individuals in this group having untreated caries present. There does, however, appear to be a decrease in England from an overall figure of 46% in 1998 to 28% in 2009 and from 52% to 28% in Northern Ireland. Worryingly, an increase has been seen in Wales from 41% to 43% (Scotland is not covered by the survey). Also, there is an increasingly prevalent type of caries, root caries, which develops around the roots of teeth which have been exposed as a result of loss of gingival coverage. In the 1998 survey, 29% of those in the 65+ group had root caries and an average of 10 teeth had susceptible surfaces in each individual (Nunn *et al.*, 2000). Root caries figures are not yet available for 2009.

Turning to tooth loss, in the most recent survey (2009), 94% of adults retained some natural teeth, although this obviously varied with age with almost 100% of those below 45 having some teeth and only 53% of those 85 or over (The NHS Information Centre, 2010). Between 1978 and 2009 there has been a marked reduction in complete edentulousness (no natural teeth left). For example, in England, edentulousness has dropped from 28% to 6%. However, although edentulousness is declining, it is unlikely to disappear completely as the incidence of new cases was 0-3% in under 65 year olds and 3-4% in 65 years or older over the 10 year period from 1988 to 1998 (Steele *et al.*, 2000) (figures are not yet available on incidence from 2009).

2.3 Dental services in the UK

Dental services and therefore management of caries in the UK is delivered in a mixed market with both public and private providers, based mainly in primary care general dental practices. The public provision of dental services is through the National Health Service (NHS), which commissions dental services from independent primary care practices at a local, primary care trust (PCT) level. Although a number of local initiatives are funded through local commissioning, the bulk of dental care is provided under nationally agreed arrangements (Holmes *et al.*, 2009). It is planned that PCT based commissioning of dentistry will end in 2012, with regional or national commissioning bodies taking over (Department of Health, 2010a). Throughout the thesis, where policy makers are referred to, in the NHS context, this can be thought of as PCT commissioners at present and the commissioners of whatever body is in place subsequently.

2.3.1 Historical developments

Upon the inception of the NHS in 1948, dental services were delivered under a nationally agreed system, with no local input. Initially, all dental services were free to the patient thus conforming to one of the guiding principles of the NHS, that all treatment should be free at the point of delivery (i.e. the patient pays nothing directly). Services mainly consisted of fillings, extractions and dentures and dentists were paid by the government on a fee per item of service basis, retaining their status as independent businesses. However, with the high disease prevalence, particularly of caries, the service was quickly overwhelmed and charges for dental treatment were introduced within three years, on a co-payment basis, with patients paying a fixed percentage of the

fee for each service and the government paying the remainder (King, 1998). By the time this arrangement for dental services ended in 2006, the patient paid 80% of the nationally set fee for each item of service with the government paying 20%. Aside from the introduction of new items of service as dental technology evolved and alterations to the fees and patient payable percentages, the system changed little until 1990. By this time, caries incidence had decreased dramatically, especially in younger groups as described in Section 2.2.2, and demand from patients was changing with an increased emphasis on saving teeth and aesthetic treatments. However, the system was still operating in the same way as when it had been set up (to deal with an overwhelming treatment need), leading to concerns by the late 1980s that dentists may have been over-treating patients (Schanschieff, 1986). So, an element of capitation for registering patients was introduced in 1990 in an effort to encourage less active treatment. This new system was very successful, so much so that, once again, it became unaffordable for the government and so a major cut of 7% in the fees for service items quickly followed in 1992 (Bloomfield, 1992). This was predictably unpopular with dentists and there was a substantial shift of dentists away from NHS provision to private dentistry. This shift has continued ever since, leading to dentistry operating in a truly mixed market of private and state provision.

However, even the 1990 changes did not truly address the changing dental epidemiology and treatment needs and demands, and so a number of new ways of working were piloted in so called Personal Dental Service (PDS) contracts by various dental practices between 1998 and 2006 (Department of Health, 1998), with many of them after 2002 following principles outlined in a review of dental services, called "Options for Change" (Department of Health, 2002).

By 2006, there was general agreement that the main contractual arrangements needed to change, and despite plans to model these on aspects of the generally successful PDS contracts, this proved impossible to implement due to financial problems of rolling this out nationally. Although it remains undocumented, it is widely understood that the projected fall in patient charge revenue would have left a £200 million deficit in the NHS dental budget. Instead, a new system was rapidly introduced in England and Wales without piloting (National Health Service (General Dental Services Contracts) Regulations, 2005). This system remains in place currently and is described below. In

the meantime, Scotland and Northern Ireland have continued with a fee per item of service system with some small amendments.

The new arrangements in England and Wales have proved unpopular with the profession and patients alike. For example, a postal survey of dental practitioners in Wales found that only 11% of the dentists surveyed liked the new method of remuneration (Chestnutt *et al.*, 2009). The influential parliamentary health select committee decided to investigate the system and their report (House of Commons Health Committee, 2008) found that the new system was failing to improve access, failing to increase prevention, and meant that some patients were not receiving the treatment they needed. The government therefore commissioned an independent review (Steele, 2009). The review recommended a series of major and minor changes in how NHS primary dental care is delivered. Some of these recommendations are now being piloted with the hope of implementing a new system nationally.

It is worthwhile noting that through the whole history of the NHS, including in the post-2006 system, there has always been provision for exemption from patient charges for certain groups including children under 18, those under 19 in full time education, mothers during pregnancy (and for 1 year post-natally) and those on income support welfare benefits (National Health Service (General Dental Services Contracts) Regulations, 2005). Additionally, there is currently a low income scheme where patients with low incomes can apply for a means tested reduction in the amount of dental charge they pay.

2.3.2 Current arrangements

The current arrangements have been in force since 2006 in England and Wales. The dental budget is devolved to PCTs who commission services from local independent dentists, working in primary care practices. In 2009, it was estimated that the NHS spend on dentistry for that year would be £2.25 billon, with patients contributing a further £550 million through patient charges (Steele, 2009).

Dentists are paid by negotiating an open-ended contract with their PCT to carry out a specific amount of dental work annually for a set sum of money. The dental work is defined by the number of courses of treatment (one course being all of the treatment a patient requires at one point in time) with different courses carrying a different value

depending on their complexity (National Health Service (General Dental Services Contracts) Regulations, 2005). The complexity is split into three bands, with band one courses of treatment being valued at one unit of dental activity (UDAs) and including examinations, radiographs, and prevention including basic periodontal treatment (scale and polish). The second band, attracting 3 UDAs, includes any direct work to the teeth such as restorations (fillings), extractions and RCTs as well as anything in band 1. The final band includes any dentistry where any work is prepared by a dental laboratory and fitted to the teeth, including crowns (caps), bridges (fixed false teeth) and both partial and removable complete dentures, as well as work in band 2 or 3. Contracts tend to be compared by dividing the total financial value by the number of UDAs to be delivered to give a price per UDA figure. It has been reported (British Dental Association, 2006) that contractual negotiations by different PCTs and dentists has led to a large variation in the "value" of a UDA with the range of average UDA values in 2006 for those PCTs where data were available being £14 to £36.

The patients' charges also relate to these three complexity bands, with 3 nationally set charges based on which band the patients most complex treatment falls in to. In the year the field work for the thesis was carried out (2009), the patient charges were £16.20 for the first band, £44.60 for the second and £198 for the third. These increased in April of that year following the annual review of the charges to £16.50, £45.60 with the upper band remaining at £198.

There is also a large and increasing private provision of dentistry in the UK. Although the exact national spend is difficult to determine, in 2006, for the first time, the proportion of mean earnings for a dentist were higher for private work than NHS work (The NHS Information Centre, 2007). This does not, however, mean that more treatment was provided privately as costs in the private sector are likely to be higher. From the patient's perspective, there are several different payment schemes in private dentistry (Office of Fair Trading, 2003). The most basic of these is a fee per item of service scheme, where the dentist sets fees for each of the items they provide and the patient pays for these directly out of pocket. Alternatively, the dentist may charge per unit of time, typically an hourly rate, with the patient paying this and any extra costs such as laboratory bills for any work prepared there. There are also many insurance-based schemes where a general health insurer, a dental specific insurer, or occasionally

insurance offered on a practice basis will cover the fee per item or time charges above. In such schemes there are often exclusions as to which treatment items or which expenses will be covered. A final example of a private payment system is a weighted capitation-based payment, where the patient pays the dentist a regular monthly fee set on disease risk levels which entitles them to receive any treatment required although again there are certain exclusions. The context that the empirical research in the Prevention Study in this thesis takes place in was a group of practices offering one such weighted capitation-based scheme, in this case, run by the UK based company, Denplan.

2.4 Evidence-based dentistry and decision making

As with all of healthcare, there has been an increasing emphasis on evidence-based practice in dentistry and although dentistry has been slower in adopting the principles, there has been an growing interest about incorporating evidence-based dentistry in daily practice, mainly with the aim of improving individual health outcomes (Richards and Lawrence, 1995).

Evidence-based healthcare has been defined as the "process of systematically finding, appraising, and using contemporaneous research findings as the basis for clinical decisions" (Rosenberg and Donald, 1995). As well as equipping practitioners with the tools to find, appraise and use the evidence, evidence-based practice depends upon having good evidence in the first place (McGlone *et al.*, 2001). It is perhaps chiefly in this area that dentistry has been lacking compared to some other branches of healthcare (Gordon and Dionne, 2004; Mjor *et al.*, 2005) and it is noteworthy that one of the key recommendations of the recent review of NHS dentistry was for more research into effectiveness of basic dental care such as caries and periodontal management (Steele, 2009).

Evidence-based practice can be used to ensure the most up to date process, materials and technology are used correctly for a procedure, but it is also used at an earlier step in a patient's journey, that is in the decision making process. Good decision making has been recognised as a key aspect of evidence-based practice (Sackett *et al.*, 1996). The decision making process can be viewed from two different levels; that of the individual

decision made between a patient and dentist and population level decisions which policy makers and funders must make.

The academic discipline concerned with decision making and developing formal rules for evidence-based decision making is decision analysis. Decision analysis uses both patient preference and clinical data to determine the best option in the face of the uncertainty inherent in health decisions. The emphasis in decision making is for shared decision making between clinician and patient, which has obvious ethical and clinical advantages (Charles *et al.*, 1997). For clinicians to share decision making, they must understand patient preferences and so formalised measures of patient preference are vital to good shared decision making and therefore to implementing evidence-based practice (Laine and Davidoff, 1996).

In a systematic review, Rohlin and Mileman (2000) identified 67 articles dealing with decision analysis in dentistry and oral health published between 1969 and 1998 and noted a gradual increase in the rate of publishing over the period until 1994 after which the rate surprisingly declined. Using the same search criteria presently suggest that the rate has now increased again and decision analysis is, once more, a growing field in dental research.

Having now set the general scene, the next section is concerned with the specific context and evidence-base for the two dental interventions that form the focus of the thesis: RCT and prevention.

2.5 Root canal treatment

RCT, or endodontics (see Level 4 of Figure 2.1) has been practised in some form since Chinese and Egyptians started in ancient times. However, modern endodontics can be traced to the 1930s when experiments established several of the principles of bacteria infecting root canal systems. Since then, huge advances have been made in improving the techniques of endodontics, although there is some debate over whether this has improved success rates with Harty and Pitt Ford (2004) finding a consequent improvement in both survival of teeth and more technical success measures, contrasting with Ng *et al.* (2007) who found no such improvement. However, whichever data are used, a success rate of retaining 100% of teeth in the longer term has not been achieved, and in some systems it is considerably lower. For example, in NHS general dental

practice, the 10 year survival rate (in terms of teeth retained in the mouth) of 30843 root canal treated teeth was 74% (Lumley *et al.*, 2008). This compares with an 8 year survival rate of 97% of 1462936 teeth in one insurance system in the USA (Salehrabi and Rotstein, 2004). The reasons for this marked difference have not been fully explained. Some of the difference may be due to case mix and case selection but may also relate, in part, to the systems of remuneration and expectations of outcome in the two systems.

2.5.1 UK policy context

In the NHS, pre-2006, RCT was one of the items on the fee per item scale, with several different fees depending on the complexity of the tooth being treated. There was evidence of a general feeling by the late 1990s that the fees paid to the dentists did not cover the costs of performing gold standard RCT, and therefore there were suggestions that sub-standard RCT was being performed (McColl *et al.*, 1999). This may form some of the explanation of the lower success rates in the NHS than the US insurance setting.

The contractual changes in 2006 further altered the fees that could be charged, whilst still failing to address, and possibly exacerbating, the problem of underpayment. In the 2006 system, RCT falls into the same band as the alternative treatment, extraction (National Health Service (Dental Charges) Amendment Regulations 2008), although in terms of the conceptual model of caries (Figure 2.1) this is a move from Level 4 to Level 5. Given that extractions are usually less complex and less costly for a dentist to provide than RCTs, extractions have been incentivised over RCTs. Additionally, with the band providing 3 UDAs for the dentist, there is still an argument that the fee that the dentist receives does not cover the costs of providing a gold standard RCT. This feeling has been illustrated in a sample of dentists, who when completing a survey noted that they felt that RCT was financially unviable (Davies and Macfarlane, 2010). Interestingly, one positive incentivisation of the system, is that, on the basis of evidence relating to tooth survival rates, it has been recommended that any molar tooth that has RCT should have a full coverage restoration (crown) placed over it (Ng *et al.*, 2010), and this would place the treatment in the next band, offering 12 UDAs, which may provide the opportunity of covering the cost of a high standard RCT, and hence be more attractive to dentists. However, even this view is a simplification as these 12 UDAs would also cover any other treatment required and so the decision to provide a crown

may be influenced by other treatment needs. Certainly if other treatment were needed the opportunity for covering the cost (or subsidising) of the endodontic treatment payment would be reduced.

2.5.2 Evidence-base for root canal treatment

The evidence-base for RCT is rapidly growing reflecting a rapidly advancing technological market in this area, with new innovations being developed constantly with the aim of improving the efficiency or quality of treatment.

One of the major issues in developing an evidence-base for endodontic treatment is that there has been little agreement in terms of what constitutes a success or a failure (Creugers *et al.*, 1993). On a superficial level, it may be that retention of a tooth over a defined period is the measure of success, and this is almost certainly the most relevant to a patient. However, this quickly becomes complicated if the criteria are extended to retention of a symptomless tooth, with different levels of symptoms (most often pain) seen as acceptable by different investigators. Another, widely applied, measure of success is the more clinical measure of a resolved or resolving apical radiolucency on a radiograph; infection within a necrotic tooth will begin to erode bone around the opening at the end of the root (apex), creating a radiolucent area around the end of the root. Once the infected, necrotic tissue is removed, bone replaces this eroded area, resulting in a reduction and eventual resolution of the radiolucency. However, this does not necessarily relate to the symptoms, and is not easy to measure reproducibly. Indeed, radiolucencies are usually measured using plain radiographic films, but a recent review highlighted under-estimates using simple, but very commonly used, plain radiographic films compared to more comprehensive cone beam computed tomography radiography (Estrela *et al.*, 2008). In patient terms, the most appropriate measure of success is probably a symptomless retained tooth (Pedrazzi *et al.*, 2008). However, this ignores the benefit of having a sound foundation for other restorations on the tooth, which may not necessarily be the case in a symptomless tooth. Patients may not be able to judge this (Abrams *et al.*, 1986) or perceive this as a benefit.

A multitude of clinical trials and subsequent systematic reviews have defined gold standard practice, and it is not within the remit of this review to discuss the techniques employed, other than to note that these gold standards are not always followed in

primary dental care on a day to day basis, particularly where the health system in operation makes this difficult as described in Section 2.5.1 (McColl *et al.*, 1999).

2.5.3 Success of treatment

The opening paragraph of section 2.5 described the 10 year survival rate of endodontically treated teeth on the NHS as 74% (Lumley *et al.*, 2008). A more relevant study to this thesis, concerned only with molar teeth showed a success rate of 91% (Tickle *et al.*, 2008). However, this study only examined 174 patients in one PCT and was purely cross-sectional with a variety of lengths of time since RCT (0-7.7 years), indicating that although the context studied in terms of teeth may have been more relevant than that in the study reporting the 74% success rate, methodologically the study was much weaker. Whichever figure is used, it may be that the success rate is seen as acceptable value for the money put into this treatment on the NHS system. However, this question of value for money, or efficiency has not actually been addressed.

Whichever success rate is chosen as the benchmark for RCT, it is clear that it is not 100%. The alternative, extraction of the tooth (moving to Level 5 in Figure 2.1), is a final outcome and therefore could be said to be 100% successful. Even if long term post-operative complications of extraction such as nerve damage or residual cysts are considered, the success rate is still extremely high (Simon and Matee, 2001).

However, it would seem plausible that a gap, following an extraction, and a retained tooth which has been endodontically treated would be viewed very differently by patients. For example, some patients may view an extraction as a (small) step between the health states of being completely dentate and edentulism, which may be more important for some patients than others (Nassani *et al.*, 2009). The differing views between a gap and a retained tooth will depend on patients' individual oral health values and so personal preference may be more important than success rates or costs.

If an extraction and prosthetic replacement is considered (moving to Level 6 in Figure 2.1), the comparison with a retained tooth may become more equal. The prosthetic options can be split into three categories at a superficial level, although within each category a variety of options and designs exist. The three categories are (partial) removable dentures, bridges (otherwise known as a fixed partial denture) and implants.

Again, success rates vary hugely depending on the population and the particular option or design (Torabinejad *et al.*, 2007). However, a recent extensive cost-effectiveness evaluation summarised the data available and modelled long term outcomes for each of the options (Pennington *et al.*, 2009), albeit for an anterior tooth rather than a posterior (molar tooth) as the focus is in this thesis. The long term outcomes are shown in Table 2.1.

Option	Male age 35 Cost (£)	Longevity (i.e. non-implant prosthesis years avoided)
1 Extraction	731	0
2 One RCT	805	15.81
3 RCT then re-RCT	828	17.29
4 RCT then surgical re-RCT	847	17.51
7 RCT/re-RCT/Implant	1071	21.58
8 RCT/surgical re-RCT/Implant	1079	21.59
5 RCT then Implant	1113	21.47
6 RCT/Implant/2nd Implant	1140	21.85
9 Implant	1623	20.12
10 Implant then 2nd implant	1717	21.73

Table 2. 1 Lifetime costs and prosthesis years avoided by different strategies for a non-vital incisor tooth. (adapted from Pennington *et al.*, 2009)

If the question of whether RCT or extraction with or without different prostheses should be chosen (at an individual, patient level) or available (at a health system level) is considered, it can be seen that these success rates are an important factor, especially when other factors, in particular costs are also considered. Indeed, there has been much unresolved debate over whether RCT or implants (which are comparatively costly) should be the first line treatment choice for a non-vital tooth (Felton, 2005; Trope, 2005; Zitzmann *et al.*, 2009).

The opposing arguments discussed by these authors are firstly that implants which are more predictable than RCT would potentially offer lower lifetime costs, and provide better oral health related quality of life, whereas others have argued that RCT is less

invasive, may provide very similar oral health related quality of life and the cheaper initial cost would offset any of the long term maintenance and replacement costs associated with lower success rates.

It is interesting to note that despite this extensive discussion, very little work on patient preferences or health economics has taken place in this area. One interesting exception is the cost-effectiveness analysis described above (Pennington *et al.*, 2009) in which the assumption was made that implants and RCT would be the preferred options over bridge and denture prostheses (on the basis of oral health related quality of life). Based on this assumption, the main outcome measure (selected mainly as other, more patient-centred, measures were not available) used was the longevity of the RCT or implant or in other words non-implant prosthesis (gap, denture and bridge) years avoided.

Using immediate extraction (or zero prosthesis years avoided) as the baseline, for a 35 year male having RCT, the incremental cost effectiveness ratio (ICER) was an extra £5 per extra prosthesis year avoided for RCT, with the option of an implant being both less effective and more costly than other options (i.e. dominated in cost effectiveness analysis terms). Interestingly, if RCT failed (moving back to the left in Level 5 of Figure 2.1) it was still more cost-effective to have a re-RCT than an implant, and it was only after the second failure (i.e. failure of the re-RCT) that implants became more effective at an extra cost of £57 per extra prosthesis year avoided.

2.5.4 Hierarchies of decision making

It is useful at this stage to comment on the emergent issue of the different levels of tooth state, treatment and decisions, particularly as the hierarchy and ordering of decisions informs the methodology and analysis of the Molar Tooth Study.

In Figure 2.1, the levels were split into root canal treated tooth, followed by extracted tooth, followed by prosthetic replacement, and this is indeed the path that a tooth would follow, and may well be the order of decision taken. However, as shown in the diagram, it is possible to miss out the root canal treated tooth stage and go directly to extraction, and indeed, in properly informed patient-centred decision making, the choice between saving a tooth (RCT) and extracting it, will be the first choice to be made. There is, however, also an argument to say that this initial choice, may actually be more complex as the prosthetic decision (or moving to Level 6 in Figure 2.1) may be made as part of

the same decision as extracting or saving the tooth, so that the choice may be a three-way decision (save, extract and leave a gap or extract and replace), or perhaps even a five way choice (save, extract and gap, extract and denture, extract and bridge, or extract and implant).

When viewing these choices in terms of oral health related quality of life, it may be more intuitive to think of this decision as the five-way choice, given that the options of saving the tooth and an implant may be the closest to a sound tooth, with a gap being the opposite end of the spectrum.

In reality, a variety of hierarchies of decisions probably exist, depending on how dentists present the options to patients, how patients conceptualise and therefore make decisions, and how quickly the series of decisions needs to be taken (e.g. an urgent painful situation versus an elective decision). However, there is little if any published work to date on hierarchies in the decision being investigated; saving, losing and replacing teeth. Interestingly, in the current NHS system, there may be an incentive for dentists to split the decision into smaller components over time, so as to split the treatment into separate "courses of treatment", which bring a number of UDAs for each course, thereby earning the dentist a greater number of UDAs in total.

In this thesis, the assumption is made, in the main, that the initial decision to remain on Level 4 or move to Level 5 of Figure 2.1 (save or extract the tooth), is the first step in the decision making process, and then the next decision is whether and how to move to Level 6 (leave a gap, or have a prosthesis, and which type).

2.6 Prevention of caries

The interventions and decisions discussed in Section 2.5 come at the end point of the caries process (as seen in Figure 2.1 where Section 2.5 has dealt with Levels 4, 5 and 6). This second example, prevention, is at the opposite end of the process (Between Level 1 and 2 in Figure 2.1), and can be seen, in health terms, as an upstream process, i.e. prevention targets the cause of disease rather than treating the consequences (further downstream) or whatever is done in terms of prevention has an effect downstream (or later in the disease process) (McKinlay, 1979). In health terms then, it can be seen that upstream or proactive approaches are preferable by avoiding any ill health altogether.

In oral health, the realisation in the 1940s that fluoride and subsequently alterations in diet (in the 1950s) could play a role in preventing caries was fundamental to the long standing philosophy that as well as treating disease, dentists have a duty to prevent oral disease (Ismail *et al.*, 2001). Eventually, the principles of caries prevention became well established as the four pillars of prevention, as described in Section 2.2.1 and shown in Figure 2.1. These are oral hygiene (brushing and use of other aids), diet (limiting sugar intake), the use of fluoride (in different forms) and the use of sealants to protect tooth surfaces (Murray *et al.*, 2003). As reported in Section 2.2.1, a fifth area, biological management is gaining credibility (Baelum, 2008).

2.6.1 UK policy context

Although this section will concentrate on NHS policy context, it is worthwhile remembering that private systems also play an important role in UK dentistry. Many of these systems work on a fee per item basis and so the issues to be outlined relating to the pre-2006 NHS system also relate to these systems. Insurance and capitation based system have a separate set of problems, and these will be discussed at appropriate points in the section below.

As explained in Section 2.3.1, in the UK, the NHS dental service, when originally set up, was focussed on treating the huge amount of disease present and little thought was given to prevention. This meant the NHS system incentivised treatment rather than prevention. Though reasonable in the early NHS, with the changing epidemiology of caries, a treatment based dental system became increasingly inappropriate.

The first attempt to address these issues was in the 1990 reforms when a small capitation element was introduced to dental contracts which was given for patient registration and was to include cover for preventive care (Yule, 1993). However, prevention was not a mandatory element for receiving the capitation payment and so there was still no incentive for preventive care, and there was little evidence of active prevention being undertaken by dentists.

The first policy document formally to recognise this problem was the dental response, Modernising dentistry: implementing the NHS plan (Department of Health, 2000a), to the wide-ranging NHS plan (Department of Health, 2000b). This response recognised that NHS dental services needed to be delivering preventive advice in order to improve

oral health as well as reducing health inequalities. The concepts introduced in this policy document were taken further with practical ideas to implement in the seminal document Options for Change (Department of Health, 2002). This document included further emphasis on prevention, in particular by recommending an oral health assessment as the gateway to NHS dentistry, with each assessment focussing on prevention and oral health promotion before any treatment, and it was expected that the subsequent 2006 reforms in the dental contract would implement this recommendation.

However, the final contract implemented in 2006 and currently in use did not incentivise prevention. All preventive advice and intervention is included in band 1 which also includes an examination. It is not possible to deliver prevention meaningfully without doing an examination. However, it is possible to do an examination without delivering any prevention. The dentist would receive the same number of UDAs (one) (UDAs are defined in Section 2.3.2) whether or not any prevention was delivered, and therefore prevention is still not incentivised. This view was shared by dentists, with, for example, a survey of dentists in Wales 18 months after the contract was implemented showing that 83% felt that the new contract did not allow them to spend more time doing prevention (Chestnutt *et al.*, 2009). This was one of the major criticisms of the Health Select Committee review of the 2006 contract (House of Commons Health Committee, 2008). Another survey found that one of the largest barriers for dentists to providing prevention was the lack of financial viability (Tomlinson and Treasure, 2006). This problem may also be true in private insurance-based and capitation systems if providers are not given an explicit incentive to provide prevention, although the problem is reduced as the dentist should see the benefit of prevention in terms of reduced treatment to be provided in the future, an incentive in its own right for dentists working in a capitation system.

Following these criticisms of the state-provided system, the recent review of NHS dentistry (Steele, 2009) made several specific references and recommendations regarding the delivery of prevention in any new system, most notably including quality and outcome measures designed to encourage prevention as part of the remuneration package. This approach has been adopted by some insurance and capitation based private systems.

One of the difficulties faced in trying to increase prevention is concerned with the fact that caries prevention can be either intervention based (e.g. application of varnishes or sealants) or advice based (e.g. diet advice or toothbrushing instruction). It could be that dentists are wary of providing interventions with potentially greater time costs and consumable costs for no extra payment. This is likely to be especially true in capitation based systems. On the other hand, patients could potentially be wary of paying for advice without any tangible intervention. There has been little or no research on the influence of this concept.

2.6.2 The evidence base

Taking into account the context, it is important to consider the evidence-base for caries prevention. Over the last 60 years, a great deal of research has evaluated the effectiveness of different preventive regimes and interventions, and this advice has been synthesised in many forms.

In the UK, in an effort to address the lack of prevention in NHS dentistry, the Department of Health together with the British Association for the Study of Community Dentistry, developed a "Prevention Toolkit" bringing together the highest level evidence and presenting its recommendations in an easy to implement format for dental practitioners (Department of Health and British Association for the Study of Community Dentistry, 2009). This has built on a network of guidelines produced by several organisations including the Scottish Intercollegiate Guideline Network, the British Society of Paediatric Dentistry and the National Institute for Clinical Excellence (NICE).

The evidence-based recommendations are still centred around the pillars of prevention, namely dietary intervention, oral hygiene advice, fluoride and fissure sealants, and of the 50 or more recommendations regarding caries, approximately half are backed by Grade 1 levels of evidence (the highest level of evidence).

Of interest to this thesis are those recommendations concerning fluoride, which can be delivered in five common formats, through toothpastes, mouthwash, supplements (tablets and drops), systemically through addition to water or other ingested materials and through the use of professionally applied fluoride varnishes. These fluoride varnishes deliver a high concentration of fluoride and are applied directly to the teeth to

act in a topical manner and the toolkit recommends application twice yearly for all patients and up to 4 times a year for those at risk of caries. The evidence-base for this particular recommendation is a Cochrane Systematic Review (Marinho *et al.*, 2002), which addressed only children. A separate review drew the same conclusions for children and extrapolated this to adults, whilst acknowledging the evidence-base for this was very weak (American Dental Association, 2006).

One question left unaddressed in either review is whether the decrease in caries is of more value than the cost of providing the varnish. This is a complex area with long term costs of treatment avoided, costs of providing the prevention, benefits to patients and society in terms of reduced caries and reduced treatment and disbenefits in terms of having prevention provided all important factors in the question. There is no other evidence to address this question with relation to varnish.

An additional concern not dealt with in the reviews is the distribution of caries in the population, where a small proportion have a large amount of disease. For example, in the UK, 57% of 5 year old children have no caries but in those that do the mean number of decayed teeth is 3.7 (Pitts *et al.*, 2007). It is unclear whether fluoride varnish addresses this inequality, which is probably the largest current dental public health concern in the UK.

More recently, chlorhexidine based varnishes have been investigated as an alternative to fluoride varnish. The evidence-base for these varnishes is small but growing quickly and initial results seem promising, especially in adult groups where there is little evidence for fluoride varnishes. The initial proposal followed successful in-vitro work (Emilson, 1994). Initial clinical results were mixed (vanRijkom *et al.*, 1996) but good results have been reported with a new formulation with a higher concentration of chlorhexidine (Banting *et al.*, 2000).

One particular use of chlorhexidine varnish is in the management of a specific form of caries, root caries, which forms on root surfaces of teeth exposed following gingival (gum) recession. This tends to affect older adults in which recession is more prevalent. One particular product has been developed as a high strength chlorhexidine varnish for use in older adults at risk of root caries. Existing research has shown the varnish is effective (Banting *et al.*, 2000). However, in addition to the questions about the value of

prevention already posed, this new varnish offers us further questions comparing the value of the existing fluoride varnishes and the newer chlorhexidine varnishes.

2.7 The need for patient preferences

There are several questions which arise in both of the areas of dentistry discussed in Sections 2.5 and 2.6. In the area of endodontics, it can be seen that further understanding of the factors influencing the decision making process would enhance patient level decision making (Laine and Davidoff, 1996), as well as health service design and commissioning (Holmes *et al.*, 2009). Additionally, an understanding of the benefit to patients would allow full evaluation of different treatment strategies including RCT, which is important in commissioning services (Donaldson and Shackley, 1997a).

In prevention, further work is needed on valuing prevention over treatment in order to compare benefit to cost. In addition, further understanding of patient choices and decision making surrounding prevention may allow better marketing and more appropriate provision to patients, increasing uptake. Finally, as new preventive technologies become available, such as the chlorhexidine varnish discussed, it is important to be able to quantify benefits in order to assess the efficiency of new technologies.

Answering all of these questions depends in whole or in part on understanding patient preferences or values. Although these two examples are used in this thesis, it can be seen that the questions outlined will apply to many other areas of oral healthcare, and that patient preferences are an important element of understanding and improving oral healthcare (Matthews *et al.*, 1999b). Despite the need for patient preference data outlined here, to date, little work has been carried out looking at patient preferences in dentistry as a whole (Vernazza *et al.*, in press). The nature of preferences and their measurement as well as their use in oral health will be discussed in detail in Chapter 3.

2.8 Conclusions

There are many areas of oral health that would benefit from a deeper understanding of patient preferences. In this chapter, two specific examples have been outlined, the treatment of a non-vital molar tooth and prevention of caries. It is a clear that these two areas alone raise a large number of questions where an understanding of patient preferences is vital.

For treating a molar tooth, there is controversy surrounding the best treatment option. This manifests as difficulties for patients choosing treatments at an individual level, and for policy makers and commissioners wishing to make the best treatments available for their populations. A comprehensive cost-benefit analysis, incorporating monetary valuations of preferences would give some direction to the current debates, particularly as these centre on long term efficiency. In addition, the preferences themselves, and understanding of the decision making processes, would help policy makers understand the needs and demands of their populations.

There are questions about the efficiency of prevention over treating the disease that would have otherwise been prevented. Again, a comprehensive cost-benefit analysis informed by patient preferences would be one tool in addressing this question. Patient preferences would also be useful for policy makers in understanding how prevention is valued and so how it is best delivered (given the public health importance of delivering prevention).

This thesis therefore aims to elicit patient preferences for these two areas of dentistry and also explore the influencing factors. This is reflected in the aims presented at the end of Chapter 3.

In Chapter 3, the economic theory behind patient preferences will be outlined, alongside a commentary on existing work on patient preferences in oral health. The chapter will outline the reasoning behind choosing one particular measure for this thesis and will underline some of the methodological issues encountered throughout the thesis.

Chapter 3. Preference-based measures and their use in oral health

3.1 Introduction

The argument that patient preferences have a key role to play in high quality, evidence-based oral healthcare has been set out in Chapter 2. Therefore, preference-based measures will be explored in more detail in this chapter. The remainder of Section 3.1 will introduce the notions of preference and utility in the context of economic evaluation. Section 3.2 will then address non-monetary valuation methods leading to a discussion of their current use in oral health in Section 3.3. Monetary valuation of health will then be discussed in Section 3.4 again leading to a discussion of oral health application in Section 3.5. Section 3.6 will address methodological concerns in using WTP before the conclusions of the literature review are drawn in Section 3.7 leading to a statement of the aims of the thesis in Section 3.8.

3.1.1 The role of economic evaluation

Several of the questions posed in relation to the two dental scenarios given in Chapter 2, are questions of efficiency, about how to use resources optimally. Appraising efficiency alongside efficacy (can it work?), effectiveness (does it work?), and availability (does it reach those who need it?) is an important part of addressing the quality of healthcare (Drummond *et al.*, 1997). Economics, which is founded on the principle of scarcity, is concerned with efficiency, as evaluation of efficiency becomes important when it is seen that resources are scarce across the whole of society (resources are never unlimited) and there is often debate about how best to use these resources.

This is true in any sector, for example, transport or education and healthcare is no exception, as illustrated by the questions posed following the exploration of the two dental examples in Chapter 2. In healthcare, there is not unlimited time, equipment, or money, amongst other things, to do all of the things that would be possible to secure or improve health. Hence, choices must be made about how best to use these scarce resources. Possible interventions that will use the resources therefore have to be appraised in order to make better informed allocations of resource.

When efficiency is appraised, two questions can be addressed:

- Is the most being gained from the resources used to achieve a specified health outcome?

- Is the intervention worth doing compared to other things that could be done with the same resources?

These two questions address technical efficiency and allocative efficiency respectively.

Technical efficiency is concerned with producing maximum output from scarce resources; the output has already been defined and efficiency looks at how best to achieve it (or alternatively this can be seen as producing a set output using the minimum resource). Donaldson & Shackley (1997a) define this as having a defined goal or objective and looking at how best to achieve it and Drummond (1997) argues that this is a narrow question where, for example, in health economics, it is looking at health benefits only.

Allocative efficiency, on the other hand, is a broader concept than technical efficiency, looking across different programmes with potentially different outputs, and requires judgements on which allocation of resources produce the most social welfare for society. Donaldson & Shackley (1997a) and Drummond (1997) define allocative efficiency questions as looking at whether a goal is worth achieving or how much of society's resources should be allocated to achieving it, and Jones-Lee (1989) states that allocative efficiency addresses the wider question of maximising social welfare and deciding an appropriate budget size for a programme.

Economic evaluations are concerned with comparing the inputs with the outcomes, or the costs with the benefits (cost and benefit here being used in their broadest sense). There are different forms of economic evaluation and which is used depends, in part, on whether a technical or allocative question is being asked. The four major types of economic evaluation are:

- Cost minimisation analysis
- Cost effectiveness analysis
- Cost utility analysis
- Cost benefit analysis

Although these analyses address different questions, they also vary by how their outcome (or benefit) is measured, but not by how cost is measured (cost measurement is therefore usually less contentious than benefit measurement). The differences are outlined in Table 3.1.

	Efficiency Question addressed	**Outcome measure**
Cost minimisation analysis	Technical	No outcome measure, only input costs considered
Cost effectiveness analysis		Outcome measured in natural/clinical units
Cost utility analysis	Technical and/or allocative	Outcome measured in terms of "health state utility" and life years gained, usually combined in the form of quality adjusted life years (QALYs)
Cost benefit analysis	Allocative	Outcome valued in monetary terms so that costs and benefits can be directly compared, or at least combined and then compared with costs and benefits of other uses of a given budget

Table 3. 1 Characteristics of different economic evaluations

3.1.2 Cost-effectiveness analysis and clinical measurements

In cost-effectiveness analyses, benefits are measured in natural units such as millimetres mercury blood pressure reduction. This is a simple, clinically acceptable and widely accepted way of looking at benefits. However, these natural unit measurements often do not reflect the impact on the patient, and so do not measure health in its wider definitions, for example, the widely accepted "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 1946). This is only one of many definitions of health but over 60 years after its first use, it is still relevant, marking a widespread acceptance of the concept of health as broad based, beyond clinical measurements and moving towards a more patient-centred view.

Measuring health in these terms, where impact on the patient is the key, becomes more difficult, and hence a variety of measures based around health related quality of life (HRQoL) have been developed, which are more patient centred and reflect a broader view of health. There are a wide variety of definitions of HRQoL from measures that reflect holistic wellbeing including social, emotional and physical aspects to measures which deal with how health affects ability to live a fulfilling life (Carr *et al.*, 2001).

Wilson and Cleary (1995) developed a conceptual model of health related quality of life (Figure 3.2) which shows patient characteristics and environmental characteristics influencing biological function, symptoms and perceptions which all in turn influence HRQoL. Carr *et al.* (2001) extend this by arguing that HRQoL is the difference between expectations and experience of health, and that current measures do not assess this satisfactorily.

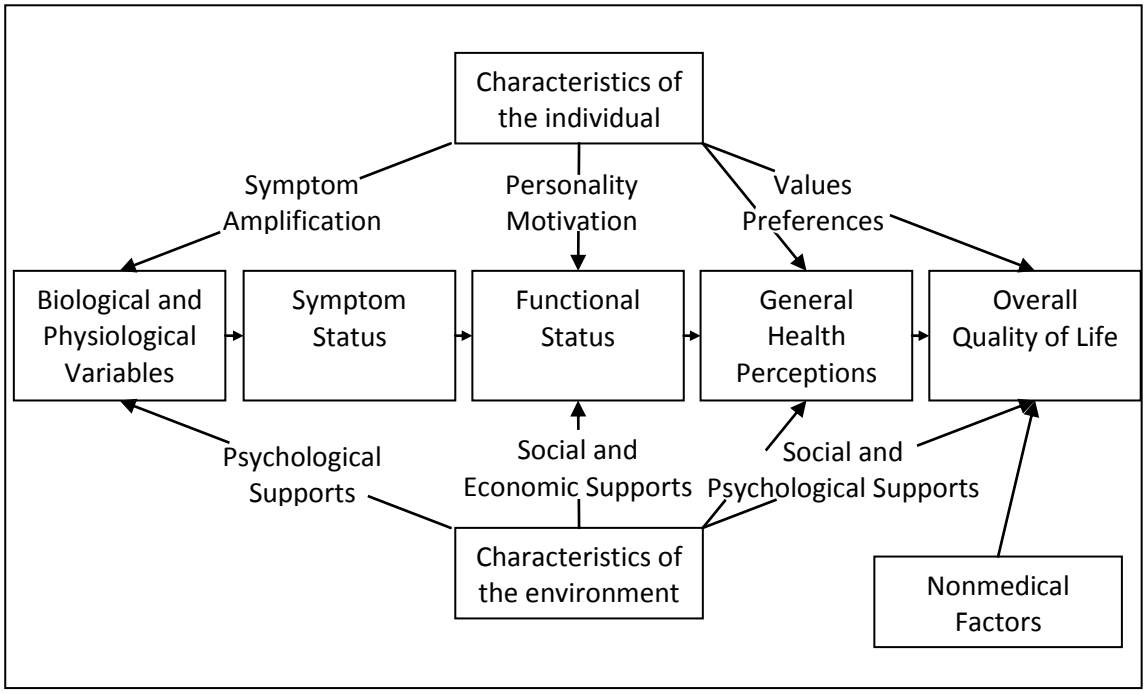

Figure 3. 1 Wilson and Cleary's (1995) Conceptual Model for Health Related Quality of Life

The measures currently used include both generic and specific measures (Guyatt *et al.*, 1993). Generic measures are usually health profiles which have a number of domains or attributes such as mobility or communication and each can be assigned a level. Specific measures are instruments that deal with a particular area such as a function, population or disease (Guyatt *et al.*, 1993). They have the advantage that they are often more responsive and clinically relevant but obviously do not allow comparison across different areas.

Although HRQoL shows the impact on the patient more clearly than natural unit clinical measurements, it still does not indicate the value people put on different dimensions of health relative to each other and, by extension, being in different overall health states, based on their preferences for such dimensions and states. This strength of preference (or valuation) is termed utility. In economic terms, utility is the broadest form of measurement of outcome, and the type of outcome measure necessary to answer

questions of allocative efficiency, being the outcome that is used in cost utility and cost benefit analyses (as can be seen in Table 3.1).

3.1.3 Utility

As described in Section 3.1.1, cost-utility and cost-benefit analysis rely on measures of preference. One of the most accepted theories of preferences is von-Neumann Morgenstern utility theory, based on a normative model which describes decision making in uncertainty (Von Neumann and Morgenstern, 2007). This has been widely accepted as the definitive decision making model, although there have been doubts expressed as to its validity (Gafni *et al.*, 1993). Uncertainty in this context is characterised in the form of a gamble, for example in health, typically, the respondent will be in health state, for example having caries in a tooth, which is certain, and there will be a treatment available which should resolve the caries but this is uncertain and if it fails it will make the caries worse. The respondent therefore has to decide whether to remain with the certain disease or take the gamble of a successful treatment. The theory states that in areas of uncertainty, such as health, individuals should choose the gamble that maximises the benefit or personal satisfaction, in this case, health. This benefit or satisfaction is termed utility, with "utils" being units of social wellbeing, or satisfaction, and so the theory follows that individuals will behave in ways that maximise utility, including making choices and taking gambles that maximise utility.

3.1.4 Cost utility analysis and health state utility valuations

As a theoretical construct, utility cannot be measured itself. Typically, in health, this has been overcome through the concept of "health state utility". The nomenclature has been used in various ways in the literature leading to confusion, and so in this thesis, this specific definition of utilities (as described in the remainder of this section) will be referred to as health state utility. Where the more generalised (and immeasurable) concept of utility as an idea of value is referred to, this will simply be called utility.

With health state utilities, utility is indicated using a scale of preference for being in a particular health state, with 1 equating to full health and 0 equating to death (Torrance, 1986) with states worse than death with a negative score also possible. The actual measurement of degrees of impairment uses a trade off of, for example, time or risk of

death against health or, in this case, health utility. This will be explained in detail in Section 3.2.

An easier method than the direct measurement using trade offs is to use a multi-attribute health scoring system where pre-measured utility scores have already been assigned to each of the possible levels or combinations in the scoring system (Torrance *et al.*, 1982). However, in order to work out the pre-determined scores, the basic methods of trade off referred to in the previous paragraph must still be performed for a relevant population. These multi-attribute methods simply avoid participants having to go through the health utility determination tasks themselves.

Whichever method is used, the most common way of using the values is to combine them with a measure of time spent in the health state to give "quality adjusted life years" (QALYs) (Williams, 1985). Other measures such as the Healthy Years Equivalent (HYE) have also been developed (Mehrez and Gafni, 1989) and used specifically in oral health (Birch *et al.*, 1998). HYEs and QALYs will also be dealt with in Section 3.2

In cost utility analysis, the cost is divided by the number of quality adjusted life years (QALYs) to get a cost per QALY (or more accurately when comparing two programmes, the extra cost per extra QALY as a marginal approach is employed). This then allows decision makers (usually by referring to a pre-agreed threshold) to decide whether the programme is worth implementing compared to another.

Although the advantages and disadvantages of health state utility and QALYs will be described in Section 3.2, it is important to consider at this stage that it has been suggested that health state utilities do not fully reflect the impact on the person, and may just reflect health benefits (Donaldson and Shackley, 1997a). Considering health benefits alone conflicts with the view that patient preference goes beyond health benefits to include many other aspects of care and its delivery such as the process needed in the intervention (e.g. keyhole surgery versus conventional open surgery) or the location where care can be delivered (at many sites locally or at a single distant centre) (Donaldson and Shackley, 1997b).

3.1.5 Cost-benefit analysis and monetary valuation

An alternative way of measuring preferences is to obtain monetary valuations for health. The most accepted way of valuing preferences for a non-market based goods (such as health) in monetary terms is contingent valuation (CV), most usually in the form of WTP (Donaldson *et al.*, 2006). In this technique, the respondent is presented with a hypothetical scenario, for example being in a particular health state, and asked the maximum they would be willing to pay to be in the scenario, or alternatively to get out of the scenario (Mitchell and Carson, 1988). This method attempts to value preferences using money as a proxy for utility (Drummond *et al.*, 1997).

It has been suggested that monetary valuation provides a broader valuation than health state utilities including non-health aspects (Donaldson and Shackley, 1997a). This argument will be discussed along with the theoretical background and measurement techniques used in monetary valuation in Section 3.4.

In cost-benefit analysis, the cost of the programme can simply be subtracted from the monetary worth to see if there is a net benefit. The concept of WTP and the issues surrounding it will be explored further in Section 3.4 and studied in the empirical section of the thesis. The argument that WTP is the most promising measure for oral health preference valuation and cost-benefit analysis the most appropriate economic evaluation will be developed throughout the remainder of the chapter.

There are a number of concerns with both health state utility measures and monetary measures. For health state utilities there are concerns, on a theoretical level, that the measurement techniques are not consistent with welfare economics and that aspects of individuals' health values such as the delivery of the health care (process utility) are excluded by the measurements techniques. In oral health, measuring health state utility uses the full health to death scale, which is generally inappropriate, whilst the lack of required sensitivity of the measures to small changes in health is also a concern. With monetary valuation, there is a different set of issues including the hypothetical nature of the exercise, the association of WTP with ability to pay, valuation of multiple parts versus the whole of a treatment, and the effect of knowledge of (adjusted, government controlled) prices on WTP valuations. All of these issues will be explored in subsequent sections.

3.1.6 The use of cost-utility and cost-benefit analysis

It can be seen that both cost-utility and cost-benefit analyses address allocative questions and include utility as an outcome (through a proxy measure) (Donaldson and Shackley, 1997a). The analyses may not give the whole answer, as, in either approach, the size of the (usually publicly determined) budget constraint is not taken into account. So, even if there is a favourable cost per QALY or a positive net benefit, a programme may not be affordable and therefore may not be implemented. However, these approaches which address allocative efficiency can be used, in conjunction with information on budget constraints, in priority setting for policy makers (and for clinical decision making at an individual level). An additional advantage of the cost-benefit approach is that the budget constraint problem can be overcome by eliciting values for several programmes competing at the margin of the budget and these can be used directly in comparative CBA approaches (Shackley and Donaldson, 2000).

The outcome for both types of analysis includes some notion of patient preference. Therefore understanding of patient preference and the advantages, disadvantages and validity and reliability of each elicitation method is vital to conducting comprehensive economic analysis, such as cost-utility analysis and cost-benefit analysis and to assessing allocative efficiency. The remainder of the chapter is therefore dedicated to these facets of different preference-based measures commencing with non-monetary (health state utility) measures in Section 3.2 and moving on to monetary measures in Section 3.4.

3.2 Non-monetary valuation

3.2.1 QALYs

The basic construction of a QALY valuation for a particular health state is the number of years of life spent in that state multiplied by a health state utility based weighting of the health state (i.e. the preference for being in that particular health state) (Williams, 1985). So, for example, a health state which lasts 10 years and is valued at 0.9 in terms of health state utility would give 9 QALYs. Thus, 1 QALY is equivalent to 1 year in full health.

QALYs can be either generic or condition specific (Donaldson and Shackley, 1997a). Generic QALYs are determined by developing a classification of possible health states

based on generic determinants of health (usually a quality of life measure). Health state utilities are then determined (see Section 3.2.3) for each of the possible states within the classification. Then, when the classification is used, the pre-existing health state utility score can be looked up for any particular level within the classification. In contrast, condition specific QALYs are determined by presenting a detailed description of a particular condition or intervention and a health state utility score is determined for this.

3.2.2 HYEs

The development of the HYE followed the belief that QALYs do not fully represent preferences and hence are not based in utility theory (Mehrez and Gafni, 1989). In particular, there is concern that the assumptions required for health state utilities and QALYs to be considered true utilities are so restrictive as to be unrealistic. It has been argued that HYEs do not suffer the same need of restrictive assumptions and reflect preferences fully (Gafni *et al.*, 1993). The HYE is determined by establishing what length of time in full health is equivalent to a set time in the health state of interest (at a lower utility level).

3.2.3 Methods of valuation

Two pieces of information are needed in QALY determination. Firstly the time spent in a particular health state, and second the utility associated with that health state to be used as a weighting. Times can be determined from clinical observation or estimates, but the utilities are more difficult to obtain (Williams, 1985). Three main methods have developed, the visual analogue scale (VAS), standard gamble (SG) and time trade off (TTO) (Torrance, 1986). It has been argued that of these SG is the only one to hold with utility theory fully (Torrance, 1986).

VAS involves the subject simply placing health states on a linear scale between 0 and 1 (death and full health respectively). SG involves the subject being presented with a choice between being in the health state of interest for a set time (t) and treatment. The treatment has two possible outcomes immediate death or full health for the set time, t. The probability (p) of the treatment providing full health rather than death is varied until the subject is indifferent between treatment and the health state. At this point the probability of full health with treatment is equal to the utility for the health state of interest. TTO was developed as a simpler measure than SG, particularly by eliminating

probabilities which can be difficult to grasp (Drummond *et al.*, 1997). With TTO the subject is given two possibilities, living in the health state of interest for a set time (t) followed by death or living in full health for a variable shorter time (x), followed by death. x is varied until the subject is indifferent between the two choices. The utility is then given by x/t. The choices underlying SG and TTO are illustrated in Figure 3.2.

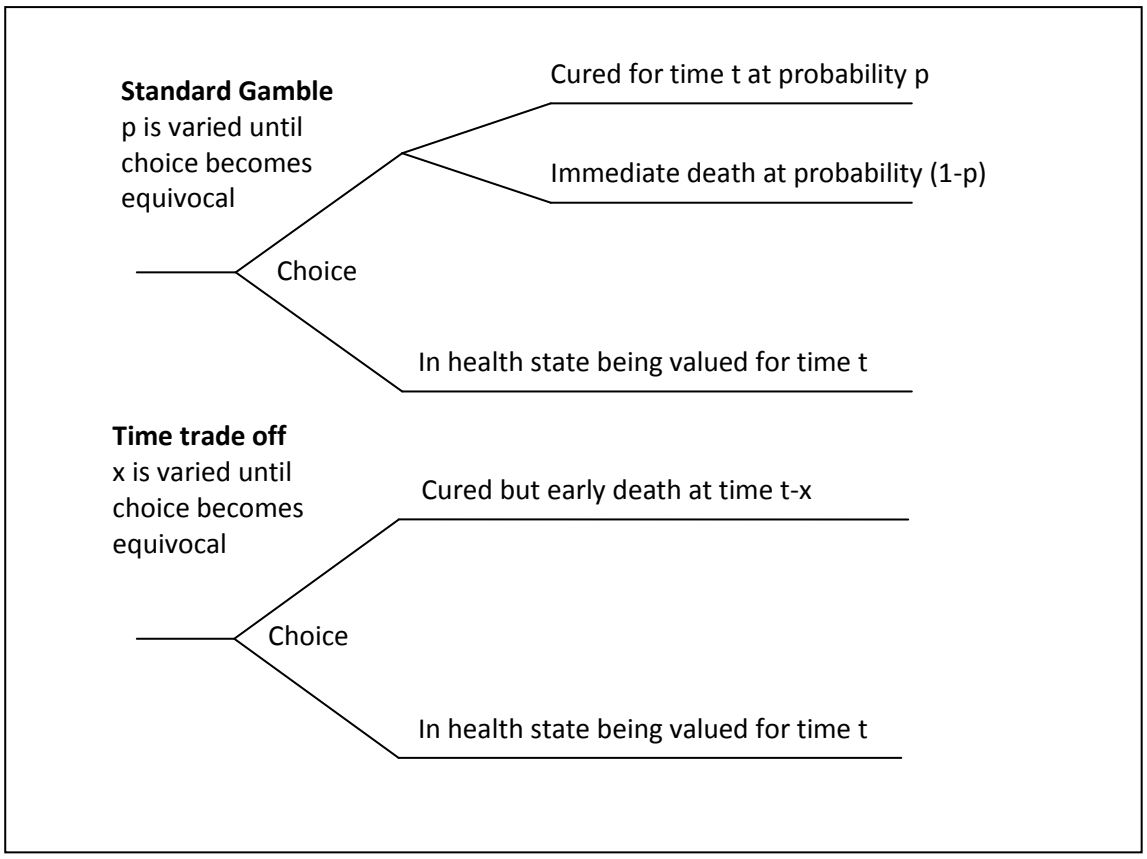

Figure 3. 2 Diagrammatic illustration of choices in standard gamble and time trade off (adapted from Drummond (1997))

Although VAS and TTO are simpler than SG, neither are developed from utility theory or incorporate risk into their assessment and have been criticised for this. Encouragingly however, TTO has shown similar, although not exactly equivalent, scores to SG measurement (Drummond *et al.*, 1997).

Although the health state utilities must be determined for condition specific QALYs, published values for different health states can be used with generic QALYs. Usually this will involve the use of a multi-attribute classification system (Torrance *et al.*, 1982). Here, an extension of utility theory, multi-attribute utility theory must be applied. In doing this one further assumption is required over the standard utility theory; the independence of attributes. This assumption can take three levels: order one

(multilinear) independence where there is no interaction between utilities for levels of any one attribute and levels on any other attribute; mutual (multiplicative) where there is no interaction between utilities for levels on some attributes and levels of other attributes; and additive where there is no interaction between utilities of any attributes (this rarely holds) (Torrance *et al.*, 1982).

Various multi-attribute systems have been described. Originally the most developed of these was the health utilities index (HUI) (now with three versions Mark I-III) (Feeny *et al.*, 1996). This system has various attributes (7 in Mark II) such as sensation, mobility, emotion etc. each with between 3 and 5 levels described. In the Mark II system this gives 24,000 different states (with the various combinations of different levels across each attribute). Utilities are then determined for a smaller number of key states using one of the methods described above, across a large representative sample, and the theory allows health state utilities for all states to be calculated. Then, whenever the system is used, health state utilities can be looked up rather than being determined individually.

Following development of the HUI, a European wide group, EuroQol, was set up to develop a new multi-attribute model and this was first published in 1990. There have been several revisions with different numbers of domains and the most accepted version today has 5 dimensions and is therefore know as EQ-5D (Brooks, 1996). A summary of early work on the instrument (Brooks, 1996) showed construct validity but that the instrument was not as sensitive as some others. More recent work comparing the EQ-5D with a newer measure, the SF-6D (Petrou and Hockley, 2005), found that both measures were empirically valid in that they reacted as expected, although the SF-6D was more efficient.

HYEs are determined using a two stage SG measurement (Mehrez and Gafni, 1989). The first stage involves choosing between the path through various health states over a set time and treatment that could either result in immediate death or perfect health for the same time, with the probability of death and health being altered until the subject is indifferent between the treatment and the health states path. This gives the health state utility of the whole path. The second stage involves the subject being asked the same choice, but this time the probability of death or health following treatment is fixed at the level given in the first stage and the time of the health states path of interest is varied.

This gives the number of healthy years with the same health state utility as that determined in stage 1, or the HYE. As can be seen, this is somewhat more complex than any of the main three QALY valuation methods.

3.2.4 HYEs versus QALYs

There has been much debate over the superiority of HYEs over QALYs. Initially when introduced, Mehrez and Gafni (1989) claimed the HYE to be superior to the QALY as it avoided restrictive assumptions which the QALY model required. This was followed by responses including the claim that the 2 stage gamble for HYE was equivalent to a one stage TTO measurement (Buckingham, 1993; Culyer and Wagstaff, 1993), and whilst Gafni and Birch (1997) acknowledge that the HYE is based on a TTO measurement (in the 2nd stage), they show that TTO based QALYs and TTO based HYEs are different with the HYE requiring less assumptions.

Another claim of superiority is that the HYE reflects risk attitude (a necessity for any utility based function) whereas QALYs measured with VAS or TTO do not (SG does incorporate risk) (Mehrez and Gafni, 1989). However, Buckingham (1993) states that the two gambles used in SG cancel each other out. Mehrez and Gafni (1993) refute this stating that as the gambles are neither equal nor opposite, they do not cancel out. A further problem claimed by Culyer and Wagstaff (1993) is that neither method reflects time preference (or risk attitude to years of life). Gafni, Birch and Mehrez (1993) refute this stating (as does Buckingham (1993)) that the TTO valuation includes time preference implicitly, and that Culyer and Wagstaff's concern holds true only because they are assuming one specific utility function to be universal, which cannot be correct.

Therefore, it seems that the QALY requires various assumptions to fit with the utility model, some of which are unlikely to hold. The HYE on the other hand is more firmly rooted in utility theory. However, the QALY has become much more widely accepted than the HYE, possibly due to the relative ease of measurement. Neither method is perfect (or universally agreed upon), but it is essential to have some measure of preference to answer allocative efficiency questions, and there are no better alternatives which are health state utility measures (Gafni and Birch, 1997).

It must be remembered that theoretical "utils" cannot be measured directly and health state utilities have been developed as a proxy for utility. Similarly, monetary valuation

of health can also be a proxy for theoretical "utils", although monetary valuation and health state utilities are derived in entirely different ways, and may or may not be good proxies for utility. However, monetary valuation could provide a valid alternative to QALYs and HYEs, with both advantages and disadvantages over these measures. Monetary valuation will be outlined in Section 3.4 onwards.

3.3 Use of non-monetary preference measures in oral health

Once again, continuing the theme from Chapter 2 and using caries as an exemplar, there is one common non-preference-based index used in caries measurement which is the DMFT (decayed, missing, filled teeth) (Kidd, 2005). Here subjects are examined visually and the number of teeth that are decayed, missing and filled are recorded. There are variants on this such as the dmft used to record primary (baby) teeth and DMFS where the number of decayed, missing or filled surfaces (each tooth having five surfaces in the oral cavity) is recorded. This is a basic index with reliability dependent on the subjectivity of the examination, no consideration of whether the lost and filled teeth were lost or filled due to caries or some other reason and no recording of lesions which are not clinically visible. Nevertheless, it is an easily applied index, it can be easily adapted as an outcome measure and it has been widely accepted.

A new system, the International Caries Detection and Assessment System (ICDAS) has been developed and early evaluation suggests it is a practical and valid system (Ismail *et al.*, 2007), but this has yet to gain widespread acceptance. Both of these indices are entirely clinical and therefore may not consider the impact on the patient (as discussed in Section 3.1.2), for example in terms of pain or functionality or appearance. In order to do this, the impact on quality of life must be considered.

3.3.1 Oral health related quality of life

Although oral health is part of general health, the definition of oral health has been developed further with the development of a conceptual model of oral heath (Locker, 1988). This is shown in Figure 3.3. The model is supported by empirical evidence, although in reality it may be more complex than that shown in Figure 3.3 (Baker, 2007). As with general health, natural unit measurements, such as DMFT, do not necessarily reflect health when it is defined in this way, and so once again, we must look at other measures.

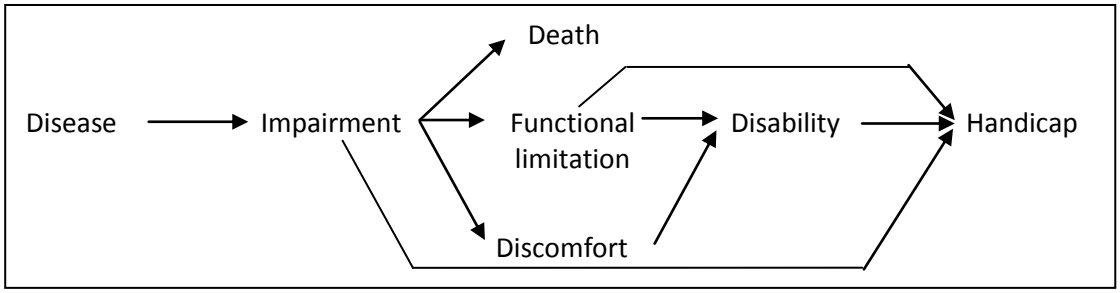

Figure 3. 3 Conceptual Model of Oral Health ((Locker, 1988) adapted from WHO (1980))

Thinking about measuring health in the terms defined in the conceptual model Inglehart and Bagramian (2002) describe four components of Oral Health Related Quality of Life (OHRQoL); functional, psychological, social, and experience of pain/discomfort. The level of each component is defined by the person, the situation and their interaction.

Although global ratings of HRQoL can measure changes in OHRQoL and have been used, several specific multiple-item measures have been developed that deal with oral health or aspects of it, usually fitting Locker's conceptual model described above. The most established instruments include the Oral Health Impact Profile (OHIP) (Locker and Slade, 1993), the General Oral Health Assessment Index (GOHAI) (Atchison and Dolan, 1990), the Dental Impact on Daily Living (DIDL) (Leao and Sheiham, 1995), the Oral Impact on Daily Performance (OIDP) (Adulyanon and Sheiham, 1997) and the Oral Health Related Quality of Life - UK (OHQoL-UK) (McGrath and Bedi, 2001). Of these OHIP has become the most established and so will be described in more detail here. The OHIP has seven domains; function, pain, physical disability, psychological disability, social disability, handicap (it can be seen that these domains fit closely with Locker's model) (Slade and Spencer, 1994). There are 49 questions and the response for each is on a five point scale from "very often" to "never". The scores can then be added to provided an overall score, or more usefully, the number of items at a particular level can be counted (Inglehart and Bagramian, 2002).

As was found with general health, HRQoL measures do not measure the value or preference that patients put on being in a health state. In order to address questions of allocative efficiency as detailed in Section 3.1.1, there is a need for measures which incorporate the value or preference for being in health states.

3.3.2 Use of health state utilities in oral health

Measurement of health state utilities, as described earlier in the chapter, can be undertaken for dental health states, and this has been done in a limited number of dental settings. Table 3.2 outlines these studies and in addition, studies using WTP are included here but discussed later. As well as the three standard utility measures (VAS, TTO, SG), one study attempted to use specially adapted dental measures of dental free time trade off (DFTO) and dental visual analogue scale (DVAS) (Fyffe *et al.*, 1999).

Study	**Measure used**	**Intervention/State measured**	**Sample**
Antczak-Bouckoms and Weinstein (1987)	TTO, SG	Periodontal treatment alternatives	Patients - secondary care
Fyffe and Kay (1992)	SG	Tooth states (caries related)	Dentists, General population
Reit and Kvist (1998)	SG, VAS	Endodontic retreatment	Dental Students
Dixon and Shackley (1999)	WTP	Water fluoridation	General population
Fyffe *et al.* (1999)	DFTO, DVAS	Tooth states (caries related)	Adolescent patients
Matthews *et al.* (1999a)	WTP	Periodontal therapy	Patients - secondary care, Dentists
Kvist and Reit (2002)	SG	Endodontic retreatment	Dentists
Matthews *et al.* (2002)	WTP	Anaesthetic Gel	Patients - secondary care, General population
Birch *et al.* (2004)	WTP	Dentine Regeneration	General population
Nassani *et al.* (2005)	VAS	Interventions to maintain a shortened dental arch	Partially dentate patients
Thierer and Friedman (2006)	TTO	Oral health states	Older adults
Oscarson, Lindholm and Kallestal (2007)	WTP	Caries Prevention	General population (19 year olds)
Tianviwat, Chongsuvivatwong & Birch (2008b)	WTP	Children's extractions, restorations, prevention	General population (Parents)
Tianviwat, Chongsuvivatwong & Birch (2008a)	WTP	Children's restorations, prevention	General population (Parents)
Esfandiari *et al.* (2009)	WTP	Implant supported dentures	Patients - secondary care,
Nassani *et al.* (2009)	VAS	Missing teeth	Patients - secondary care,
Rosvall *et al.* (2009)	WTP	Orthodontic Appliances	Not stated
Leung & McGrath (2010)	WTP	Single Implant Restorations	Patients - secondary care,

Table 3. 2 Studies in dentistry measuring utilities and WTP (TTO=Time Trade Off, SG=Standard Gamble, VAS=Visual Analogue Scale DFTO=Dental Free Time Trade Off, DVAS=Dental Visual Analogue Scale) Adapted from Vernazza *et al.* (in press) Note that interventions outside of dentistry have been excluded e.g. dento-facial surgery.

It can be seen from Table 3.2, that there is only a very limited number of studies measuring health state utilities in oral health and there has only been one attempt to use utilities in an economic analysis (Bhuridej *et al.*, 2007). Cost-effectiveness analyses, using natural unit measurements are the predominant analyses done in dentistry. These are usually limited to technical efficiency type questions, although some address allocative efficiency where extra benefits and extra costs have been quantified and compared between programmes. Even where this is the case, with no use of preference-based measures, it is unclear if the benefits are valued and to what extent by patients or the public.

This predominance of CEAs was also the case in medicine also although more recently, particularly since QALYs have been widely accepted by agencies responsible for health intervention evaluation such as the National Institute for Health and Clinical Excellence (NICE) in the UK, the use of CUA has grown remarkably.

In dentistry, however, this change of emphasis from CEA to CUA has not yet materialised and there is little sign of any growth in the numbers of CUAs or CBAs undertaken at present.

3.3.3 Special issues in utility measurement in oral health

The reason for the lack of utility measurement and CUA use in oral health may be due to several problems with using utilities that are specific to dental settings. One of the problems with using existing utility measures in dentistry, is that changes associated with an intervention on a single tooth are likely to be very small as utility is measured on a scale of 0-1 where 1 is full health and 0 is death (Drummond *et al.*, 1997), and therefore these will be difficult to measure. This is combined with the problem that death is not easily compared to dental health states and so it is not a useful outcome measure to which patients will relate.

Another major problem with utility measurements in dentistry is the complex nature of the relationship of the status of one tooth with that of the rest of the dentition and oral health, as well as the relationship between an intervention and further interventions that may be required over time. So, saving a tooth may have a different effect on oral health leading to the intervention to save the tooth being valued differently depending on many factors, for example:

- the prognosis of this tooth (i.e. what are the chances of the intervention actually resulting in retention of the tooth)

- the aesthetic impact of its loss (i.e. an anterior (front) tooth is likely to be valued more highly than a posterior (back) tooth)

- whether there is an opposing tooth to occlude with (bite against) and whether there are sufficient other teeth present to allow efficient eating (masticatory or functional impact)

- what options are available if the tooth is lost (e.g. is a removable partial denture the only option or could a fixed bridge be used)

With many factors influencing the value of a dental intervention there may be certain points in the lifetime of a dentition (i.e. different health states) where the decisions become particularly difficult because value changes are larger, where QALYs may be sensitive enough and useful. These points in the lifetime of a dentition (or oral health states) will be discussed in more detail in Section 3.5.3. However, these pivotal points have not been defined and may be different for every patient. This means that QALYs may not be useful at other non-pivotal points in the lifetime of a dentition and that QALYs would only be useful at different times for different patients.

Finally, process utility is probably a hugely important aspect of dentistry, probably much more so than in many other areas of health care. For example, dental anxiety and phobia is common in the UK population (The NHS Information Centre, 2010) and for those patients with marked anxiety, a dental treatment option may not be selected for the final oral health outcome but rather for the amount of perceived pain it is likely to cause or even something as specific as to reduce the number of local anaesthetics or avoid the use of a dental hand-piece (drill), where a patient has a particular anxiety about this aspect of the process. Existing health state utility measures do not capture this notion of process utility well.

3.3.4 Quality adjusted tooth years

The quality adjusted tooth year (QATY) (Birch, 1986), was developed for dentistry, partly to address some of the problems described in Section 3.3.3. With a QATY the

quality and number of extra years of life gained is not measured, but the focus is on the quality and number of years a tooth is retained before extraction. Although this addresses the major problem concerning how oral health maps onto the scale used in health state utilities (particularly with its anchor point of death), the quality aspect is still based on the similar principles to the health state utility measures with all of the generic problems of described before. Additionally, the new measure does not correct for the dental specific problems of the complex relationship of one tooth with oral health and process utility.

Although QATYs would allow comparison between dental states, they could not be compared with other interventions measured with QALYs. Possibly as a result of these potential issues, QATYs have not been widely adopted with only two studies using the measure (one using utilities derived from Time Trade Off (TTO) measurements (Antczak-Bouckoms and Weinstein, 1987) and the other (Cunningham *et al.*, 2003) using utilities derived from another study (Fyffe and Kay, 1992)).

3.3.5 HYEs in dentistry

Another alternative proposed for dentistry is HYEs as described in Section 3.2.2. Although use of HYEs would address some of the generic problems with QALYs, as described in Section 3.2.4, many of the dental specific problems remain the same. There has only been one study measuring HYEs in dentistry (Birch *et al.*, 1998) and it is likely that for dental measurements the complexity of the measure has led to it not being widely accepted. As with QALYs and QATYs, HYEs may have a place in oral health measurement, and HYEs would be the more appropriate measure if arguments of theoretical superiority do hold true. In particular, HYEs may be of use in the measurement of oral health states, rather than in valuing specific interventions.

3.4 Monetary valuation of health

Given the problems with health state utility based measures, both generically and in oral health, outlined in Sections 3.2 and 3.3, the alternative of monetary valuation will be explored in this section and its application to oral health in the subsequent section.

Valuation of health care outcomes in monetary terms has long been proposed as a suitable valuation measure for economic analyses, and indeed is the measure necessary in a CBA. It has the intuitive appeal that it can immediately be compared with costs

which are almost always expressed in monetary terms themselves (O'Brien and Gafni, 1996). However, there are further advantages over this obvious appeal, as well as the method's own disadvantages. The main methods will be discussed in 3.4.1, and then the most accepted measure, WTP, will be discussed for the remainder of the chapter, including an outline of the advantages in Section 3.4.2, some of the criticisms of the method in Section 3.4.3, its application in oral health in Section 3.5 and then some of the methodological issues in its use in Section 3.6.

3.4.1 Main methods of monetary valuation

There have been three major methods of monetary valuation of health.

Human Capital Approach. In this approach, the valuation of health is based on what individuals would produce if they were in full health, using market wage rates (Drummond *et al.*, 1997). This, although practical and easy to measure, does not sit well with welfare economics as it is based on the assumption that the only goal is to increase national production, thus ignoring other benefits of health and also those who do not earn a wage (O'Brien and Gafni, 1996).

Revealed Preference (RP). In this approach, preferences are obtained by observing the trade offs made in real situations between money and health, such as observing pay for jobs with different risks, or looking at travel costs to get to services with different characteristics (Carson *et al.*, 1996). A meta-analysis (Carson *et al.*, 1996) shows that generally RP gives higher values than contingent valuation (explained below), but that the correlation between the measures is good. However, a major criticism of RP is that the monetary values are associated with other factors than the characteristic being considered, and that the context makes these values non-generalisable (Jones-Lee *et al.*, 1985). The measurement of revealed preferences also relies on an actual market being available for what is valued. It can be imagined that this is often not the case, especially in health.

Contingent Valuation (CV). In this approach, individuals are asked to imagine a hypothetical scenario and then assign a value to the scenario in monetary terms, in a questionnaire or interview format, usually in terms of the maximum they would be willing to pay to secure the outcome, or less often what they would be willing to accept in compensation for not having the outcome. This is a measure of the strength of

preference for an outcome (Donaldson, 2001). Although a simple concept, it can be seen that by measuring the strength of preference of individuals, the measure is rooted in welfare economic theory (O'Brien and Gafni, 1996). This third method has become the most widely accepted for cost benefit analysis.

WTP is the generally accepted monetary valuation method used in cost-benefit analysis, as well as being a useful measure of patient preference which can be used in decision analysis. The advantages will be laid out in the following section.

3.4.2 Advantages of WTP

As well as being consistent with welfare economics and directly comparable with costs, the third major advantage is that WTP captures a broad range of benefits, including capturing how individuals value such things as the process of care (surgery versus medication for example), or the provision of information (Donaldson and Shackley, 1997b). This notion of process utility has been shown to be an important component of overall utility but is difficult to measure (Donaldson and Shackley, 1997b). It has been argued that these aspects are not captured by health state utility measures such as SG or TTO (Birch *et al.*, 1999). It is interesting that in this paper, although the study concerned an influenza vaccination, the example used to illustrate process utility is dental local anaesthetic, which, as the authors point out, people are likely to pay a measurable amount for but would not be willing to trade off life years or chances of survival for (as with TTO and SG).

Other externalities such as the benefit to non-users of others having health care (for example the benefit to an individual's health from another having a vaccination for a communicable disease (selfish externality) or the benefit gained from knowing that another individual is receiving health care or increasing their utility (paternalistic and altruistic externalities)) are also not usually incorporated in health state utility measures. It has been shown that including these externalities can influence the ranking of programmes derived from CUAs and the use of WTP is proposed as one solution to this problem (Labelle and Hurley, 1992)

Additionally, WTP avoids problems of separating quality from length of life, which is a major criticism of the QALY (Donaldson *et al.*, 2006).

3.4.3 Criticisms of WTP

Despite its advantages over some other measures, WTP is not without its problems, and several issues have been debated at length. The next section will discuss each of these controversies in turn.

3.4.3.1 Ability to pay

Perhaps the most common argument against WTP is its association with ability to pay, and the distributional issues this brings (i.e. those who are able to pay more have a greater influence on WTP and so have a greater influence on decisions) (Gold, 1996). However, it has been shown that ability to pay does not necessarily affect the final outcome (where strengths and directions of preferences are similar for both high and low income groups), and where it does, sensitivity testing will reveal how much of a weighting would be necessary to reverse a decision (Donaldson, 1999; Donaldson, 2001). Policy makers can then decide if this negates the outcome. Additionally, other measures such as QALYs are not free from such distributional issues either (Donaldson, 2001).

3.4.3.2 Embedding

Another criticism is the problem of embedding or scope insensitivity, where values obtained for different programmes or different scales of programmes (e.g. cleaning pollution in one lake or five) are very similar (Diamond and Hausman, 1994). To use a dental example, it may be that a programme to provide dental sedation for 500 patient treatment episodes is valued similarly to one designed to provide 1000 episodes. It is more difficult to imagine this phenomenon holding true on an individual intervention level, for example valuing having one or five restorations similarly.

In the more recent literature (Olsen *et al.*, 2004; Goldberg and Roosen, 2007) the topic of embedding has been more clearly defined, with distinctions drawn between scope insensitivity (changes in scale of a single programme) and embedding (changes between different programmes or parts of programmes). This topic, however, is complicated by the previous lack of clarity with terms of scope insensitivity, scale insensitivity, embedding and part-whole bias all used interchangeably. The two issues of scope insensitivity and embedding as defined above will therefore be considered jointly which can be justified as Goldberg and Roosen (2007) describe the distinction as relative.

One of the first studies to investigate embedding systematically showed a strong embedding effect across a series of paired part and whole valuations, where part was usually valued at a similar level to the whole (Kahneman and Knetsch, 1992) and there have been others who have found similar insensitivity or unexpected direction of sensitivity (e.g. the sum of WTP for the parts exceeds the WTP for the whole) (e.g. Bateman *et al.*, 1997) including in health (e.g. Olsen *et al.*, 2004). However, the evidence is mixed on this issue and other studies have shown sensitivity to scope or embedding.

One recent experiment (Goldberg and Roosen, 2007) where different levels and different types of food safety risks were valued showed that WTP increased as risk reduction increased for individual risk types (although not at the expected rate given expected marginal returns) but that when changes in multiple risk types were introduced simultaneously, WTP did not behave as expected. An experiment more closely related to heath care (Philips *et al.*, 2006) asked WTP for cervical cancer screening and found that those who perceived the benefits to be greater gave higher WTP and when valuing an enhanced screening programme, those who perceived the incremental improvement to be greater gave higher incremental WTP values. However, another experiment (Olsen *et al.*, 2004), closely related to health care, showed that there was no significant difference in WTP when the size of programme effects was altered (either in terms of number of patients treated by programmes for heart operations, cancer radiotherapy and helicopter ambulance services or in terms of risk reduction for heart disease). Smith (2005) describes an experiment which shows that sensitivity to scope is linked to income effects and also draws the conclusion that results and conclusions from WTP studies in environmental economics may not apply in health.

Scope sensitivity has been recommended as a key test of validity in contingent valuation (Arrow *et al.*, 1993), and so with the general evidence pointing to scope insensitivity, it appears that many contingent valuations could be invalid. However, the situation is not this simple, as there may be good reasons for scope insensitivity. In one study WTP was measured alongside attitudes, behaviour and knowledge of the part and the whole for each of four different environmental goods (Heberlein *et al.*, 2005). The good were: improving water quality in all lakes versus one specific chain of lakes; increasing the wild wolf population to 800 versus 300; protecting biodiversity in a whole state versus 2

counties in the state; eliminating Chippewa Indian spear fishing in all lakes versus one specific chain of lakes. The authors conclude that WTP will show scope when respondents have good knowledge of and well formed attitudes towards the good, the part and the whole, and that where respondents have more knowledge, a more positive attitude and more experience of the part, they will value this more highly in terms of WTP. Although this seems to violate expected economic behaviour in terms of scope, it seems logical psychologically. However, it is unclear as to how these conclusions would apply to health, as it is much less likely that any health "good" would be viewed in the same way as the environmental goods in the above study, where there was more knowledge, more positive attitude or more experience of the part than the whole.

Carson *et al.* (2001) find that scope insensitivity is not a major issue in environmental studies in a substantial review, and suggest that where scope insensitivity is found it is due to the poor design of studies. They do, however, recognise that scope insensitivity may be more of an issue where the task is concerned with valuing small changes in risk, such as in health.

One proposed reason for embedding is that respondents are providing values of having any programme rather than none or that individuals do not have clear ideas of their values. This can be overcome in some situations (especially when comparing two health care programmes) by adopting a "marginal approach" to WTP, where individuals are asked what *extra* they would be willing to pay to secure their preferred programme (Donaldson, 2001).

3.4.3.3 Validity - Is the measure preference-based?

Diamond and Hausman (1994) argue that WTP does not reflect preferences and that WTP responses may not be based in economic theory but rather may reflect an altruistic "warm glow" feeling, a feeling of what is best for the country, or a reaction to actions that have happened, and so rather than expressing preferences they are doing an informal CBA themselves. However, it would seem that if these are the values that a patient has, and if they get utility from being altruistic, these values are indeed their correct values. Indeed Olsen and Donaldson (1998) have shown altruistic motivations to be more important than selfish ones in valuations in health care.

The EuroWill project looked at convergent validity in terms of whether explicitly stated rankings of programmes were the same as rankings implied from WTP valuations and found inconsistency between the two approaches meaning there is a low convergent validity (Olsen *et al.*, 2005). The authors suggest that in one situation (where WTP values were the same for all programmes) that the respondent is expressing a general positive attitude to the programmes rather than expressing their preferences. It would seem possible that this is the case more generally and may explain the results here. This is a significant problem for WTP.

In order to understand the issue of validity better, it is important to understand how respondents come to their WTP valuations. In a review of qualitative studies looking at this aspect (Baker *et al.*, 2008) one major cognitive process was "mental accounting" where respondents decide on values that will not disrupt their normal financial affairs or where respondents decide on a benchmark based on what they have contributed for another worthy cause in the past (often with very little similarity to the good being valued) or for a similar good. Other themes which may affect the validity included a lack of trust where respondents do not believe the benefits being valued will be realised; moral outrage at having to pay for a good that is "beyond value"; the warm glow of moral satisfaction where respondents offer a token payment towards a good. The authors conclude that given the above cognitive processes, WTP surveys must be designed carefully to minimise these but caution that even with good design these problems may persist. However, it is likely that in dentistry, where respondents will often be used to paying for the good anyway, these problems will be minimised. If the example of the molar tooth RCT is taken, it can be seen that: trust could be an issue ("The RCT might not work"); moral outrage will be minimal as patients are used to the idea of charges for dentistry; warm glow is not appropriate for individual valuations, but may be if a whole programme is valued.

3.4.3.4 Payment vehicle bias

The method used to elicit values can lead to variation in results obtained, and there has been much investigation of the best payment vehicles.

One study (Champ and Bishop, 2006) looked at differences in actual payments using two common methods, dichotomous choice and payment card, for an environmental

good (electricity from cleaner sources). In this context, although more people were willing to pay with the payment card method, the payment amounts were much higher with dichotomous choice. The authors state that this means that sensitivity to elicitation format in hypothetical contingent valuation should not be viewed as evidence of a lack of validity, as this sensitivity is observed in real decisions also.

Another study (Smith, 2006) looked at WTP in health and compared random, high to low and low to high payment card methods. The author found no significant difference between any pair of valuations except that high-low gave higher values than either of the other two formats. This suggests a starting point bias with high-low, but unexpectedly not with low-high. However, there was less uncertainty about WTP responses with the random method than either of the other two. The authors therefore suggest that this method will provide the most reliable results.

Wiser (2007) investigated differences in WTP when either collective (i.e. mandatory for all) or voluntary contributions are described and found a higher WTP when contributions are described as collective.

In another environmental study, payment card, single dichotomous choice and double dichotomous choice formats were compared (Xu *et al.*, 2006). In this study dichotomous choice methods gave significantly larger WTP amounts (by a factor of 5 and 7 for single or double choices respectively) than payment cards. The authors suggest this is due to "yea saying" where people respond yes to questions even if they might not actually pay in real life. The authors suggest that this effect may have been magnified in this study where the population had only recently been able to exercise democratic rights.

A purely experimental laboratory based exercise (Vossler and McKee, 2006) found that there were significantly more deviations between WTP values and expected values with payment card or dichotomous choice with follow up than single dichotomous choice. However, where payment cards were used, those that encourage more thought by asking respondents to consider each value in turn rather than to pick a value from a list, gave fewer deviations.

However, despite the possibility that the methodological problems may be common to all areas, it has been argued that findings with WTP in environmental economics are not necessarily applicable to health economics (as outlined in the section on scope sensitivity, 3.4.3.2) (Smith, 2005).

3.4.3.5 Hypothetical scenarios

Another criticism is that WTP scenarios are hypothetical and may not reflect true values in terms of what respondents would pay in an actual situation. A test of this aspect of WTP would show criterion validity. It has been suggested (Arrow *et al.*, 1993) that with hypothetical scenarios respondents may give larger values than they actually would pay, especially where there is no chance of this being carried through to real situations (no incentive). This is also termed hypothetical bias. Recognising this as a major potential source of bias, the NOAA review (Arrow *et al.*, 1993; Christie, 2007) recommended comparisons of real and hypothetical WTP as one of the key areas of research. Although this research, where hypothetical values can be tested in real situations, can be done in certain branches of economics, typically environmental, there are fewer opportunities in health, especially in the UK, where the vast majority of health is free at the point of delivery. However, dentistry, where there are user co-payments, offers this possibility, with the added advantage that there are a range of prices and values in the market.

Vossler & McKee (2006) investigated hypothetical bias in a laboratory experiment using a variety of elicitation formats and found there was no difference between hypothetical and real WTP for an abstract public good. The experiment was set up so that participants already had their valuation and this was imposed on them. The authors suggest that the lack of bias in this experiment may be because hypothetical bias occurs at the valuation formation stage rather than at the value elicitation stage. Cummings *et al*. (1995) performed another set of laboratory experiments, where participants did use their own valuations and using a variety of subjects and questionnaire formats, found differences in real and hypothetical WTP responses for a variety of private goods. These laboratory experiments generally provide evidence that hypothetical and real WTP do differ.

In the field, the findings of the laboratory experiments were reinforced by looking at the case of conservation of rare birds (Christie, 2007). Here participants were asked firstly

to state their intention to make a donation and then either to state a WTP amount for conserving the birds or asked to make an actual donation to the cause. When comparing the two groups WTP is three times greater than actual donation, but if zero bids or donations are removed from the analysis, the mean amount is the same; it appears that this discrepancy is due to a significant number of people in the actual donation group who stated an intention to make a donation but then did not actually make the donation, whereas this was not true in the WTP group. This suggests with WTP more people may state a positive amount than they would in reality, possibly due to the "warm glow" effect.

In health there have been two studies comparing real and hypothetical values, although neither is in a context that is particularly useful for this study. Firstly, Kennedy (2002) investigated stated WTP in one population for adaptations to houses to prevent lung cancer by reducing radon exposure and compared this to actual payments made by a similar population. It was found that WTP (stated preference) did overestimate actual payments made (revealed preference) but not markedly. The weaknesses of this study are that this good could be viewed as a private good rather than a typical health related public good and that the values were not compared for the same individuals. In the second study (Bryan and Jowett, 2010), the same population had WTP values elicited and made payments for the good, which in this case was a patient self management device which measured blood clotting in patients taking warfarin from which adjustments to dosages of warfarin could be determined. Although this good is still not a true public good, it is closer than that in the previous example. In this case, higher WTP was the strongest predictor of a decision to purchase the device and 74% of those who purchased the device had a WTP greater than the price with 66% of those who did not purchase having a WTP less than the price.

From these two studies, it could be argued that hypothetical bias is not a great problem in using WTP in health. However, the laboratory and environmental field studies suggest that the challenge for WTP survey designers is to try and make the scenario as real as possible. In order to address this challenge, Cummings and Taylor (1999) introduced the concept of "cheap talk" where part of the script for the WTP interview included a description of hypothetical bias and an indication of the level of hypothetical bias expected in the valuation. This script was tested in a series of laboratory

experiments for different public goods and for each a difference was found between real and hypothetical responses and between hypothetical and cheap talk responses, but not between real and cheap talk responses, indicating the success of this measure in lowering hypothetical WTP towards to real WTP.

However, Aadland and Caplan (2006) remark that the cheap talk scripts used in the above studies are not generalisable and that the data required to give specific levels of expected hypothetical bias would not be available and may need to be too specific in each study to be practically useful. In a large sample field setting they found that their own cheap talk script (with a move away from describing positive bias to a neutral statement that bias changed responses, not necessarily increased them), actually increased hypothetical WTP. An alternative strategy to deal with hypothetical bias, consequentialism, has also evolved. Cummings and Taylor (1998) first introduced the concept (referred to as "realism") in a laboratory experiment where they varied the probability that a WTP referendum decision would be binding (actually incurring payment i.e. consequential), finding that only at high probabilities of realism did the stated behaviour replicate actual behaviour.

Landry and List (2007) compared four different valuation techniques, hypothetical, cheap talk, consequential and real, in an experimental setting. The findings again suggest that hypothetical values are much higher than real values, but that when cheap talk or consequential designs are used, stated values match real values more closely, with consequential designs being indistinguishable from real values. However, the consequential aspect is clearly defined (as a probability that the WTP expressed will be binding). In field settings it is more difficult to be objective about the consequentialism of the WTP scenario, and there has been little further work to date on consequentialism.

3.5.2.6 Protest responses

Whenever a value of zero is given as a response in a WTP exercise, it could mean two things; the valuer attaches no utility to the good being valued (i.e. a true zero) or the valuer does not wish to engage with the valuation exercise for some reason (a protest zero) (Mitchell and Carson, 1988). This leaves difficult questions about how to discriminate between the two types of zero and then how to incorporate them in an analysis. It has become standard practice to ask zero respondents for their reasons why

they responded zero, and to use this to separate true from protest responses. One example is given in Table 3.3, and this was the set of responses that the responses in the empirical section of the thesis are based upon.

Response	True (value is zero) or protest (unwilling to answer)
"this programme is of no value to my household";	True
"other programmes are more valuable";	Protest
"other public sector budgets should be cut";	Protest
"other groups in society should pay";	Protest
"users should pay";	Protest
"the health service should be more efficient";	Protest
"I can not afford it";	True
"I prefer other ways of paying";	Protest
"Other (please specify)".	Protest

Table 3. 3 Possible responses following zero valuations and their classification as true or protest responses (Ryan *et al.*, 2004)

3.5 Monetary valuation in oral health

Given the problems with utilities and QALYs both generally and in oral health, WTP has been proposed as the best measure for dentistry (Matthews *et al.*, 1999b; Birch and Ismail, 2002), in a move paralleling the conclusion that it is the best measure for general health. However, the argument is even stronger for dentistry, where, for example, many people in the UK do pay for dental treatment, meaning that WTP may be a more appropriate measure than is some other areas where health care is free at the point of delivery.

3.5.1 Problems of using WTP in oral health

Unfortunately, the familiarity with payment which is seen as an indication for using WTP in oral health also carries a negative risk that individuals may be influenced by the price they are familiar with when giving their maximum WTP. This could be seen as a type of anchoring bias (Kahneman *et al.*, 1999). It has been found that even very arbitrary references to prices (such as the price of a completely different good being sold in an adjacent shop (Nunes and Boatwright, 2004)) can influence valuations (Kahneman *et al.*, 1999), and therefore it could be imagined that prior knowledge of prices would have a major anchoring effect. Another consideration if this influence is real is that individuals' valuations may not be independent of the charging regime (payment vehicle) that they usually use, and so this will also need to be included in any

analyses as a potential influencing factor. This influence may be particularly interesting in UK dentistry with the recent change in system described in Section 2.3.2.

Another problem with using WTP rather than QALYs, which as discussed in Section 3.3.2, are the most accepted measure of value in health generally, is that it may have the effect of separating oral health from health. In broad terms, using monetary valuation should ensure comparability of oral health with general health. However, if individual programmes are to be compared, it may be difficult if oral health programmes are valued in monetary terms and other health programmes have been valued in health state utility terms, as is often the case. This could be problematic as general health and oral health are closely linked (Sheiham, 2005) and oral health should be viewed as part of general health.

3.5.2 Use of WTP to date

There have been several studies successfully using WTP in dentistry (Dixon and Shackley, 1999; Matthews *et al.*, 1999a; Cunningham and Hunt, 2000; Matthews *et al.*, 2002; Birch *et al.*, 2004; Tianviwat *et al.*, 2008a; Tianviwat *et al.*, 2008b; Esfandiari *et al.*, 2009; Rosvall *et al.*, 2009; Leung and McGrath, 2010), as shown in Table 3.2. Each of the studies will now be described in detail.

Dixon and Shackley (1999), elicited WTP values for a community water fluoridation scheme to prevent caries from 100 members of the public. Water fluoridation is a controversial area, and therefore some people were opposed to the scheme. For those in favour, WTP was elicited in terms of extra taxation using a payment card method. For those opposed, half the sample was asked for WTP values to avoid and half Willingness to Accept (WTA) values in terms of compensation. Of those opposed, more than half gave protest zero responses, with the remainder giving a mean WTP that greatly exceeded the mean WTP value of those who were in favour.

Matthews *et al.* (1999a) conducted a pilot study using 23 patients and 18 staff from a periodontal clinic for different periodontal treatments, in a questionnaire format, using a payment vehicle of increases to insurance premiums. Respondents chose their preferred treatment option and then indicated what their WTP was for this treatment. The questionnaire was well accepted and understood, with some evidence of both reliability and validity.

Cunningham and Hunt (2000) asked 40 patients about to undergo orthognathic (facial) surgery for their WTP values for the surgery using a payment card method in a questionnaire. They also elicited SG utility scores and found that the correlation was in the expected direction in terms of strength of preference.

Matthews *et al.* (2002) conducted a study looking at a novel periodontal anaesthetic gel (as an alternative to a local anaesthetic injection) with 97 periodontal patients and 196 members of the public. WTP was elicited using a computer based questionnaire and 2 payment vehicles were used, a one-off fee and an increase in monthly insurance premiums. The median WTP for the periodontal patients as a one-off fee was 10 Canadian dollars compared to 20 Canadian dollars for the public. For both groups, the median insurance payment was 2 Canadian dollars.

Birch *et al.* (2004) elicited WTP values for a novel treatment involving dentine regeneration in carious teeth, from 611 members of the public (380 with dental insurance). Those with insurance completed WTP scenarios involving an increase in monthly insurance premiums and those who were uninsured had scenarios involving one-off fees, both completed in telephone interviews. The mean WTP with a 95% success rate was $262.70 for those not insured and $11.00 for those insured, whereas with a 75% success rate the figures were $210.90 and $9.20 respectively. Econometric analysis suggested a great deal of unexplainable variance. There was good test-retest reliability and face validity in terms of increasing WTP for increasing success rates was observed in almost all cases.

Oscarson *et al.* (2007) asked 82 nineteen year olds, of whom 30 were at high risk of caries and 52 were in a low risk control group, WTP for preventive care in an interview using a single dichotomous choice followed by open ended response format. Mean WTP was 1405 Swedish Krona and 1087 Swedish Krona over a year for the high risk and control groups respectively, with only risk status and living in a rented flat increasing WTP. When input into a CBA, the net social benefit was positive, indicating the preventive programme should be implemented.

Tianviwat *et al.* (2008b) elicited WTP values for prevention (a sealant) and treatment (a restoration) of childhood caries from 205 parents, using a bidding game approach in an interview setting. The mean WTP for prevention was 225.30 Thai Baht and 225.60 Thai

Baht for treatment. Significant factors increasing WTP were parents with greater incomes, greater education, no restorative experience and younger parents. An earlier study by the same group using the same elicitation methods (Tianviwat *et al.*, 2008a) compared two different settings (hospital versus school based) for three treatments (preventive sealants, restorations and extractions). There was no difference in WTP for the different settings across the whole sample, although some differences were found when individual income groups were examined.

Esfandiari *et al.* (2009) conducted a WTP study looking at preferences for implant retained overdentures for edentulous patients. Thirty six patients who had either a new conventional full denture or a new implant retained over denture were asked for their WTP in an interview. Firstly participants were given the characteristics of two dentures in terms of function and asked what they would be willing to pay extra to have the better denture with the median values being 300 Canadian dollars for current conventional denture wearers and 1000 Canadian Dollars for current implant denture wearers. The dentures were then revealed as conventional dentures and implant retained dentures, and participants were asked if they would have been willing to pay the actual difference (2400 Canadian Dollars), with surprisingly 61% accepting. Finally, referring to their actual new denture rather than the hypothetical scenarios above, participants were asked if they were paid to return to their health state pre-new denture what their WTA amounts would be and 92% said they would not go back at any WTA amount.

Rosvall *et al.* (2009) elicited values for different types of orthodontic appliances from a sample of 50 individuals (the recruitment strategy is not clear), after asking for ratings of attractiveness of the various appliances, using a computer based questionnaire. Patients were asked what extra they would pay over the price of a standard appliance for the various different appliances for both themselves and their child. Increased WTP was linked to increased attractiveness ratings.

Leung and McGrath (2010) conducted a WTP study for implant replacement of a single anterior and also a single posterior tooth. Fifty one dental patients (a convenience sample) were asked for their preferred treatment option (removable partial denture, fixed partial denture (bridge) or implant) and their WTP for their preferred option in terms of one-off fees using a questionnaire. 94% preferred implants for anterior teeth and 84% for posterior teeth with mean WTP of 11000 and 10000 Hong Kong dollars

respectively. The WTP was higher for females, those with no missing teeth and those with higher educational levels.

It is difficult to draw any conclusions from the above studies, as all were valuing different goods, conducting different experiments (or answering different questions), and used different methods. Generally, it seems that predictive factors are variable in each study and do not have great predictive ability. Where methodological tests have been performed, WTP has been shown to be generally reliable and valid. Most of the studies were performed on small convenience samples (with none performed in dental primary care where the vast majority of dentistry is delivered (Steele, 2009)), and in some cases the methodology was questionable. Perhaps the main emerging theme is how useful WTP can be in answering a great variety of different policy questions.

Therefore, ten studies have been identified using WTP in dentistry (with only one study using WTP in CBA (Esfandiari *et al.*, 2009)). Compared to the total number of economic evaluations in dentistry, this is still a small minority: cost effectiveness is the most established technique in oral health, with CUAs (using QALYs) the most established analyses in general health. Given the strong underlying rationale for using WTP in oral health settings, there is a need for well designed, large scale application of WTP to oral health interventions and states, to complement the few good studies to date in demonstrating the feasibility of WTP and to begin to investigate some of the issues particular to oral health.

3.5.3 Valuations of oral health versus oral healthcare

It is important at this stage to draw a distinction between valuing health and valuing healthcare. It is clear from the studies described in the previous section that to date WTP has been used in oral health to value healthcare (or a public health intervention in the case of Dixon and Shackley (1999)) and this is usually the case in areas of health other than oral health. The conventional view is that individuals would demand health and so healthcare is a derived demand being a means to an end (Grossman, 1972). It would therefore seem more important to value health rather than healthcare, but this would ignore the important issue of process (dis)utility as well as some aspects of externalities and may therefore only lead to a partial valuation, giving only directly health related utilities (in a similar way to health state utility measurement). If healthcare is valued

instead, the complete utility contribution from an intervention or programme is more likely to be valued.

Although the question of what should be valued will primarily depend on the question being addressed by the valuation exercise, it can be seen that in the vast majority of cases, where an allocative decision between different healthcare programmes is being taken then it is likely to be healthcare that should be valued. There may be some situations where a more generic health state valuation is required, but these will be less common in policy issues. It is therefore logical in this thesis to measure healthcare rather than health. This issue is expanded on in the following section extending the argument about what should be valued to what level health or healthcare should be valued at. The issue of valuing a health state or intervention has been raised in the context of QALYs, where Nord et al. (2009) note that this issue has not been explored in the literature. Some empirical data presented by the authors subsequently suggest that the difficulties of valuing interventions may be an issue for QALYs (Nord et al., 2010) and they propose further study. This thesis contributes to this debate.

3.5.4 Valuing interventions, health states and programmes

As discussed in the previous section, it can be seen that valuations have been undertaken at various levels. Firstly, the individual can value their own health state or a hypothetical state they could be in (this is the only option with health state utilities but can also be done with WTP). Secondly, a population level programme can be valued (as is seen in many of the environmental WTP examples given in Section 3.4), or finally an individual can value a personal intervention that they could hypothetically receive (to get them into or out of a health state) (as is seen in several of the dental WTP studies described in Section 3.5.2). Taking the example of valuing programmes versus personal interventions, it can be argued that if policy makers are making resource allocation decisions, it may be more useful to ask individuals to value a whole programme, as this may perhaps be more likely to include selfish and altruistic externalities as described in Section 3.4.2 (Labelle and Hurley, 1992). However, individuals are not conceptually used to valuing whole programmes, and in dentistry (with its patient charges), it can be imagined that this type of valuation may be more likely to suffer from embedding bias, increased numbers of protest responses and hypothetical bias compared to valuing personal interventions. Additionally, if personal interventions are valued, these figures

could be used to look at individual decision making behaviour as well as being of use to policy makers in resource allocation.

Valuing health states compared to valuing personal interventions is addressed in the previous section where it was stated that valuing health states is more difficult conceptually, being more abstract, and may also exclude notions of process utility, as is seen in health state valuation using SG and TTO (Birch *et al.*, 1999). However, it is useful to consider that a use of health state valuations is where health states in a specific area (such as oral health) are to be compared with health states in general health, which has been shown to be important in Section 3.5.1. In oral health, it may be that a series of important health states such as edentulism, having a full complement of natural teeth, or moving from having enough teeth to cope to requiring a prosthesis could be defined and valued, and that some of the interventions such as RCT could fit within this series of larger oral health states. It may be that the conceptual model in Figure 2.1 could form a basis for this work. However, this is currently beyond the scope of the thesis and to conclude this sub-section, given the above arguments, it is argued that valuing personal interventions may be a better approach than valuing population level programmes, unless there is a specific need for valuations at a programme level. This is therefore the approach taken in the empirical section of the thesis.

3.6 Methodological issues in WTP

Where contingent valuation is undertaken and WTP is measured, there are many factors which must be decided upon in the design of the elicitation survey. To begin to address this, a conceptual framework, listing the different designs possible, has been drawn up (O'Brien and Gafni, 1996). This framework is more applicable to WTP elicitation for programmes rather than personal interventions (as detailed in Section 3.5.3), but no alternative framework has been developed for personal interventions. Many of the questions raised are also applicable to personal intervention valuations and so the framework is presented here and influences the methodology of this thesis. In the framework, questions that must be addressed include:

- What is the problem we are addressing? Is it CBA, a demand forecast, marketing survey?
- Does the programme exist currently?

- Who will gain (or lose) utility with the programme?
- Are we evaluating from the original (pre-programme) or new (post-programme) perspective (compensating or equivalent variation)
- Who should evaluate the programme; those who currently do/would use it; those with potential to develop a need; those with no potential to need?
- How should it be framed: ex-post user based or ex-ante insurance-based?
- How much detail should the programme be defined in and should each component of the programme be valued separately (decomposed) or all together (holistic)?
- How should values be elicited; an open ended question; using a bidding method; a dichotomous choice (yes/no to a particular value)?

A good WTP study will have considered the above questions and justify their answers. Although this is not a direct validity measure, if these have been considered, it is likely that the results will be more valid.

One of the most variable areas is the elicitation of values. The methods for eliciting values have been classified into open ended questions, dichotomous questions (yes or no to one value), or bidding games and each will yield different results (Donaldson *et al.*, 2006). There is much debate as to the superior method and each has its own advantages and disadvantages (O'Brien and Gafni, 1996) as discussed in Section 3.4.3.4.

Given the importance to the methodology of this thesis, the different methods are explained below:

- Open Ended – The respondent is simply asked to give a value for how much they would be willing to pay with no prompting or suggestion of values or ranges.

- Dichotomous choice – The respondent is offered a single value and is asked whether they would be willing to pay this amount. Different values are used for each respondent across the whole sample.

- Dichotomous choice with follow up – The respondent is offered a single value as in simple dichotomous choice but if they refuse they are then offered one further lower value, with accepters being offered one further higher value and again asked if they would be willing to pay. As with simple dichotomous choice, different values are used for each respondent across the whole sample.

- Bidding method – This involves respondents being offered a single value and asking if they would be willing to pay this amount. If the answer is yes, then a higher amount is offered, if the answer is no, a lower amount is offered. This process is repeatedly iteratively at pre-agreed intervals of value until the answer is reversed, indicating a maximum WTP value.

- Payment card – This involves a card with a range of values on, which the respondent looks through and then decides which of the values is the maximum they would be willing to pay.

- Shuffled payment cards – This final technique involves having multiple cards each with one value on. These are then shuffled and presented to the respondent to categorise one at a time into "would pay" "wouldn't pay" or "not sure." Once all of the cards have been sorted the respondent is invited to decide on a final maximum value between their lowest "would pay" and highest "would not pay" values.

Unfortunately for assessing any of the methodological issues, a measure of validity is difficult to determine, as we have no "gold standard" for eliciting monetary values of preferences, and so we must rely on measures on convergent validity. Application of convergent validity is extensively demonstrated by Carson *et al.* (1996) in a meta-analysis comparing RP with CV.

3.7 Conclusions

Chapter 2 concluded with a statement of the need for preference based measures to be used in oral health. In particular, using the two examples chosen in this thesis it was shown that a number of questions and issues exist: which treatment option is best for an extensively decayed molar tooth from the point of view of an individual patient making the decision and the policy maker deciding which programmes of treatment to fund (questions which a cost-benefit analysis could address); is it best to treat disease or prevent it, again from both the individual and policy maker point of view; what are the needs and demands of the population for both of these examples; if prevention is agreed to be a worthwhile activity how should policy makers increase uptake.

These questions could all be addressed, at least in part, by understanding patient preferences, both in terms of direction and strength, measured in a systematic way. The economics based principle of utility is one such systematic way of thinking about preferences and the two alternatives of monetary and non-monetary valuation have been discussed and compared in this chapter. In general terms, there are strong arguments that health state utility measurement may not be fully compatible with economic theory and its use in CUA may not fully address the type of questions being posed. Monetary valuation, and in particular the most accepted method of valuation, WTP, used in CBA does not suffer from these same problems and values health in its broadest sense and therefore may be more appropriate in terms of addressing the questions posed.

In oral health terms, there are additional problems with health state utility measurement, the most important of which is the lack of sensitivity to the smaller changes of utility likely in oral health. WTP again does not suffer from these problems and indeed may be more appropriate in a system where patients are used to paying for healthcare as is often the case in oral health.

There are, as expected, a number of issues with using WTP generally, such as the link with ability to pay and the hypothetical nature of the exercise, and also in its specific use in oral health, especially where the imperfect market may bias participants' responses. Despite the need for preference-based measures in oral health and the argument that WTP would be the most appropriate method, very little work has been undertaken in applying WTP to oral health and investigating some of the specific

methodological issues. This is therefore the emerging programme of work for this thesis.

3.8 Aims of the thesis

The conclusion reached in the previous section suggest that the programme of work for this thesis is in applying WTP to oral health, specifically the two dental examples chosen and whilst undertaking this application to study methodological aspects of WTP that are particular to using WTP in oral health. The aims will be addressed in two studies, one for each example with some aims addressed by both studies and some aims addressed in one study alone. They are presented in this way below.

Aims addressed in both studies

1. To use WTP in two examples of oral health choices (the preservation or loss of a non-vital molar tooth and the uptake or refusal of a caries prevention product)

2. To investigate factors affecting oral health choices and WTP (for the two dental examples)

Aims addressed in the Molar Tooth Study

3. To investigate part versus whole bias in the dental setting

4. To investigate the influence of actual price on WTP valuations

Aims addressed in the Prevention Study

5. To investigate the influence of payment vehicle on WTP and actual payment for preventive products

6. To investigate the difference in stated versus revealed preference (hypothetical bias) in oral health

7. To investigate differences in the value of prevention between two countries (the UK and Germany)

Chapter 4. Molar Tooth Study: Method

4.1 Introduction

In Chapters 1, 2 and 3, the argument was developed that patient preferences are fundamental to a deeper understanding of oral health decision making at both patient and population level and that they form a vital part of planning and commissioning services. It was concluded that the most appropriate way of measuring patient preferences in oral health is using monetary valuation, specifically WTP. The issues arising from these arguments informed the aims for this thesis, laid out in Section 3.8. This Molar Tooth Study addresses Aims 1 and 2 in conjunction with the Prevention Study and addresses Aims 3 and 4 by itself. The methods for the study are described in this chapter.

The study was built around a series of WTP experiments conducted with a mixed and broadly representative sample recruited in primary care dental practices. Each participant was asked to complete a questionnaire to collect demographic data and details of previous dental experience. The participants were then taken through a WTP scenario which involved firstly making a choice about preferred treatment option for a non-vital molar tooth and then valuing this using WTP. Finally, participants were exposed to the current price of the treatment options and changes in preferred treatment choice and WTP were measured.

In this chapter, the sample, setting and recruitment will first be described, followed by the design of the questionnaire, including the interventions being studied. The interview technique will then be outlined followed by a description of the data analysis.

4.2 Sample and setting

4.2.1 Sample

The sample was drawn from a population of patients aged 18 years and over attending 8 dental practices in the North East of England. All patients were asked by the dentist at the end of their appointment if they wished to be involved in the research. Only patients who agreed to be involved and gave written consent after further explanation of the study (usually immediately, although a cooling off period was also possible, if desired) were included in the sample. Additionally, as the interventions being discussed would only be done on a natural tooth, those with no teeth (edentate) were excluded from the

study, usually based on the dentist's judgement, with these patients not invited by the dentist to participate. The inclusion and exclusion criteria are shown below (Table 4.1).

Inclusion Criteria
18 years of age and older
Dentate in at least one arch
Willing and able to provide informed consent
Exclusion Criteria
Unable to understand questionnaire/interview

Table 4. 1 Inclusion and exclusion criteria

Pre-study calculations of necessary sample size focused on the part versus whole experiment where participants were to be randomised into two groups and asked WTP in different ways. However, the part-whole experiment could only be done with those choosing extraction rather than saving the tooth, and each sub-sample by choice of subsequent treatment (comprising 4 prosthetic options) would need to be analysed separately. It was therefore assumed that around 50% would choose extraction based on data from the 1998 ADHS (Kelly *et al.*, 2000) (2009 data were not available at the time of this decision), and in the absence of any relevant data it was assumed that the sample would choose from the 4 options equally, leaving 25% of the extraction sample in each sub-sample (or 12.5% of the whole sample).

As there was little or no similar data available, it was difficult to determine minimally important differences and to calculate sample size definitively (given the lack of information on likely variance), and so it was agreed that the effect size calculations should be conducted in terms of standard deviations. Using a significance (alpha) of 0.05 and power (beta) of 0.1, for an effect size of 0.5 Standard Deviations, 85 people would have been needed in each arm in each sub-sample. This meant that in each sub-sample 170 participants would be needed, and based on the likely split of sub-samples, the total sample required would have been 1360. This was the target sample size at the commencement of the study. After 250 participants had been recruited, mid-study analysis was undertaken to check on sample size calculations, and due to a larger than expected variance, it was apparent that the detection of an effect size smaller than 0.5 standard deviations was necessary and this would have demanded an impractically large sample size.

It was therefore decided to proceed without the necessary power for the part-whole experiment to be conclusive. The next most demanding analysis in terms of sample size was the investigation of which factors affected WTP and choice and so it was decided to recruit sufficient patients to satisfy this analysis. This was to be analysed using regression analyses, which it is difficult to determine sample size for. However, some have suggested an events per variable (EPV) approach for logistic regression, with a recommendation of at least 10 EPVs (Peduzzi *et al.*, 1996). Based on this approach, with an estimate of 50% taking RCT as their preferred option and a maximum of 20 variables in the model a sample size of 400 would be necessary to satisfy the initial logistic regression (10 events would occur in 20 cases at a 50% rate and so 20 cases multiplied by 20 variables would be 400). This figure of at least 400 was taken as the revised aim.

4.2.2 Setting

The setting for recruitment and interviews was a series of primary care dental practices. Several practices were approached which were already known to the research team as willing participants in dental research. Of these, 8 responded positively in allowing the participants to be recruited and interviewed at the practice. The nature of each practice is shown in Table 4. 2.

Study practice number	IMD Score of practice postcode	Approximate estimate of number of patients registered	Approximate estimate of % NHS patients
1	7.72	12500	98
2	63.21	27000	100
3	61.68	12500	98
4	49.71	6500	99
5	38.65	35000	80
6	15.35	5500	98
7	37.06	17000	99
8	47.32	8500	99

Table 4. 2 Details of research sites (dental practices) IMD = Index of Multiple Deprivation (a relative measure of deprivation based on small geographical areas)

In each practice, the interviews took place in a private room, usually a spare dental surgery, although the dental chair was not used to minimise anxiety. Practical measures were taken as locally appropriate to minimise risks to the researcher and participant from being alone in a private room together.

4.2.3 Recruitment

All patients falling within the inclusion and exclusion criteria were asked by their dentist if they would be interested in taking part in the study, following a brief explanation. If the patients were interested, they then saw the interviewer, who gave a full explanation verbally and in written form (a participant information sheet). Participants were given the option of considering the study and returning at a future date if they wished, or if consent was forthcoming immediately, an immediate interview. A further option was the immediate refusal of consent from the participant.

4.3 Data collection

4.3.1 Interview logistics

The interviews were all conducted by one researcher, the author of this thesis. After consent had been gained, participants were interviewed in a structured manner. Firstly, a consecutive identification number was assigned to the participant. This was then entered on an identification sheet, which the participant completed with their name and address. This was kept separate from the interview data and retained by the practice, so that if necessary, participants could be contacted in the future. The same identification number was entered onto the questionnaire, described below, which the interviewer completed on the participant's behalf, using the questionnaire as the script for the structured interview. The interventions being evaluated were then explained by the interviewer and the interviewer guided the participant through the WTP elicitation exercise, also described below.

4.3.2 Questionnaire design

Before eliciting WTP, routine data were collected using a questionnaire (Appendix A). Several basic demographic questions were included in the questionnaire such as gender and age in years. Postcode was also included, as this was used to assign an index of multiple deprivation (IMD) score. Questions relating to other socio-demographic indicators were based on best practice guidelines from the Office of National Statistics (Office for National Statistics, 2007a; Office for National Statistics, 2009). Income bands were also based on these guidelines but this was problematic as most data collected by ONS does not follow their own recommendation on bandings. Socio-economic status was based on the National Statistics Socio-Economic Classification

(NS-SEC), also part of the above guidelines. The self-coded version was used, where classification is based on both employment status (employed or self-employed, employer, manager, supervisor or supervised) and occupation. The answers to the standardised questions were then combined using the flowchart (Figure 4.1) and table (Table 4.3) to give a socio-economic classification as below:

1 - Managerial and professional occupations

2 - Intermediate occupations

3 - Small employers and own account workers

4 - Lower supervisory and technical occupations

5 - Semi-routine and routine occupations

6 – Not classified (unwilling or unable to answer and not working including full time students)

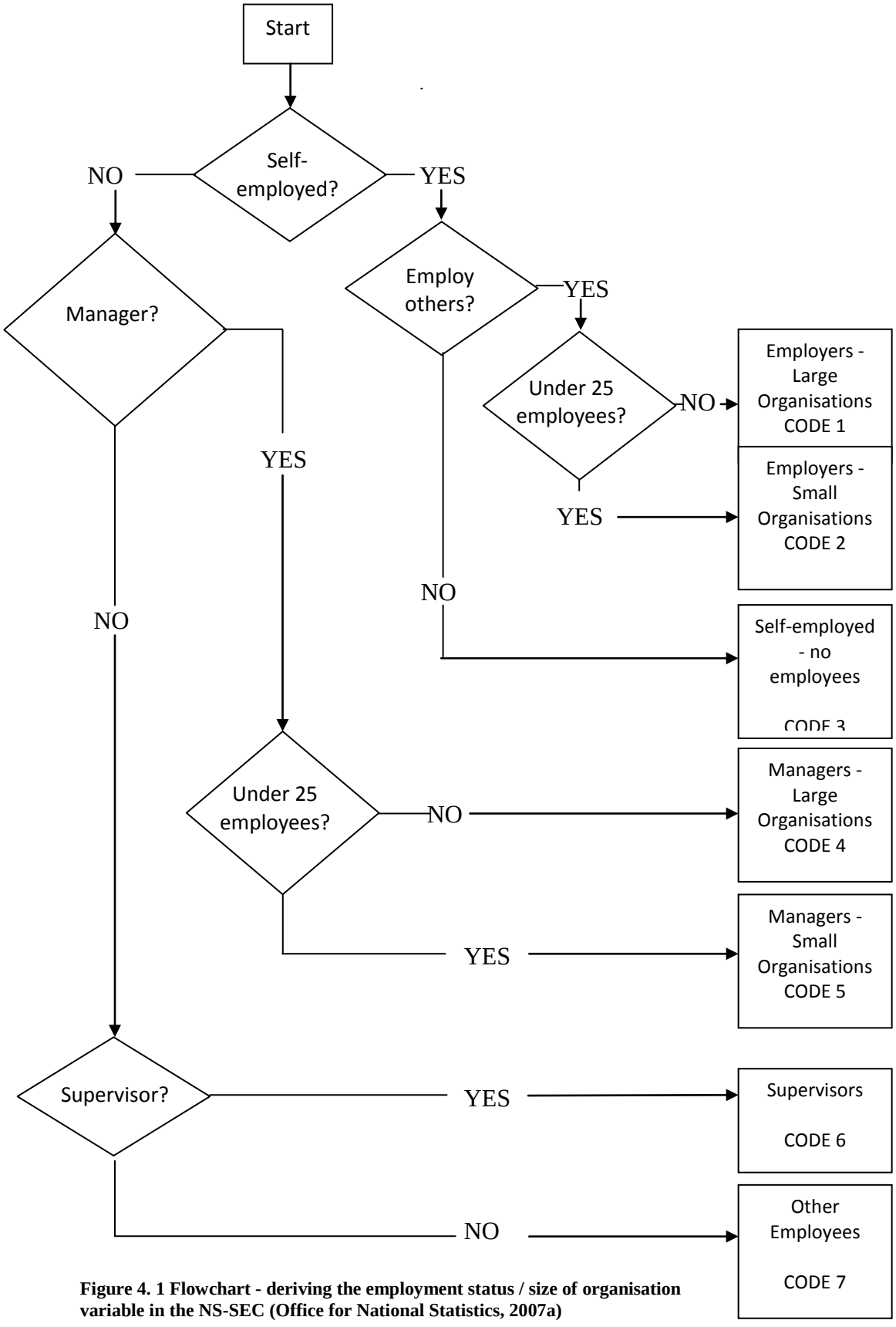

Figure 4. 1 Flowchart - deriving the employment status / size of organisation variable in the NS-SEC (Office for National Statistics, 2007a)

NS-SEC SELF-CODED MATRIX DERIVATION TABLE: FIVE CLASSES							
Self-coded Occupation	***Employment status / size of organisation***						
	1 Employers - large organisations	2 Employers - small organisations	3 Self employed - no employees	4 Managers - large organisations	5 Managers - small organisations	6 Supervisors	7 Other employees
1 Modern professional occupations	1	1	1	1	1	1	1
2 Clerical and intermediate occupations	1	3	3	1	1	1	2
3 Senior managers or administrators	1	3	3	1	1	1	1
4 Technical and craft occupations	1	3	3	1	1	4	4
5 Semi-routine manual and service occupations	1	3	3	1	1	4	5
6 Routine manual and service occupations	1	3	3	1	1	4	5
7 Middle or junior managers	1	3	3	1	1	1	1
8 Traditional professional occupations	1	1	1	1	1	1	1

Table 4. 3 Matrix for determining NS-SEC from all variables (Office for National Statistics, 2007a)

The remaining questions concerned dental status and were based around the decennial ADHS (Kelly *et al.*, 2000; The NHS Information Centre, 2010). These included frequency of dental attendance, payment for dental care, dental experience of a variety of procedures, experience of dental pain and number of natural teeth remaining. For this final question, the ADHS relied on clinical examinations, which were not undertaken in this study and so self-reporting was used instead. Based on the work of Walls and Wilmot (2002), broad bands of fewer than 10, 10-19 and 20 or more were used. The borderline between 19 and 20 is also important as this reflects the widely accepted principle of the shortened dental arch, an indicator of a minimal functional dentition (Kayser, 1989).

4.3.3 WTP scenarios

Before going on to describe WTP elicitation methods, it is useful to describe in more detail the scenario presented to participants. The dental decision upon which the scenario in this study is based is the choice of treatment options available for a non-vital molar tooth. The basic decision is whether to save or extract the tooth. If saving the tooth is chosen, this will involve a RCT, and as the scenario used involved an extensively broken down tooth, the gold standard treatment would also involve the provision of a crown to protect and restore the tooth after RCT. Where extraction is chosen, there is a further decision whether or not to replace the missing tooth with a prosthesis, the options being no treatment (leave a gap), have a removable partial denture, have a bridge (or fixed partial denture) or have a single implant supported restoration. These interventions are described in detail and in context in the literature review in Chapters 1, 2 and 3.

Participants were asked to imagine that they had a full set of adult teeth but that one of their lower first permanent molars was badly broken down and non-vital. Participants were advised that the tooth had caused some discomfort over recent months but was not causing pain at the present moment. They were also advised that an abscess was forming and the tooth would be uncomfortable in the future if something was not done. In providing this information, the option of doing nothing was excluded, although participants could still make this choice through giving a valuation of zero. They were then given the options of saving or extracting the tooth and then the 4 prosthetic

options. All of these items were described in lay terms and supplemented with photographs or illustrations (as shown in Appendix B). The wording used in the scenario is shown in Figure 4.2. Where participants asked for clarification a standard glossary (Appendix C) giving more detailed explanation was used where possible or reasonable explanations were given by the interviewer (a dentist).

Initial script read to all participants:
Now I want you to imagine that you have all of your adult teeth but that one back tooth (2nd from the back) is broken down and the nerve is dead. You are not in pain at the moment, but you are slowly getting an abscess on it and there has been a bit of discomfort in recent months. The dentist tells you that it is likely to become uncomfortable at some stage. You cannot see this tooth from the front when you smile but you do use it for chewing. There are two choices. Firstly you can keep the tooth by having a root canal treatment. This involves the dentist making a hole into the tooth to get to the nerve, cleaning the inside of the tooth, filling it and putting a metal crown (cap) on top. The other choice you have is to have the tooth extracted. There are various options following extraction including just leaving a gap, having a removable denture to replace the tooth, having a bridge (artificial tooth) fixed to teeth next to the gap, or an implant screwed into your jaw to support an artificial tooth. It is important to be aware that these options exist, but at the moment we are only interested in whether you would keep the tooth or extract it. We are not interested in exactly what you would do afterwards. Which would you prefer to have?
Script read to those choosing extraction:
When you chose to have your tooth extracted, you may remember that I said there were several options about what to do afterwards. These were leaving a gap, having a removable denture to replace the tooth, having a bridge (artificial tooth) fixed to teeth next to the gap, or an implant screwed into your jaw to support an artificial tooth. Which would you prefer to have?

Figure 4. 2 Script for interviewer in explaining the scenario used alongside written explanation and illustrations

4.3.4 Willingness to pay elicitation

Following this outline of the scenario, WTP was elicited for the preferred choice, in a face to face setting.

Where preservation of the tooth by RCT and a crown was chosen, WTP was elicited immediately as below. However, where extraction was chosen, participants were randomised into one of two groups to allow an experiment relating to part-whole bias to be undertaken. The randomisation was based on a block randomisation (using Microsoft Excel 2007), with a block size of 30, with allocations placed in numbered sealed

envelopes which were opened and used on a consecutive basis. For those allocated to the part group, after choice of extraction, WTP was elicited for extraction only in the first instance. The options post-extraction (leave a gap, partial denture, bridge or implant replacement) were then outlined as detailed in Section 4.3.3, and the participant invited to make a choice. WTP for this second intervention was then gained. For those allocated to the whole group, after choice of extraction, options post-extraction were outlined and then WTP was gained for the extraction and the post-extraction choice together.

WTP was elicited using a shuffled payment card method, in which a range of values are printed on individual cards (see Figure 4.3 and Appendix B) and presented to the participant one at a time in a random order (Smith, 2006). The participant then decides for each value whether they are willing to pay the amount, unwilling to pay it or unsure, placing the card on a sheet with corresponding areas marked on it. This then leaves a range between the lowest value that the participant is unwilling to pay and the highest value that they are willing to pay. The participant is then asked to name the value between (and including) these values that would be the maximum they would be willing to pay. The decision for each card therefore is similar to a dichotomous choice (as recommended by Arrow and Solow (1993)), but the whole process finishes with an open ended question. This approach minimises some of the problems associated with using either one of these methods on their own, such as starting point and range bias and making the cognitive task too difficult. The WTP exercise was prefaced with an explanation of this method along with a script (see Figure 4.4) to ensure that patients understood that the exercise was hypothetical but to encourage realistic and budget constrained responses.

£1	£5	£10	£20	£30
£50	£75	£100	£150	£200
£250	£500	£750	£1000	£1500
£2000	£3000	£5000	£10000	£20000

Figure 4. 3 Values used on bidding cards for initial WTP elicitation

Script preceding WTP elicitation:
Now, I have a set of cards with different amounts of money printed on them. I want you to consider each card individually and decide whether you would be willing to pay that amount for your preferred option, saving the tooth. When you are thinking about this, we do not want you to think about how much you guess it would cost or what you have paid in the past for similar treatment, but just what value you put on the treatment yourself. It is also important for you to consider this in terms of what you can afford, for some of the larger amounts this might require taking out a loan or something similar but as this is something that you could theoretically choose to do it should come into your consideration. Also, we should be absolutely clear, this is a theoretical exercise. We are doing this to see how you value treatment, so there is no question of it altering what you or anyone else might pay for dental treatment at the moment or in the future. Bearing this in mind, you should look at each card, and place it in one of these piles. If you would definitely not be willing to pay that much, you should place it here. If you would definitely be willing to pay that much, place it here, and if you are not sure, place it here. *WHEN PARTICIPANT HAS PLACED ALL CARDS, IF ANY IN UNSURE PILE ASK:* Now that you have had chance to think a little more, do you want to reconsider any of the cards you were unsure about. *WHEN PARTICIPANT HAS FINISHED PLACING ALL CARDS ASK:* Because there are only twenty cards, there are gaps between the amounts you had to decide about. You have chosen *(SAY AMOUNT)* as the highest amount you would be willing to pay. Would you actually be prepared to pay any more or just *(SAY AMOUNT)*?

Figure 4. 4 Script for interviewer preceding WTP elicitation

Where participants gave a zero value, they were asked to identify the reason for the zero valuation from a range of options presented verbally and on a card (see Table 3.3 and Appendix B). This allowed zeros to be later classified as true zeros or protest responses as described in Section 3.2.5.6.

A further experiment was then undertaken to address how WTP is affected when there is a real market (albeit, in this case, an imperfect one with government intervention) which participants may be influenced by. Therefore, the next step was to present the participant with an estimate of current prices for all of the options discussed. Where the treatment was available on the state (NHS) system this price was used. Implants are not generally available on the NHS and so an estimate of the private cost was taken from a small survey of private implant providers in the geographical area of the study practices. The participant was then asked to view these as a minimum price and asked if their preference for treatment had changed. If their preference remained the same, the

participant was then asked for a revised maximum WTP (if it had changed at all), in an open-ended format. Where a new option was chosen, a new WTP was determined using the shuffled payment card method described above, but with the lowest possible value set to the price described, rather than £0.

4.3.5 Piloting

The full process of recruitment, interviewing, data input and basic analysis was piloted for a full day, at one of the practices, one month prior to the start of the main data collection phase. Following participant feedback, small adjustments were made to the wording of the questionnaire. The decision was also taken to use the questionnaire as a script for the structured interview rather than allowing the participant time to complete this on their own. This decision was based on the recognition that there would be numerous questions from participants about completing the questionnaire, and it was considered more efficient for the interviewer to explain these as they were eliciting answers.

4.4 Data analysis

4.4.1 Data input and validation

Data were coded directly onto the questionnaire script (Appendix A) and were then inputted by one researcher (the author of this thesis) into Microsoft Excel (2007). Validation consisted of performing rationality and consistency tests on the whole sample.

4.4.2 Descriptive analysis

Descriptive data analysis consisted of proportions selecting different treatment options and means with standard deviations along with medians and quartiles for WTP data broken down by treatment option. In addition, each of these was broken down by demographic and dental factors. Initial choices were compared with revised choices following disclosure of actual prices to participants and broken down by WTP using contingency tables. Finally, the part versus whole experiment was analysed by comparing the two randomised samples using a Mann Whitney U test.

4.4.3 Modelling and detailed analysis

In order to understand fully how the dental and demographic factors influenced both direction (treatment choice) and strength of preference (WTP), a range of econometric analyses were carried out. These consisted of a series of regression analyses as detailed in Figure 4.5. The initial dichotomous choice between saving the tooth or extraction was investigated using a simple logistic regression. The more complex 4 way choice of post-extraction treatment was investigated using a multinomial logistic regression. It is also possible to look at the final choice level, giving 5 choices of save tooth, extract and leave, extract and denture, extract and bridge and extract and implant, again using a multinomial logistic regression. This final way of looking at choice may be the most valid when it is considered that the 5 choices could be ranked in terms of oral health outcome or cost so that saving the tooth and implant would be similar and at the opposite end of the scale to extraction and a gap. This hierarchy effect was discussed in Section 2.5.4. The analysis, therefore, that treated all 5 options independently rather than in a nested fashion was considered the most appropriate.

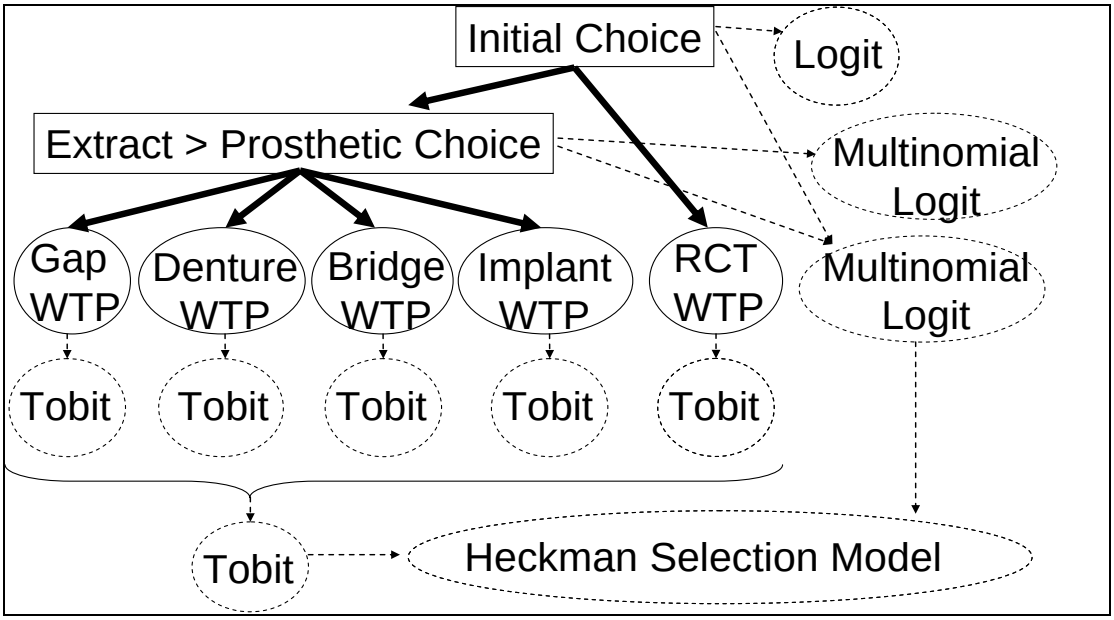

Figure 4. 5 Econometric modelling with data stages in unbroken lines and regression analyses in broken lines

The WTP data can be analysed using a tobit regression model, which accounts for the censoring of WTP data at zero. Tobit models have been recommended for analysis of WTP data because of this censoring effect (Halstead *et al.*, 1991) (although some have expressed doubts about the use of the technique proposing more complex alternatives

(Donaldson *et al.*, 1998; Yoo *et al.*, 2000)). The WTP can be dealt with on a whole sample basis (i.e. the WTP to deal with the problem). However, it is likely that WTP will not be independent of treatment choice and so it may be better to consider individual tobit models for sub-samples selected by treatment choice. However, an alternative way to use the whole data but to control for the treatment choice is to use a Heckman, or sample selection model. In this process, a first stage of the model explains treatment choice and gives a coefficient which can be used as an error term in the second stage of the model which looks at WTP, but now corrected for treatment choice.

Each model was selected based on backwards stepwise elimination, with the essential variables of experience of RCT, extraction and crowns maintained in all choice models and income variables maintained in all WTP models. These variables, henceforth referred to as "mandatory" variables were selected as essential based on their theoretical relevance to the dependent variable being modelled. In each case Akaike information criterion (AIC), Bayesian information criterion (BIC) and McFadden's pseudo R^2 measure of fit statistics were used to compare models to enable selection of the best fitting model, with BIC being the key statistic used. Although true R^2 statistics, based on residual sums of squares (RSS) cannot be used with the logistic and tobit models used, all three statistics (AIC, BIC and pseudo R^2) involve RSS (Gujarati, 2003). AIC and BIC are both relative measures, used for comparing models to select the best one, but not used in absolute way to accept or reject models. Both AIC and BIC penalise for the number of predictors used, but BIC penalises more heavily by involving number of observations in the penalty weighting (also log transformed) rather than a constant (Burnham and Anderson, 2004). The pseudo R^2 can also only be used as a relative statistic in finding the best model, not as an absolute value (as a true R^2 would be), and does not penalise for number of predictors (Veall and Zimmermann, 1996). Thus BIC, having the most stringent penalty was used as the key choice statistic.

Variables in the final Heckman selection model were kept the same as the models that this was based on (i.e. the logit for choice and the tobit for overall WTP).

4.5 Ethical approval and governance

Ethical approval was sought through the NHS National Research Ethics Service and the application was approved by the County Durham and Tees Valley 2 Research Ethics Committee. North of Tyne consortium of primary care trusts (PCTs, local NHS bodies) acted as the research sponsor and therefore the protocol was approved by them after being independently reviewed by 2 anonymous peer reviewers. The study was selected at random for a research governance audit and there were no adverse comments from the sponsors. Additionally, research and development governance approval was sought from each of the PCTs (i.e. Newcastle, North Tyneside, Gateshead and North Tees) where research would be taking place, as the responsible bodies for the primary care dental practices.

Chapter 5. Molar Tooth Study: Results

5.1 Introduction

The Molar Tooth Study involved interviewing participants about demographic and dental details and then undertaking a WTP task to determine direction and strength of preference for treatment options for a non-vital lower molar tooth. The demographic details of the whole sample will be presented initially, in Section 5.2, along with appropriate whole population figures for comparison. Direction of preference data are then explored in the context of the dental and demographic data in Section 5.3. The final section (5.4) of the descriptive analysis consists of WTP data. Next in Sections 5.5 and 5.6, data are presented relating to the two methodological experiments comparing part versus whole valuation and then looking at the influence of actual price on both preference direction and strength. Finally the econometric analysis is shown with a series of regression models in Section 5.7.

5.2 Demographic and dental details

In total 503 participants were interviewed. The breakdown by practice is shown in Table 5.1.

Practice No.	Number of participants	Percent of whole sample
1	39	8
2	176	35
3	55	11
4	32	6
5	54	11
6	21	4
7	59	12
8	67	13

Table 5. 1 Recruitment figures by practice

Data for most interviews was complete except in 18 cases where the participant refused to give income details, in 2 cases where they refused to give their educational status and in 8 cases where an index of deprivation score could not be matched to their postcode (due to errors in reporting postcode).

The basic demographics and dental history of this sample are given in Tables 5.2 to 5.12 alongside population figures. For demographic variables, the population figures are for

the North East (NE) Strategic Health Authority. These demographic population figures are taken from the 2001 National Census (Office for National Statistics, 2001) with the exception of income figures which are taken from ONS Family Resources Survey 2007-8 (Department for Work and Pensions, 2008). For dental variables, population figures from the ADHS are used. Where data were available from the 2009 ADHS (The NHS Information Centre, 2010), this is used at an England level (regional breakdowns were not available at the time of writing). If the initial release of 2009 data did not cover the variable being addressed, Northern and Yorkshire or North region level data from the 1998 survey (Kelly *et al.*, 2000) were used. For dental tables, the source of population figures will be cited in the table title. It should be remembered that the figures from the 1998 ADHS were 12 years old, and as such may be inaccurate.

Figures for usual method of paying for dentistry were not available for the population in the same format as had been asked in this study (See Table 5.9). However, in the ADHS (Kelly *et al.*, 2000) in the Northern and Yorkshire region, 85% were NHS patients and 10% paid mainly privately. Additionally it was reported that 55% paid for treatment with 36% being exempt from payment. These population figures, in particular, are likely to be inaccurate given their age and the changes in dental service context in the UK (see discussion in Section 2.3.2).

From these tables, it can be seen that the sample is broadly representative of the population. The sample contains slightly more females, a slightly older age profile, contains more people who are living in a deprived area, with a slightly lower household income profile, are more qualified and have a similar SES (socio-economic status) profile, although this is difficult to compare given the high number unclassified in the population. The sample consists of more regular dental attendees and has a higher proportion of NHS patients, which is unsurprising given the recruitment strategy. Recent dental experience is difficult to compare given the different data collected but seems to be broadly in line with the population figures, and number of teeth is very similar. The possibility of weighting the data is discussed in Section 6.2.1, but it was agreed not to do this.

Gender	Number of participants	Percent of whole sample	Percent of NE population
Male	227	45	48
Female	276	55	52

Table 5. 2 Proportions of sample and North East England (NE) population by gender

Age	Number of participants	Percent of sample	Percent of NE adult population
16-24	45	9	16
25-34	73	15	31
35-44	84	17	
45-54	115	23	33
55-64	97	19	
65-74	61	12	15*
75+	28	6	6*

Table 5. 3 Proportions of sample and North East England (NE) population by age bands (* age band boundaries in population data is 79 giving bands of 66-79 and 80+)

IMD Quintile	IMD range for sample	IMD range for NE population
Q1 (least deprived)	00.0-14.20	0.00-11.95
Q2	14.30-26.99	11.96-20.50
Q3	27.00-36.99	20.51-30.94
Q4	37.00-48.10	30.95-43.64
Q5	48.20-80.00	43.65-80.02

Table 5. 4 Ranges of Index of Multiple Deprivation (IMD) scores in sample and North East England (NE) population quintiles

Weekly gross income	Number of participants	Percent of sample	Percent of NE population
£0-£99	36	7	2
£100-£199	88	18	15
£200-£299	92	19	18
£300-£399	47	10	14
£400-£499	47	10	11
£500-£599	39	8	7
£600-£699	41	8	8
£700-£999	43	9	13
£1000+	52	11	12

Table 5. 5 Proportions of sample and North East England (NE) population by income band

Highest qualification gained (equivalent)	Number of participants	Percent of sample	Percent of NE population
None/Unsure	156	31	42
GCSE (D-G)	32	6	17
GCSE (A-C)	125	25	19
A level	69	14	7
1st Degree	76	15	15
Higher Degree	43	9	

Table 5. 6 Proportions of sample and North East England (NE) population by highest qualification gained

Socio-economic grouping	Number of participants	Percent of sample	Percent of NE population
1 (highest)	177	35	21
2	58	12	9
3	34	7	5
4	82	16	8
5	139	28	24
Not classified	13	3	31

Table 5. 7 Proportions of sample and North East England (NE) population by NS-SEC socio-economic classification

Frequency of visits to dentist	Number of participants	Percent of sample	Percent of English population
Regular	377	75	61
Occasional	48	10	10
Only when having trouble	78	16	27

Table 5. 8 Proportions of sample and English population (The NHS Information Centre, 2010) by regularity of dental visits

Usual method of paying for dentistry	Number of participants	Percent of sample
NHS payer	318	63
Private fee per item	13	3
NHS exempt	166	33
Private insurance	6	1

Table 5. 9 Proportions of sample by usual method of payment for dentistry of sample

	Scale and polish			Direct Restorations			Crowns			Bridges			RCT			Extractions			Dentures		
Last experience	Number of participants	Percent of sample	Percent of population	Number of participants	Percent of sample	Percent of population	Number of participants	Percent of sample	Percent of population	Number of participants	Percent of sample	Percent of population	Number of participants	Percent of sample	Percent of population	Number of participants	Percent of sample	Percent of population	Number of participants	Percent of sample	Percent of population
In last 2 years	398	79	88	283	56	94	61	12	25	18	4	5	34	7	NA	149	30	87	59	12	NA
> 2 years	62	12		201	40		163	32		33	7		115	23		269	53		54	11	
Never	43	9	NA	19	4	NA	279	55	NA	452	90	NA	354	70		85	17	NA	390	78	

Table 5. 10 Proportions of sample and North of England population (Kelly *et al.*, 2000) by self-reported experience of different dental interventions

Most recent dental pain experience	Number of participants	Percent of sample
Never experienced	144	29
Longer than 2 years ago	185	37
6 months to 2 years ago	60	12
In last 6 months	64	13
Currently in pain	50	10

Table 5. 11 Proportions of sample by time elapsed since most recent dental pain experience bad to enough to require a visit to the dentist

Teeth remaining	Number of participants	Percent of sample	Percent of English population (boundaries <21 and 21+)
Fewer than 10	30	6	14
10-19	101	20	
20 or more	372	74	86

Table 5. 12 Proportions of sample and English population (The NHS Information Centre, 2010) by self reported number of natural teeth remaining (note: groupings used in population figures are 1-20 and 21 or more teeth)

5.3 Direction of preferences

In this section, a descriptive analysis of the direction of preference will be presented. The choice presented in the scenario was between saving the tooth with RCT or having the tooth extracted (extract). Those choosing extraction had a further choice of prosthetic replacement with the options being to do nothing (leave a gap, or "extract only"), have a removable partial denture, have a fixed bridge, or have an implant. These choices are shown on Levels 4, 5 and 6 in the conceptual model in Figure 2.1

The initial choices of the whole sample and broken down by different demographic and dental variables are shown in Table 5.13. This is, however, a simplistic view as there may be confounding factors or interactions which are not illustrated by this single variable approach. The variables' influence on choice will be explored more fully in the econometric modelling section.

All figures are % proportion of row		RCT	Extract only	Extract+ Denture	Extract+ Bridge	Extract+ Implant
Initial Choice (whole sample n=503)		53	19	3	8	17
Gender	Male (n=227)	51	21	3	9	16
	Female (n=276)	54	17	4	7	18
Age	16-24 (n=45)	42	18	7	16	18
	25-34 (n=73)	49	15	1	1	33
	35-44 (n=84)	52	20	5	6	17
	45-54 (n=115)	63	11	2	9	15
	55-64 (n=97)	46	29	2	8	14
	65-74 (n=61)	59	18	5	10	8
	75+ (n=28)	43	29	4	11	14
IMD (sample) Quintiles	Q1 (least deprived)	68	15	0	8	9
	Q2	53	20	2	11	14
	Q3	52	19	2	6	21
	Q4	52	15	5	10	18
	Q5	42	23	6	6	22
Weekly gross income	£0-£99 (n=36)	56	17	3	0	25
	£100-£199 (n=88)	45	22	3	7	23
	£200-£299 (n=92)	50	14	9	9	18
	£300-£399 (n=47)	55	19	2	9	15
	£400-£499 (n=47)	51	26	0	9	15
	£500-£599 (n=39)	51	31	3	10	5
	£600-£699 (n=41)	51	12	0	17	20
	£700-£999 (n=43)	65	16	0	5	14
	£1000+ (n=52)	65	10	0	8	17
Education (equivalent)	No qualifications (n=156)	47	27	4	6	17
	GCSE (D-G) (n=32)	41	22	13	3	22
	GCSE (A-C) (n=125)	50	21	4	10	14
	A level (n=69)	64	10	1	12	13
	First Degree (n=76)	51	14	0	9	25
	Higher Degree (n=43)	77	5	0	5	14
Dental Attendance	Regular (n=377)	56	18	2	9	15
	Occasional (n=48)	52	15	8	4	21
	Only in trouble (n=78)	38	27	4	6	24
Dental Payment	NHS payer (n=318)	53	21	3	9	15
	Private fee per item (n=13)	92	0	0	0	8
	NHS exempt (n=166)	49	18	5	6	22
	Private insurance (n=6)	83	0	0	17	0
Experience of scale and polish	In the last 2 yrs (n=398)	55	19	3	8	16
	Longer than 2 yrs (n=62)	50	19	5	5	21
	Never (n=43)	37	21	7	12	23
Experience of direct restorations	In the last 2 yrs (n=283)	55	19	3	6	16
	Longer than 2 yrs (n=201)	51	19	4	8	18
	Never (n=19)	32	21	0	26	21
Experience of crowns	In the last 2 yrs (n=61)	72	11	0	5	11
	Longer than 2 yrs (n=163)	61	15	1	7	15
	Never (n=279)	43	23	5	9	19
Experience of bridges	In the last 2 yrs (n=18)	56	11	6	17	11
	Longer than 2 yrs (n=33)	82	6	0	6	6
	Never (n=452)	50	20	3	8	18
Experience of RCT	In the last 2 yrs (n=34)	68	12	3	0	18
	Longer than 2 yrs (n=115)	65	12	2	7	14
	Never (n=354)	47	22	4	9	18
Experience of extractions	In the last 2 yrs (n=149)	42	28	4	8	19
	Longer than 2 yrs (n=269)	54	18	3	9	16
	Never (n=85)	67	8	2	4	19
Experience of dentures	In the last 2 yrs (n=59)	42	24	10	8	15
	Longer than 2 yrs (n=54)	54	19	6	11	11
	Never (n=390)	54	18	2	7	18
Experience of pain	Never (n=144)	57	14	4	5	20
	Longer than 2 yrs (n=185)	52	19	3	12	14
	In the last 2 yrs (n=60)	57	23	2	5	13
	In the last 6 months (n=64)	50	19	5	6	20
	Currently in pain (n=50)	42	30	0	6	22
Number of natural teeth	Fewer than 10 (n=30)	43	20	10	10	17
	10-19 (n=101)	55	24	3	8	10
	20 or more (n=372)	53	18	3	8	19

Table 5. 13 Initial preferences for whole sample and broken down by demographic and dental characteristics (yrs=years)

It can be seen that around half of the sample wished to save the tooth, with the remainder mostly choosing to leave a gap or have an implant. Very few participants (3 %) chose to have a denture. Initially, by looking at each demographic factor in isolation, it appears that both younger and older participants were less likely to save a tooth than the middle age bands, as were those who were more deprived and those with fewer qualifications. A pattern is less obvious looking at income bands. In terms of dental factors, it seems that those who attend only with problems are less likely to save a tooth, with private payers being much more likely to save the tooth (although this is only a small proportion of the sample). In terms of dental experience, those who had no experience of scale and polish, direct restorations and crowns were less likely to save, and those with any experience of crowns or RCT were more likely to save the tooth. Interestingly those with experience of extractions and dentures were more likely to choose not to save the tooth. No pattern was discernable relating to dental pain experience or number of teeth remaining.

5.4 Strength of preference: WTP results

WTP was elicited from participants for their preferred option using a shuffled payment card method. The initial choices and WTP of the whole sample are shown in Table 5.14. The overall mean WTP for the whole sample (the WTP for dealing with the problem, irrespective of treatment choice) was £327.66 (standard deviation (SD) 774.58).

There were only 6 zero responses in the whole data set (4 in the RCT sub-group, 2 in the extraction only sub-group). All respondents selected "I can not afford to pay it" from a set of explanations (Appendix B), indicating that these were all "true" zeros, rather than protest responses. Therefore, all of these responses were included in the analyses.

Initial choice	Prosthetic replacement	Proportion (%)	Mean (SD) WTP (£)
Save tooth (RCT + crown)	N/A	53	372.79 (991.46)
Extract tooth	None (leave gap)	19	97.86 (108.61)
	Removable denture	3	252.50 (415.13)
	Fixed partial denture	8	405.63 (633.03)
	Implant	17	422.85 (428.75)

Table 5. 14 Mean WTP values with standard deviation (SD) by initial preference

Although the exercise finishes with participants offering an open ended response to their WTP after narrowing down to a range between 2 cards, a large number of participants (79%) gave a figure that was stated on one of the cards. There may therefore be an argument that the data should be categorical rather than continuous. Additionally, Figures 5.1-5.5 show that the WTP distribution is not normal (note the broken axes in Figures 5.1, 5.4 and 5.5). This shows that the mean may not be the ideal descriptive value and so median and quartile values are shown in Table 5.15.

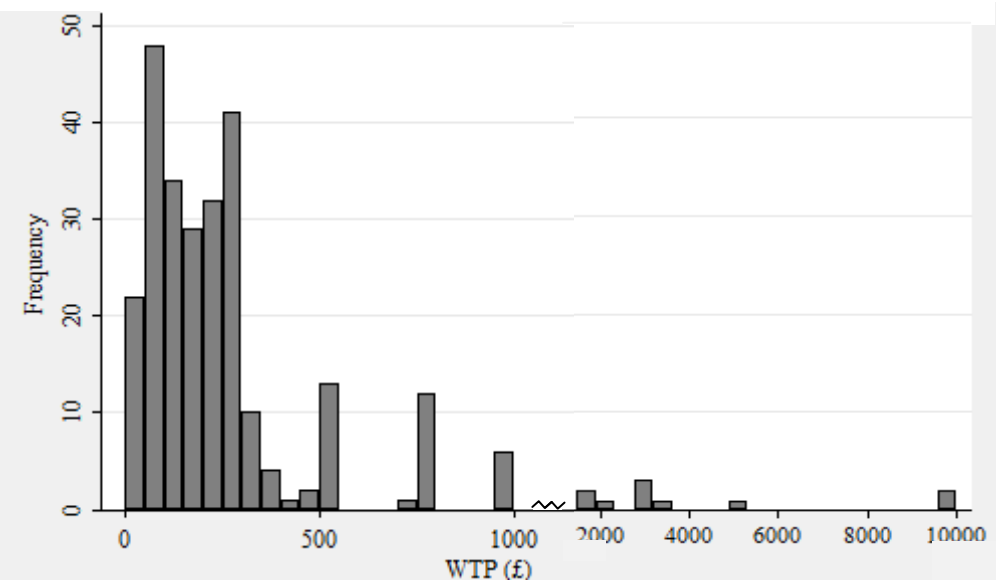

Figure 5. 1 Frequency distribution plot of WTP values for those whose initial preference was RCT

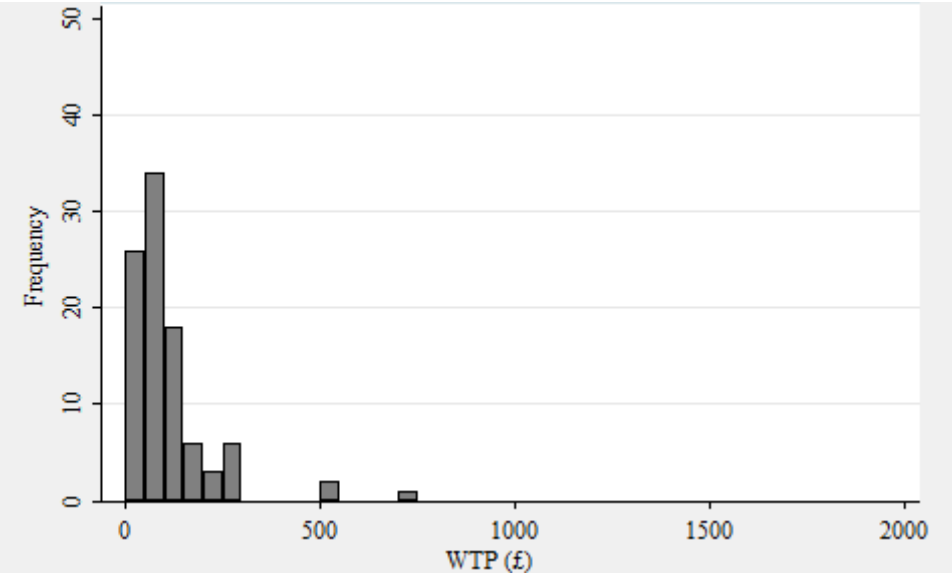

Figure 5. 2 Frequency distribution plot of WTP values for those whose initial preference was extraction only

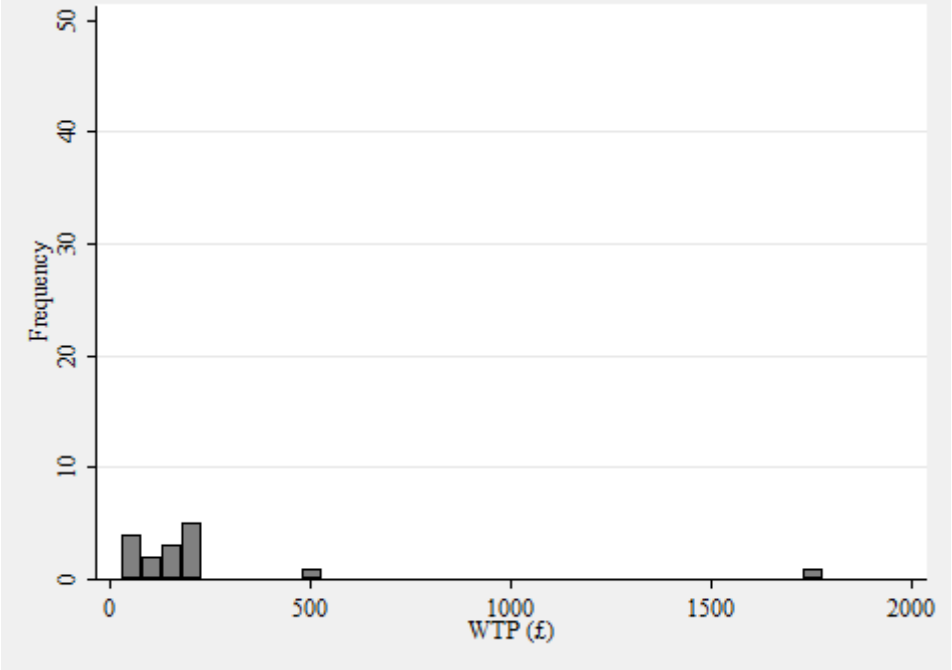

Figure 5. 3 Frequency distribution plot of WTP values for those whose initial preference was extraction and denture

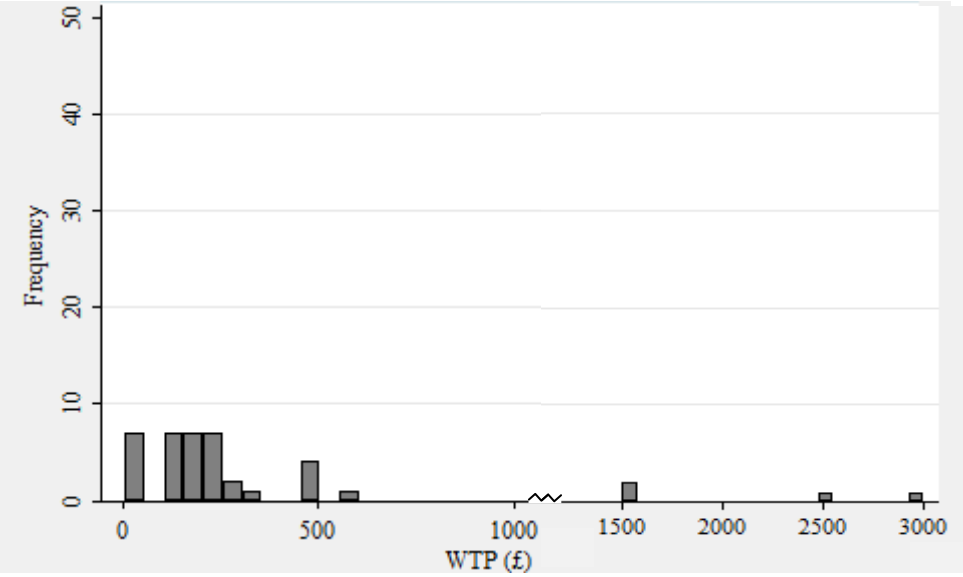

Figure 5. 4 Frequency distribution plot of WTP values for those whose initial preference was extraction and bridge

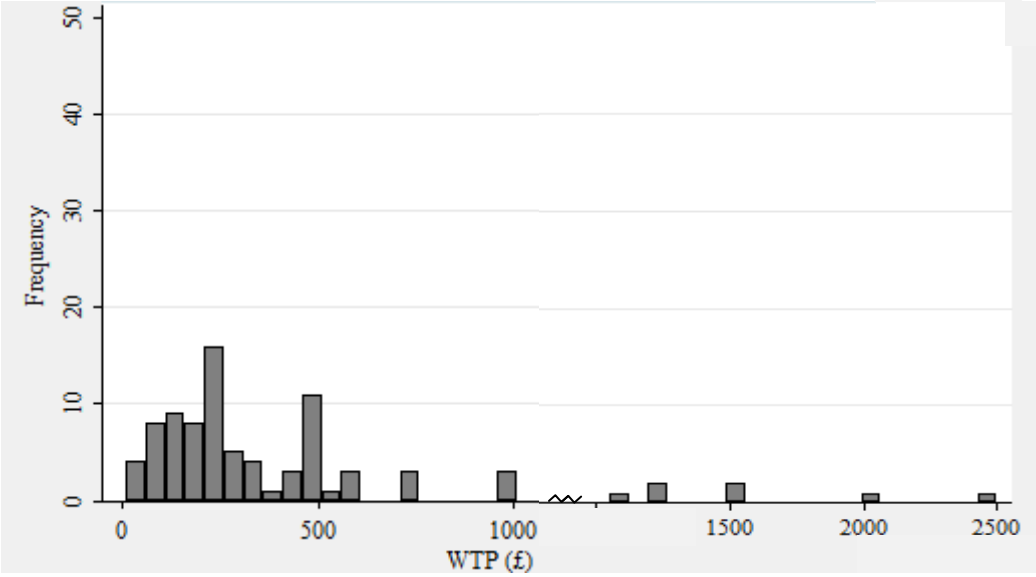

Figure 5. 5 Frequency distribution plot of WTP values for those whose initial preference was extraction and implant

Initial choice	Prosthetic replacement	Min	Q1	Med	Q3	Max
Save tooth (RCT + crown)	N/A	0	80	175	250	10000
Extract tooth	None (leave gap)	0	40	67.5	100	750
	Removable denture	30	58	163	200	1750
	Fixed partial denture	5	118	200	331	3000
	Implant	10	168.8	250	500	2500

Table 5. 15 Median WTP values with ranges and quartile values by initial preference (Med = median)

It can be seen that, according to WTP values, the strongest preference is shown for implants, followed by fixed partial dentures, saving the tooth, removable dentures and extraction only, with the mean for the highest being more than four times as great as the mean for the lowest. The medians also reflect this trend although the magnitudes of difference are not as large.

Although the mean and median values are of interest in their own right, the most important finding is the large variance. In all cases, irrespective of whether parametric or non-parametric analysis is used, it is clear that there is a large variation in WTP within the sample and sub-samples and the distribution is markedly skewed to the left;

not a surprising finding in any WTP data. The deviation is largest for saving the tooth, despite not offering the largest mean value. This may well reflect the outliers in this group, with 7 participants offering values more than 2 standard deviations higher than the mean (2 at £10000, 1 at £5000 and 1 at £3500 and 3 at £3000). This compares with 3 outliers for extraction only (2 at £500 and 1 at £750), 1 for removable dentures (£1750), 2 for fixed partial denture (£2500 and £3000) and 4 for implants (2 at £1500, 1 at £2000 and 1 at £2500). The demographic and previous dental history details of each of the outliers are shown in Table 5.16.

Although there is no clear direction for how to deal with WTP outliers, it can be thought that these participants were taken through the scenario in the same way as all participants, and therefore their values are as valid as any others. Therefore, in this study, it was decided to include these outliers in all analyses. This decision is further discussed in Section 6.2.3. The econometric models presented in Section 5.7 were all run without outliers as well, and the models without outliers are presented in Appendix D.

Preferred treatment option	WTP (£)	Age (years)	Gender	IMD score	Gross household income	Highest qualification (equivalent)	NS-SEC	Frequency of dental visits	Normal payment method	Last scale and polish	Last filling	Last crown	Last bridge	Last RCT	Last extraction	Last denture	Last pain	No. teeth
RCT	3000	45	Female	22.15	£700-£999	First Degree	1	Regular	NHS Pay	<2yrs	>2yrs	Never	Never	Never	>2yrs	Never	>2yrs	10-19
RCT	3000	44	Female	4.93	£1000+	First Degree	1	Regular	NHS Pay	<2yrs	<2yrs	<2yrs	Never	>2yrs	Never	Never	Never	20+
RCT	3000	37	Female	22.24	£1000+	Higher Degree	1	Regular	NHS Pay	<2yrs	<2yrs	Never	Never	Never	<2yrs	Never	Current	20+
RCT	3500	31	Male	6.21	£1000+	Higher Degree	1	Regular	Private fees	<2yrs	>2yrs	<2yrs	Never	>2yrs	Never	Never	Never	20+
RCT	5000	33	Female	69.84	£700-£999	Higher Degree	1	Regular	NHS Pay	<2yrs	<2yrs	Never	Never	Never	Never	Never	2yrs-6mo	20+
RCT	10000	42	Female	*	£1000+	Higher Degree	1	Regular	Private insurance	<2yrs	<2yrs	>2yrs	Never	>2yrs	Never	Never	>2yrs	20+
RCT	10000	57	Female	29.8	£0-£99	GCSE D-G	2	Regular	NHS Pay	<2yrs	<2yrs	Never	Never	Never	Never	Never	Never	20+
Extract+ gap	500	79	Male	28.95	£200-£299	None	4	Regular	NHS Pay	>2yrs	>2yrs	>2yrs	Never	Never	>2yrs	>2yrs	>2yrs	<10
Extract+ gap	500	48	Female	39.79	£500-£599	None	5	Irregular	NHS Exempt	Never	>2yrs	Never	Never	>2yrs	>2yrs	<2yrs	>2yrs	<10
Extract+ gap	750	61	Female	10.74	£1000+	First Degree	1	Regular	NHS Pay	<2yrs	>2yrs	Never	Never	Never	>2yrs	Never	Never	20+
Extract+ denture	1750	18	Female	*	*	GCSE A-C	5	Occasional	NHS Exempt	>2yrs	>2yrs	Never	Never	Never	>2yrs	Never	Never	20+
Extract+ bridge	2500	46	Male	3.08	£1000+	Higher Degree	1	Regular	Private insurance	<2yrs	<2yrs	>2yrs	>2yrs	Never	>2yrs	Never	>2yrs	20+
Extract+ bridge	3000	58	Female	26.27	£200-£299	GCSE A-C	1	Regular	NHS Exempt	<2yrs	<2yrs	>2yrs	Never	Never	>2yrs	Never	Never	20+
Extract+ implant	1500	35	Female	57.49	£100-£199	None	1	Regular	NHS Exempt	<2yrs	<2yrs	Never	Never	Never	>2yrs	Never	Never	20+
Extract+ implant	1500	85	Female	18.43	£100-£199	First Degree	1	Regular	NHS Exempt	>2yrs	>2yrs	Never	Never	Never	<2yrs	>2yrs	>2yrs	<10
Extract+ implant	2000	43	Female	19.86	£400-£499	GCSE A-C	4	Regular	NHS Pay	<2yrs	>2yrs	Never	Never	Never	>2yrs	Never	Never	20+
Extract+ implant	2500	54	Female	7.43	£1000+	First Degree	1	Regular	NHS Pay	<2yrs	<2yrs	<2yrs	Never	<2yrs	<2yrs	Never	2yrs-6mo	20+

Table 5. 16 Demographic and dental history details of outliers (one case per row) *=missing data, yrs=years, mo=months

5.5 Part – whole valuation

Of those choosing extraction as their preferred choice, participants were either asked for their prosthetic preference and asked to value the extraction and prosthesis together (whole valuation) or asked for their valuation for the extraction and then asked for their prosthetic preference and then their valuation of this only (part valuation). The mean values for whole valuation and part valuation (broken down into extraction and prosthesis and then combined for a total) are shown in Table 5.17. Although numbers are small in each sub-sample, it can be seen that part valuation produced higher total mean values than whole valuation, especially in the denture and bridge arms. These differences were tested with a Mann-Whitney U test for each sub-sample in turn, which in each case failed to reject the null hypothesis that the part valuation was the same as the whole valuation, even at a level of $p<0.1$. Therefore although differences are apparent in the methods of elicitation, these have not been shown to be statistically significant in this example. It is likely that the small sample size meant that there was a lack of power to detect any meaningful differences (see Section 6.2.2 for further discussion).

			Extraction + Gap	**Extraction + Denture**	**Extraction + Bridge**	**Extraction + Implant**
Whole valuation		n	49	7	19	45
		Mean (SD)	90.71 (96.99)	138.57 (79.67)	267.63 (330.83)	387.78 (441.06)
Part valuation		n	47	9	21	41
	Extraction valuation	Mean (SD)		143.33 (239.11)	196.67 (348.96)	200.73 (237.63)
	Prosthesis valuation	Mean (SD)		197.78 (308.75)	333.81 (505.06)	260.61 (212.60)
	Total valuation	Mean (SD)	105.32 (120.15)	341.11 (546.06)	530.47 (805.27)	461.34 (416.83)

Table 5. 17 Mean WTP values and standard deviations (SD) for part and whole valuation groups by initial preference

5.6 Influence of actual price

After the initial valuation was complete, participants were exposed to current prices for all choices and participants were then asked to re-evaluate their choice and give a revised WTP for their new choice, using the actual price as a minimum figure. The

prices used were £200 for RCT, £50 for extraction only, £200 for extraction and denture, £250 for extraction and bridge, and £1500 for extraction and implant.

In Table 5.18, the sample is broken down by initial and subsequent revised choice and the mean WTPs for initial and revised choices are given with standard deviations.

Although many participants kept to their initial choice (65%) and/or WTP (46%), this process particularly affected those who had given a lower WTP than the price for their preferred option who were then forced to choose a new option or increase their WTP for their preferred choice. In Table 5.19, for each initial choice group, the numbers increasing, reducing or keeping the same WTP is shown.

In all cases standard deviation was lower after exposure to prices. However, there was not a marked reduction in standard deviation for those who chose RCT initially and still chose RCT following exposure. This probably reflects the extreme outliers that were in this group, who mostly kept their high valuations. These few individuals have a disproportionate effect on the standard deviation in this group.

Across all sub-samples, of those whose WTP was lower than the price for their initial option, 40% kept their initial choice and raised their WTP value, suggesting that stated preference had underestimated actual preference. Of those who changed from their initial choice, a range of behaviours were observed including lowering (26%), raising (20%) and keeping the same WTP (13%).

The most interesting group are those who initially chose extractions and implants, which it can be seen, spread the most to other groups upon revealing price, perhaps reflecting their mean WTP being so far from the actual (estimated) price.

Initial choice	Revised choice	Freq.	Mean WTP for initial choice	SD	Mean WTP for revised option	SD
RCT (price £200)	RCT	192	460.52	1141.77	485.58	1131.94
	Extract + gap	59	66.44	37.89	66.27	31.43
	Extract + denture	0	-	-	-	-
	Extract + bridge	11	450.00	540.83	520.46	509.76
	Extract + implant	3	500.00	433.01	1666.67	288.68
Extract + gap (price £50)	RCT	1	40.00	-	50.00	-
	Extract + gap	93	95.21	107.86	91.34	95.19
	Extract + denture	1	250.00	-	250.00	-
	Extract + bridge	1	250.00	-	350.00	-
	Extract + implant	0	-	-	-	-
Extract + denture (price £200)	RCT	0	-	-	-	-
	Extract + gap	6	83.33	58.11	58.33	20.41
	Extract + denture	10	354.00	504.80	215.00	33.75
	Extract + bridge	0	-	-	-	-
	Extract + implant	0	-	-	-	-
Extract + bridge (price £250)	RCT	1	115.00	-	200.00	-
	Extract + gap	13	91.92	60.43	57.31	15.36
	Extract + denture	0	-	-	-	-
	Extract + bridge	26	573.65	734.49	454.80	463.03
	Extract + implant	0	-	-	-	-
Extract + Implant (price £1500)	RCT	20	432.00	459.05	290.00	177.40
	Extract + gap	27	315.74	371.68	186.67	273.00
	Extract + denture	8	368.75	149.25	243.75	105.01
	Extract + bridge	23	457.61	497.80	358.70	147.44
	Extract + implant	8	715.63	442.99	1500.00	0.00

Table 5. 18 Initial and revised WTP and standard deviations by initial and revised choice groupings

			Initial Choice				
			RCT	Extract+ gap	Extract+ denture	Extract+ bridge	Extract+ implant
Initial WTP groups	Initial WTP at or above price		132	70	7	18	4
	Initial WTP below price		133	26	9	22	82
Initial WTP at or above price	Revised choice same as initial	WTP decreased	8	6	2	5	0
		WTP same	111	61	5	13	1
		WTP increased	3	1	0	0	0
	Revised choice different to initial	WTP decreased	0	0	0	0	3
		WTP same	4	1	0	0	0
		WTP increased	6	1	0	0	0
Initial WTP below price	Revised choice same as initial	WTP decreased	1*	1*	0	0	0
		WTP same	1*	2*	0	0	0
		WTP increased	68	22	3	8	7
	Revised choice different to initial	WTP decreased	18	0	3	7	42
		WTP same	17	0	1	1	15
		WTP increased	28	1	2	6	18

Table 5. 19 Number of participants making decision to change or keep initial choice and change or keep initial WTP after being made aware of prices ***(*Participants were unwilling to pay minimum price after revision (i.e. equivalent of a true zero))***

5.7 Econometric modelling

As described in the methods section, a series of economic models were developed to explain the factors influencing the direction and strength of preference. The figure explaining the models is reproduced here (Figure 5.6) to aid understanding of this section. Each of the models was also run without the WTP outliers included (as discussed in Section 5.4) and these models are presented in Appendix D.

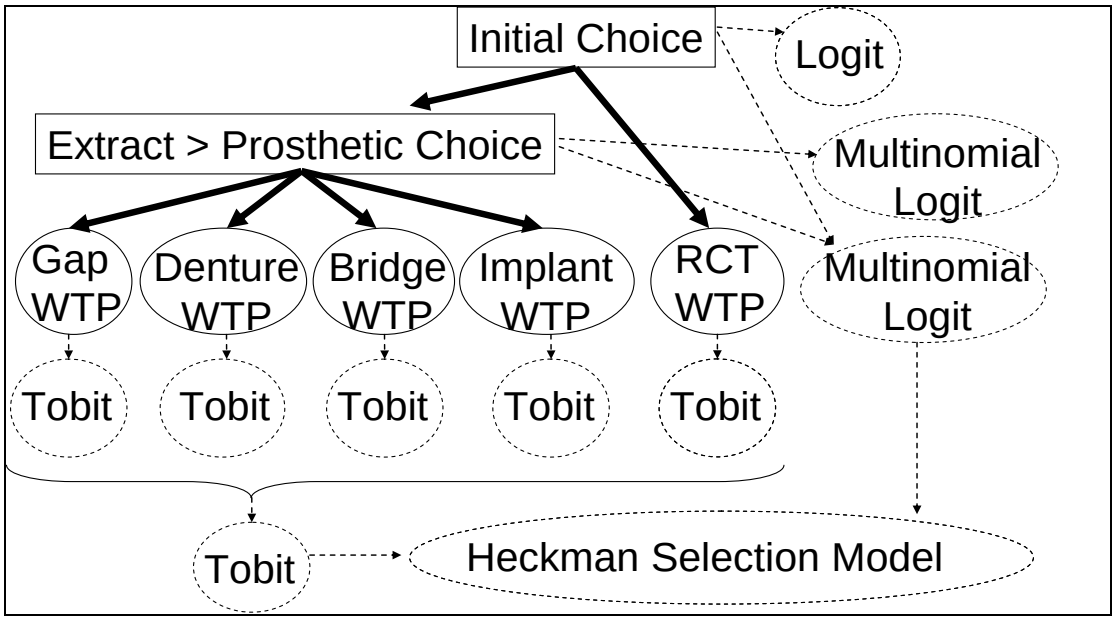

Figure 5. 6 Econometric models to be used

5.7.1 Logistic regression modelling of initial choice (extract versus save tooth)

The first model explains the choice between saving the tooth (RCT) and extracting it (with all subgroups of prosthetic choice combined into this one larger group). The model is given in Table 5.20, with significant factors of low SES, and experience of crowns, RCT and extractions. Low SES and experience of extraction made choosing extraction more likely and experience of RCT or crowns made choosing extraction less likely.

This particular model (n=503) has a likelihood ratio of chi^2 of 55.86 ($p<0.001$) with a pseudo R^2 of 0.080. This figure is of little use in isolation unlike the normal R^2 statistic; there is no equivalent of the R^2 which explains how much of the variance is explained by the model. The BIC figure is -2457.862, compared to a value of -2253.727 for a model with all variables included and -2451.319 for a model with only the mandatory variables of experience of extraction, RCT and crowns in it.

Predictor	Odds Ratio	SE	Z	P	95% confidence interval
Low Socio Economic Status (Ref mid & high Socio-economic status)	1.97	0.37	3.55	0.000	1.35-2.86
Experience of crown (Ref no experience)	0.48	0.10	-3.61	0.000	0.32-0.71
Experience of RCT (Ref no experience)	0.57	0.13	-2.54	0.011	0.37-0.88
Experience of extraction (Ref no experience)	2.81	0.75	3.86	0.000	1.66-4.75

Table 5. 20 Logistic regression model of initial choice for extraction (versus saving tooth)

5.7.2 Multinomial logistic regression on prosthetic choice

The next model contains only those who chose extraction and explains the choice of prostheses these participants make using no prosthesis (leaving a gap) as the baseline choice. Unfortunately, this leaves 2 of the sub-samples with very small sample sizes (denture with 16 and bridge with 40), making this model unreliable. In fact, the model with no predictors was better (in terms of BIC) than any other model, indicating that none of the observed variables were good predictors of choice. Therefore, no model is shown here.

5.7.3 Multinomial logistic regression on all choices combined

This model assumes no nesting of the decision choice and puts all 5 choices on an equal level, and explains the choice of treatment strategy, again using no prosthesis (leaving a gap) as the baseline choice, as it is arguably the least extensive and expensive intervention. If the baseline choice is made saving the tooth, the results are broadly similar, although those who had previous experience of crowns were less likely to choose extraction and implant than RCT. The model with extraction and gap as the baseline (n=503) is given in Table 5.21, with only the mandatory variables being left included. No experience of extractions and experience of crowns and RCT make choosing RCT over extraction and leaving a gap more likely. With extract and denture and extract and bridge there are no significant factors but the number in this subsample is small as described in Section 5.3. For extract and implant, having no experience of extractions both increased the likelihood of choosing implant over leaving a gap.

This particular model has a likelihood ratio of chi^2 of 55.70 ($p<0.0001$) with a pseudo R^2 of 0.0473. The BIC figure is -1785.925, compared to a value of -1285.311 for a model with all variables included.

Predictor	Relative Risk Ratio	Standard Error	z	p	Confidence Interval
Base Case: Extract and leave gap					
RCT					
Experience of crown (Ref no experience)	2.24	0.60	3.01	0.003	1.33-3.80
Experience of RCT (Ref no experience)	2.19	0.68	2.52	0.012	1.19-4.02
Experience of extraction (Ref no experience)	0.21	0.09	-3.63	0.000	0.09-0.49
Extract and denture					
Experience of crown (Ref no experience)	0.26	0.21	-1.64	0.101	0.05-1.30
Experience of RCT (Ref no experience)	1.54	1.11	0.59	0.553	0.37-6.32
Experience of extraction (Ref no experience)	0.63	0.54	-0.54	0.588	0.12-3.37
Extract and bridge					
Experience of crown (Ref no experience)	1.06	0.44	0.15	0.882	0.47-2.41
Experience of RCT (Ref no experience)	1.06	0.53	0.12	0.904	0.40-2.82
Experience of extraction (Ref no experience)	0.95	0.69	-0.07	0.946	0.23-3.92
Extract and implant					
Experience of crown (Ref no experience)	1.17	0.39	0.48	0.633	0.61-2.24
Experience of RCT (Ref no experience)	1.54	0.59	1.14	0.256	0.73-3.25
Experience of extraction (Ref no experience)	0.32	0.15	-2.38	0.018	0.12-0.82

Table 5. 21 Multinomial logistic regression for all choices with extract and leave gap as baseline

5.7.4 Tobit model of all WTP combined

The modelling from here onwards attempts to explain the variation in WTP. This first model uses the whole sample together irrespective of initial treatment choice. It therefore could be seen as explaining the WTP to deal with the problem of a non-vital

molar tooth. The model is given in Table 5.22, with significant factors of high income increasing WTP and previous experience of extraction lowering WTP.

This particular model (n=485) has a likelihood ratio of chi^2 of 30.06 (p<0.0001) with a pseudo R^2 of 0.0039. The BIC figure is 4789.542, compared to a value of 4861.044 for a model with all variables included and 4792.530 for a model with only the mandatory variables of high income and low income in it.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Low income (Ref middle and high income)	44.43	83.35	0.53	0.594	-119.35 – 208.21
High income (Ref low and middle income)	391.04	91.90	4.26	0.000	210.47 – 571.61
Experience of extraction (Ref no experience)	-284.82	93.61	-3.04	0.002	-468.76 – -100.88
Constant	476.40	93.53	5.09	0.000	292.63 – 660.17
/sigma	764.14	24.65			715.72 – 812.57

Table 5. 22 Tobit model of WTP to deal with problem (whole sample)

5.7.5 Tobit model of WTP for RCT

One of the issues with the previous model, using WTP for the whole sample, is that WTP is likely not to be independent of choice, and in fact this is likely to have a major influence on WTP. Therefore the next set of models are all tobit models for sub-samples by initial choice. In the case of the initial choice being extract and denture and extract and bridge, the sample sizes were not sufficiently large to produce valid models, and so models are only given for RCT, extraction and leave gap and extraction and implant.

The first model to be presented here is for the WTP of those who chose RCT as their preferred option (n=259). The model is given in Table 5.23, with significant factors of being female and high income increasing WTP and previous experience of extraction decreasing WTP.

This particular model has a likelihood ratio of chi^2 of 25.41 (p<0.0001) with a pseudo R^2 of 0.0060. The BIC figure is 2827.076, compared to a value of 2903.324 for a model

with all variables included and 2828.869 for a model with only the mandatory variables of high and low income in it.

Predictor	Coef.	SE of coef.	t	p	95% confidence intervals
Gender female (Ref male)	246.03	123.56	1.99	0.048	2.70 – 489.36
Low income (Ref middle and high income)	73.67	152.90	0.48	0.630	-227.43 – 374.77
High income (Ref low and middle income)	481.84	148.31	3.25	0.001	189.77 – 773.90
Experience of extraction (Ref no experience)	-464.76	147.41	-3.15	0.002	-755.05 – -174.46
Constant	461.01	156.35	2.95	0.003	153.11 – 768.90
/sigma	961.69	42.62			877.76 – 1045.61

Table 5. 23 Tobit regression of WTP for RCT subsample

5.7.6 Tobit model of WTP for extract and leave gap

The next model to be presented by subsample involved WTP of those who chose extract and leave a gap as their preferred option (n=88). The model is given in Table 5.24, and the model includes only the two mandatory income variables (the best model in terms of BIC values). This model was not significantly better than a model with no variables included as shown by the p value of greater than 0.05 for the likelihood ratio of chi^2. The WTP is therefore assumed to be entirely unpredictable based on the variables measured in this study.

This particular model has a likelihood ratio of chi^2 of 5.10 ($p<0.08$) with a pseudo R^2 of 0.0048. The BIC figure is 671.073, compared to a value of 729.684 for a model with all variables included.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Low income (Ref middle and high income)	-27.80	27.43	-1.01	0.314	-82.33 – 26.74
High income (Ref low and middle income)	61.72	35.63	1.73	0.087	-9.11 – 132.54
Constant	99.12	15.55	6.37	0.000	68.21 – 130.03
/sigma	111.05	8.55			94.05 – 128.04

Table 5. 24 Tobit regression of WTP for extract and leave gap subsample

5.7.7 Tobit model of WTP for extract and implant

The final model to be presented by subsample is for the WTP of those who chose extract and implant as their preferred option (n=85). The model is given in Table 5.25, with only the two mandatory factors of high and low income remaining in the model, with high income increasing WTP.

This particular model has a likelihood ratio of chi^2 of 6.98 ($p<0.05$) with a pseudo R^2 of 0.0055. The BIC figure is 893.248, compared to a value of 946.680 for a model with all variables included.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Low income (Ref middle and high income)	-29.83	100.89	-0.30	0.768	-230.50 – 170.85
High income (Ref low and middle income)	304.01	125.19	2.43	0.017	55.01 – 553.01
Constant	378.66	64.79	5.84	0.000	249.79 – 507.53
/sigma	414.87	32.07			351.09 – 478.65

Table 5. 25 Tobit regression of WTP for extract and implant subsample

5.7.8 Heckman selection model of WTP combined with correction for preference

The final model combines factors influencing choice with factors influencing WTP for the whole sample, therefore allowing explanation of WTP to deal with the problem of a non vital molar tooth taking into account the bias introduced by valuing preferred treatment option. The model (n=491) is given in Table 5.26, with a positive rho indicating there is some positive correlation between the unobserved variables for choosing extraction and the unobserved variables for WTP. The only significant factor

for WTP after including the selection term in the model was income meaning that experience of extraction was eliminated as an influence compared to the tobit without the selection correction (Table 5.22). The Wald chi^2 for this model is 10.04 ($p<0.05$) suggesting that the model is significant.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Regression model for WTP including selection correction					
Low income (Ref middle and high income)	-37.56	61.11	-0.61	0.539	-157.33 – 82.22
High income (Ref low and middle income)	213.56	78.69	2.71	0.007	59.33 – 367.80
Experience of extraction (Ref no experience)	75.27	90.60	0.83	0.406	-102.31 – 252.84
Constant	76.63	149.97	0.51	0.609	-217.30– 370.57
Probit selection model for extraction versus saving tooth					
Low Socio Economic Status (Ref mid & high Socio-economic status)	0.39	0.12	3.27	0.001	0.15 – 0.62
Experience of crown (Ref no experience)	-0.45	0.13	-3.52	0.000	-0.70 – -0.20
Experience of RCT (Ref no experience)	-0.37	0.14	-2.65	0.008	-0.64 – -0.096
Experience of extraction (Ref no experience)	0.65	0.17	3.93	0.000	0.33 – 0.97
Constant	-0.52	0.17	-3.15	0.002	-0.84 – -0.20
Mills Lambda	148.10	121.66	1.22	0.224	-90.36 – 386.55
Rho	0.357				
Sigma	415.25				

Table 5. 26 Heckman selection model for WTP with selection for extracting versus saving the tooth

Chapter 6. Molar Tooth Study: Discussion

6.1 Introduction

In this chapter, the results of the molar tooth study presented in Chapter 5 will be discussed in detail. Initially, in Section 6.2, the robustness of the data and the impact of some of the analytical decisions taken will be reviewed. This will be followed by a discussion of the direction and then the strength of preference in Section 6.3 and 6.4. Subsequently issues arising from the methodological experiments concerning part versus whole valuation (Section 6.5) and the influence of real price on valuation (Section 6.6.) will be discussed. The chapter will conclude in Section 6.7 with the implications that can be drawn for WTP methodology, for dental policy makers and for dentists and their patients. These discussions will be further developed in Chapter 10 alongside the conclusions of the Prevention Study (presented in Chapter 9), to give a holistic view of the discussions across the whole thesis.

6.2 Review of data

In this first section of the chapter the robustness of the data will be addressed, alongside a discussion of the analytical decisions taken in light of these issues. The representativeness of the sample will be addressed first, followed by a discussion of the sample sizes. The treatment of outliers will then be covered, concluding with a discussion of the most appropriate descriptive statistics to be used (mean versus median).

6.2.1 Representativeness

The first question to be addressed when discussing the representativeness of the sample is which population the sample is meant to represent. In this case, the population chosen was dental attendees in the North East of England (defining this in terms of NHS Strategic Health Authority boundaries). The principal reason for choosing this population was the question being addressed; in most of healthcare in the UK, where the service is fully funded through general taxation, it can be argued that the whole population, whether users of the service or not, should have a say about the service, and so preference should be sought for the whole population. Although this can also be argued for dentistry, where there is an element of general taxation contributing (as a subsidy), the personal contributions are greater and so there could be greater

justification for those actually accessing and using dental services to influence the decisions being taken about the service. This argument is open to interpretation, but this is the stance adopted in this study. This choice was also made for the pragmatic reason that this was a comparatively easy population to sample.

The selection of this population presents an immediate difficulty, as there are no clear data defining its demographics and so any sample cannot be compared to the population in terms of how representative it is. Data are available, however, for the whole population of the North East (including non-attendees) and so the sample proportions can be compared to these data.

These comparisons are shown in Tables 5.2 to 5.12, and as described in Chapter 5, these tables all show that the sample is broadly representative of the population (based on the data chosen). Table 5.3 shows that the youngest age band is under-represented in the sample, and the 46-65 years age bracket is over-represented. However, these mis-representations are only small. IMD quintiles are more difficult to compare, but the quintiles for the sample have consistently higher IMD boundaries, suggesting that each quintile of the sample contains slightly more deprived individuals than the respective population quintile. Income figures are broadly comparable although, perhaps slightly surprisingly, the lowest band is over-represented in the sample with the second highest band being under-represented. The sample has, as a whole, reached lower educational qualifications levels, although this area again does not exhibit a large difference. Finally, SEC is difficult to compare, as a large proportion of the population were unclassified. However, if these are excluded, it seems that the proportions are roughly correct. No explanation is offered as to why there is such a large proportion unclassified in the population statistics.

Unsurprisingly, for a sample of dental attendees recruited at dental practices, there is a larger proportion of regular attendees in the sample than would be expected in the population. The previous experience of different treatments and number of teeth remaining are very similar to population figures, although the population data available for comparison are limited.

Perhaps the most concerning factor in terms of representativeness are the proportions who are NHS or private patients. In the sample 96% are NHS, compared to the UK population proportion of 85%, although the proportion of exempt patients is broadly comparable. This is an unsurprising finding given that the practices at which recruitment took place were mainly providing NHS care (Table 4.2), and may also reflect differences between the NE and the national proportions. The fact that private patients form a very small minority of the sample, however, means that any policy implications arising from the research are more applicable to NHS policies and policy makers. This is a sensible direction in which to draw conclusions, not only in light of the sample representation, but also as the scenario (particularly in the real price section) is based on an NHS service. The findings from this study are therefore interpreted in this light.

Although, with the exception of NHS/private proportions, the sample is found to be broadly representative, one possible analysis technique to minimise differences would be the use of post-hoc weightings of the data. This option would give the benefit of making the data more representative but brings many associated problems (Gelman, 2007). Firstly, the more factors that are weighted for, the more complex the weighting and subsequently the analysis becomes. Weighting beyond one or two measures incorporates risks to the analysis which no longer outweigh any benefits. With this restriction in place, the decision about which factors to weight becomes very important and it is difficult in this study to isolate which factors would be most important to weight. Secondly and perhaps more importantly, the sample size is probably too small to allow successful and meaningful weighting. Thirdly, as has already been discussed, it becomes very difficult to obtain weights or even decide what population the sample should be weighted to. Finally, it may not be necessary to weight the data, given the aims of the thesis. The aims did not include finding an absolute monetary value of a tooth or for any of the interventions valued for this population, or finding absolute proportions for preferred choices for the population. Instead, the aims included investigating which factors influenced choice and value, and providing all of the groups are represented with sufficient numbers, these aims can be investigated with econometric modelling, as can be seen in the results.

Therefore, there is no requirement for accurate representation of the population in the sample, and so the difficulties of weighting are not justified. The results will be interpreted with this decision in mind.

6.2.2 Sample sizes

The initial sample size calculations were based on requirements for the part versus whole methodological experiments. Given the lack of previous data available, several assumptions had to be made. As outlined in the method (Chapter 4), these assumptions were tested after the collection of data for 250 participants, and it was found that a number of the assumptions had been too conservative, particularly the assumptions relating to the variance of the sample. Additionally, as the experiment could only be carried out on those selecting extraction in the initial choice and then could only be carried out on the 4 sub-groups based on prosthesis choice separately, rather than using these data taken together, the sample sizes were even smaller.

In order to inform future work in this area, a post-hoc sample size calculation was carried out. For this analysis, minimum important differences of £10 for extraction only (leave gap) and £50 for the remaining prosthesis choices were agreed. The required sample sizes were 2477, 1448, 3366 and 1544 for the sub-groups of extraction only, extraction and denture, extraction and bridge and extraction and implant respectively. Given these were the required sample sizes in each sub-group, it can be seen that the overall sample size for the whole study would have to be an impractically large number which would be impossible to recruit within the constraints of this study.

Given the impossibility of achieving sufficient numbers to draw robust conclusions in the part-whole study, it was accepted that the results for this particular aim of the Molar Tooth Study would be inconclusive. Although the results of the part-whole experiment are indicative only, the sample size requirements for other questions addressed by the study are still satisfied, in particular the econometric modelling. The sample size requirements for this element were calculated as at least 400 (this was re-confirmed after the initial assumption of 50% selecting RCT as preferred choice was proved correct) and this was achieved.

6.2.3 Outliers

The outliers in terms of initial WTP are described in Table 5.16, based on a definition of anyone more than 2 standard deviations from the mean of their treatment preference sub-group. There are a variety of ways of identifying outliers of varying complexity (Lindsey, 1994). Perhaps the simplest is to define outliers in terms of an outer percentage of the data (for example 1%), a common practice in analysis of WTP data. However, this approach does not discriminate based on how deviant each figure is, and so the 2 standard deviation definition is used in this thesis. Further techniques, for example using α trimmed means or examining individual residuals in the econometric models are beyond the scope of this thesis.

It can be seen that these outliers do not seem to have any common characteristics, and so a difficult choice is presented between excluding them from the analyses (i.e. trimming the sample) and leaving these outliers in the sample for analysis.

There are arguments on either side of this debate (Lindsey, 1994). On the one hand, it could be argued that there is nothing to suggest there is anything wrong with these valuations (having excluded errors in coding or entering the data) and although it is possible that the respondent may have misunderstood the task, again there is nothing to suggest that they did. Therefore it could be said that these are genuine valuations and part of the variation found within the sample and the population, and the figures should therefore be included.

On the other hand, however, it can be seen that these outliers have a large effect on any analysis, distorting the values that the majority of the population gave. If WTP is seen as a tool for informing policy decisions based on the preferences of the population, it can be seen that a small number of outliers influencing the majority view may be undesirable.

In this thesis, the viewpoint is taken that all of the values are legitimate and therefore should be included. However, analyses were also performed without outliers, and are presented in Appendix D. It can be seen that the outliers did not influence the general results of the modelling related to decision choices, but did, perhaps not surprisingly, alter the outcomes of the models looking at strength of preference (WTP). In these

cases, the models became less predictive and fewer significant factors were noted in each model. This is again an expected finding, as some of the variance in the sample which the models explain has been removed.

6.2.4 Means versus medians

Another analytical decision that must be made is whether to employ the mean or median and their associated distributive measures in the descriptive analysis. Perhaps the most obvious effect with the data being analysed here, which is heavily left skewed, as is seen in Figures 5.1-5.5, is that the mean will always give a higher and arguably more misleading value than the median, a common problem with WTP data (Carson *et al.*, 2001). One argument for the median is that if WTP is seen, as described in Section 6.2.3, as a measure of population preferences to inform policy making and a referendum type approach is adopted, then the median is of more use, as once the median point (in terms of cases in the population) has been passed, a majority has been secured in a referendum; so, whatever valuation the case falling at the median gives should be the one adopted (Carson *et al.*, 2001). Finally, it is noted, that the econometric models used (logit and tobit models) rely on mean values, and with no modelling alternatives, for this section of the analysis means will have to be used.

To some degree, providing it is understood that the data is left skewed, then either measure can be used, and in fact presenting both gives us a deeper understanding of the data, and therefore this is the decision taken in the thesis.

6.3 Initial preferences

Prior to this study there was very little information available on preferences for different treatment options in dealing with a non-vital molar tooth. Perhaps the most comprehensive data available in the UK is derived from the ADHS with the most recent results covering this question from the 1998 survey (Kelly *et al.*, 2000). The questions asked in the ADHS, however, do not map directly to the scenario addressed in the molar tooth study. In the 1998 ADHS, when asked to choose between a filling and an extraction for an aching back tooth 79% chose a filling, and when asked to choose between a crown and an extraction, also for an aching back tooth, 68% chose a filling.

One of the existing dental WTP studies described in Section 3.5.2 is also of some relevance here (Leung and McGrath, 2010), where participants were asked to choose preferred options for a gap (equivalent to the prosthetic choice question in this study). 84% chose implants for a posterior gap.

This study adds to this understanding by showing, in this sample, what participants would choose in a more holistic, complex, but realistic scenario compared to either of the studies above. The figures from this study (Table 5.13) show that around half of the participants (53%) would choose to save a tooth, and that when the tooth is extracted the most preferred options are to leave a gap (19% of whole sample) or have an implant (17% of whole sample). Given that saving the tooth rather than extracting it in the scenario in this study would involve a step more (having RCT) than that involved in the ADHS questions (Kelly *et al.*, 2000), it is not surprising that fewer participants choose to save the tooth, and so the figures are broadly in line with what might be expected.

It is interesting that of those choosing extraction, a much lower proportion would choose implant to fill the gap than in the Leung & McGrath study (2010). This may be, in part, due to the fact that some of those in the RCT sub-group in this study may have opted for an implant if saving the tooth was not an option, but a more important explanation is likely to be the different contexts of the two studies; the Leung and McGrath study was undertaken in Hong Kong, where there are likely to be different cultural responses to such choices, and there may also be increased familiarity with the technology of implants.

The results here illustrate a fundamental concept; that the sample, as a whole, expressed preferences for all of the treatment options, in considerable numbers. This shows that there is demand in the UK for all of the treatment options, in particular RCT, extraction followed by leaving a gap and extraction followed by an implant. For the NHS, it is therefore important to recognise that demand exists for all of these treatment options, although the demand for dentures is very low with only 3% of the sample opting for this and relatively low for bridges (8%). These figures only reflect patient preference and these choices may not be appropriate once other clinical and economic factors, assumed to be neutral in the scenario used here, are introduced. However, it may be that the NHS

may wish to consider whether dentures and possibly bridges should still be offered as a treatment option, given the very low demand. If there is still a need for these treatment options (as opposed to the demand illustrated here), it may be that this difference in expectations needs to be managed. These discussions will be expanded in the next section, 6.4, on strength of preference.

Additional knowledge the study adds is an understanding of the factors that affect the choice, illustrated with the economic modelling. It is impossible to define how much of the variance the model explains from the statistics available (i.e. there is no true equivalent to the r^2 statistic in OLS regression). However, the models are all significant, based on the significance of the chi^2 tests of the likelihood ratios for the whole model. In the initial choice model of extraction versus saving a tooth (Table 5.20), the significant factors are mostly related to previous experience, with previous experience of extraction making this a more likely choice and previous experience of crowns or RCT making saving the tooth a more likely choice. Interestingly, when looking only at the extraction sub-sample, it becomes impossible to predict prosthetic choice with the variables observed here. When all 5 choices are looked at across the whole sample, previous experience of RCT, crowns and extractions are again found to be the significant variables.

It is not surprising that previous experience is a predictor of choice, and there are at least three possible explanations: there may be some unobserved characteristics that predict participants' choices and these remain constant over time so that choice also remains the same over time so that participants will chose the same as they have in the past; when asked in a hypothetical scenario, participants may simply refer to the previous time they made a similar choice as their frame of reference; finally, participants may have enjoyed a positive (or at least better than expected) experience the last time they had a treatment, making it more likely that they will select the same choice again. The final explanation may well be a contributory factor to the second explanation also. In reality, it may be a combination of all of these factors. The influence of previous experience has also been found to be an important in one other area of oral health care (seeking emergency dental treatment) although the influence was not explored in great detail (Anderson and Thomas, 2003).

Aside from the importance of previous experience in saving or extracting the tooth, it is perhaps most important to note other factors which do not feature in the models, and therefore in this analysis have no influence on choice. These include income, age, number of teeth and method of dental payment, which it may have been postulated would influence choice.

These findings are vital if there is a need to address differences in expectations between need and demand, as discussed earlier in this section. Where previous experience is an important indicator of preference, it may be that any education in this regard will need to be directed towards those with the relevant previous experience.

Although there are few previous data that study factors affecting choice in this scenario, the 1998 ADHS (Kelly *et al.*, 2000) shows that the following all increased the likelihood of choosing extraction rather than filling or crowning a back tooth: an older age, a lower socio-economic class, an irregular attendance pattern and having less teeth remaining.

It is interesting to speculate on the difference between the ADHS where a number of factors did alter preference which were found not to influence the decision in this sample. Fundamentally, the decision was not the same, as this study involved having RCT to save the tooth, rather than just a filling or a crown. The ADHS scenario used is free of context and so the decision is probably further from true preference, and may actually reflect attitudes rather than specific preferences (as it is designed to do). For example, the concept of prosthetic replacement was not referred to or taken into account in the ADHS. It may be that when prosthetic replacements are considered, extraction becomes more preferable for certain groups that would otherwise have tried to save the tooth. This "hierarchy of decision making" effect was discussed in Section 2.5.4 and the whole context is not apparent in either the ADHS (Kelly *et al.*, 2000) or the Leung and McGrath study (Leung and McGrath, 2010). This may make the results of these studies more context specific if not less valid.

Furthermore, it may be that with the larger sample in the ADHS, differences were more readily detected, although the magnitude of difference in the ADHS suggests these would have been detected even in the smaller sample used in this study. Conversely, it

may be that with the more detailed analysis (in particular the econometric modelling) undertaken in this study compared to the simple descriptive approach of the ADHS, that the differences reported in the ADHS would not be significant when modelled together with other factors.

There is therefore an important finding here that when measuring preference around a complex decision, good information and a clear context are important. This mirrors the discussion in Section 3.4.3.5 of the literature review, concerned with minimising hypothetical bias in measuring strength of preference with WTP. In this study, it is shown that this is important in terms of measuring direction of preference also. Not only is this important for research methodology, but it is also an important finding for dentist undertaking informed decision making processes with their patients.

6.4 WTP

As has already been explained in the Section 6.2.1, the WTP figures cannot be taken as absolute values reflecting the population. However, the figures do give a vital insight into relative values between treatment options and also allow modelling of factors influencing valuation to be undertaken. Furthermore, the range of values and the presence of outliers with extreme values are important.

Firstly, from Table 5.15, it can be seen that the median figure for extraction (£67.50) is less than half of that for RCT at £175. The figures for all the prostheses are comparable to RCT at £163 for a denture, £200 for a bridge and £250 for an implant. These figures are strikingly similar to the NHS patient prices used in the study of £200 for RCT (plus a crown), £50 for extraction, £200 for a denture and £250 for a bridge (although of course in reality, the NHS prices are more complex as these "band" prices may or may not also include other treatment being undertaken in the same course of treatment) (National Health Service (General Dental Services Contracts) Regulations, 2005). Interestingly, the only figure which is markedly different from the price quoted is for the only option not available in the NHS system, implants, with the private price quoted being £1500.

This may suggest that NHS prices have been set well, relating closely to market forces, or more likely that people's valuations are based on pre-existing ideas of price. It is

likely that prior knowledge of NHS prices is very important in explaining both the market and the values in this particular cultural context. Certainly the presence of anchors have been found to be important in influencing WTP values, even where these anchors are arbitrary and not related to the good being valued (Kahneman *et al.,* 1999; Nunes and Boatwright, 2004). It would be interesting to see how these values changed with differing patient charges.

Although all of the treatment options have been valued at similar levels (with the exception of leaving a gap), they all require different lengths of time to complete, different levels of skill from the provider, different levels of invasiveness for the patient, may result in different levels of oral health and actual costs are very different.

The low figure for implants, relative to their cost, suggests that people may not have a pre-conceived idea of the price as this treatment is less widely experienced, and that the market intervention in terms of government subsidy and national price setting for NHS treatments is lowering the perceived value of dental interventions as a whole, including implants. These are costly to provide and not provided by the NHS, although the market for implants is in itself likely to be a failing or imperfect market too. This effect of government intervention has been postulated elsewhere (Donaldson and Gerard, 2005; Barros and Martinez-Giralt, 2006). Alternatively, the low value may be explained by the surgical intervention required, which may decrease the value, reflecting process utility, as it has been reported this is an important factor in decreasing the uptake of implants (Leles *et al.,* 2009). Whatever the reason, if the value elicited in this study is taken as accurate for implants, this justifies the decision not to include these as NHS funded treatment.

Probably the most notable feature of the data is the variance in the valuation by the sample. The standard deviations (SDs) are larger than the mean values in all subsamples by preferred choice, and in the case of the RCT sub-sample the SD is more than three times larger than the mean. This is a reflection of the long tail to the right of the distribution, with some very large outlying values, already discussed in Section 6.2.3. These findings indicate that preference varies greatly in the population.

The factors that affect these valuations are explored in the later econometric models (Tables 5.22-5.26), which were all significantly better than the null model. There are few explanatory factors that were significant. Having a high income and being female increased WTP in all models, and experience of some previous dental treatments had some influence with previous experience of extraction decreasing WTP in several of the models. The factors that are not significant or excluded from the model are in many ways more interesting than those that were significant. Low income was included in all models as a mandatory factor but was not found to be significant in any of the models in contrast to high income. This may suggest that it is the amount of disposable income that is important in determining choice. Those on lower and middle incomes who probably have less disposable income (which varies less with absolute income) may not vary their valuation based on their income, but those on a higher income with, probably, proportionally more disposable income do vary their valuation with income levels. Although there are no data linking preference with disposable income, in a related finding, disposable income was found to be a key influence demand for dental care (Beazoglou *et al.*, 1993; Nguyen *et al.*, 2005; Bhatti *et al.*, 2007). It is not surprising that high income is related to WTP, and with the expectation that WTP should be linked to ability to pay, this could even be seen as an indication that the WTP valuations are valid (Donaldson, 1999). However, the fact that only high income (compared to low and medium income) affects WTP suggests that ability to pay is not a major issue in the determination of WTP in this setting.

Other factors which did not feature in the models but may have been expected are frequency of dental attendance where it might have been expected that more regular attendees value their oral health more highly, and the number of teeth remaining. Again, there are few or no data concerning the link between attendance and preference or number of teeth and preference, but a demand for dental services has been demonstrated to be influenced by both changes in dental attendance (Nguyen *et al.*, 2005) and number of teeth (Grytten, 1990). With number of the teeth, the influence could be postulated to operate in two directions with the possibility that those with less teeth may have valued their oral health more highly as they had less “disposable” teeth as they approached the functional minimum for their dentition, or that they had low values for their oral health anyway, which is why they had less teeth left, it may actually be both of these factors

working against each other which means that number of teeth is not left as significant predictor of valuation. To understand this complex relationship, it would be necessary to look at different health states in terms of the whole dentition rather than single tooth events, as discussed in Section 3.5.3.

It can therefore be seen that valuations vary greatly and it is very difficult to predict this variation. This means that valuations cannot be predicted for an individual based on demographic and dental backgrounds. This is an important point for dentists, as well as policy makers, who should not make any assumptions about patient preferences and values when making decisions. This recommendation complements existing advice in the shared decision making literature (Elwyn *et al.*, 1999).

The lack of predictive ability is also important for another reason for policy makers, leaving a difficult but important question; what allocative decisions should be taken based on the valuations elicited (Eddy, 1991)? If valuations had a low variance and the confidence interval around the mean (or median) was small, the mean (or median) value could be used confidently to make allocative decisions. However, with the large variance illustrated here, it becomes inappropriate to use an average measure as a basis for policy. For example, those with a large valuation might expect a much larger dental service (or to pay more in taxation for a better dental service) than those with low valuations, but this may not be affordable. This dilemma will be further explored in Sections 6.7.2 and 10.4.1.

The findings can be compared with the only other close comparator (Leung and McGrath, 2010), where WTP was elicited for a slightly different scenario in a markedly different context. This comparator study found WTP for implants varied with gender, income and education. When compared with the tobit model for the implant sub-sample in this study (Table 5.25), it can be seen that only high income was significant in this study, although the different contexts make any differences unsurprising.

To conclude this section, it can therefore be seen that if strength and direction of preference are combined there is a large demand shown for both RCTs and implants. Whether these options can be offered in the NHS (and the demand met), depends on their affordability, which in the case of implants especially, is unlikely to be possible.

Some might argue that this would not be problematic if the strong preference is only expressed by those who are more able to pay, as they could seek this treatment outside of the system. However, even if this argument is used, this link between ability to pay (measured here by household income) and strength of preference for those preferring implant treatment has not been demonstrated here and so this is another difficult decision, leading to potential equity problems such as those already illustrated in the Canadian dental system by Grignon *et al.* (2010)

6.5 Part-whole

The robustness of the part-whole data was discussed in Section 6.2.2. Bearing this in mind, the results of the experiment are now discussed in this section. It can be seen in Table 5.17 that where the sample sizes are larger (leaving a gap, although this is not a true part versus whole experiment, and implant) the means for the two methods converge, suggesting the very divergent means for the other two sub-samples (denture and bridge) may simply be erroneous due to the very small sample sizes in these sub-samples. However, all of the mean values for part valuation are greater than the whole values, reinforcing the concerns and findings of critics of WTP (Diamond and Hausman, 1994). This would undermine the case for WTP representing true values (i.e. WTP would be prone to embedding bias or said to be "scope insensitive"). However, the lack of significance of the difference in the hypothesis tests and the change with larger sample sizes is encouraging, suggesting that reliability and possibly validity (in terms of being a valuation of health rather than a purely financial calculation) increases as sample size does. This would support the findings of Carson *et al.* (2001) who suggested that where scope insensitivities have been found they are due to poor study design or lack of sample size. This area obviously requires further investigation.

6.6 Influence of price

Although the influence of price data are possibly the most difficult to interpret in this study, they are probably the most interesting as they give an insight into how WTP valuations are formed, further insight into preferences and give additional data concerning WTP validity. Whilst interpreting these data, it is important to remember that the valuation given after the price had been revealed was still hypothetical i.e. these are still stated not revealed preferences. They do, however, give an extra insight into

what these stated preferences mean, by adding an extra element of realism and therefore potential becoming closer to revealed preference (the concept of realism and its importance are discussed in Section 3.4.3.5).

Firstly from Table 5.19, it can be seen that a full range of behaviours was seen after being exposed to the real price, with those who gave an initial WTP above the price increasing, decreasing and keeping the same valuation for the same choice as well as changing preferred choice and increasing, decreasing or keeping the same valuation. Additionally, for those who had a WTP lower than the price the range of behaviours includes keeping the same choice and increasing WTP and changing preferred choice and increasing, decreasing or keeping the same valuation. Again, this suggests that valuations and value formation are highly personal, meaning that assumptions about individuals' preferences should not be made, as discussed in Section 6.4.

Where WTP was lower than the price, some initial choices are "loyally" supported with participants keeping the choice and increasing WTP, whereas with other choices the participants tend to redistribute to other choices. For example, of the 133 participants who had a WTP below the price for RCT, around half (53%) remain loyal to RCT with the remainder choosing other options. This can be contrasted with those who initially chose implants, where of the 82 who had a WTP below the price nearly all (91%) chose a different option. This is perhaps not surprising when the initial mean WTP for implants (including those who had a WTP above) was much lower (£422.85 from Table 5.14) than the price (£1500) whereas the mean WTP for RCT was much higher (£372.79) than the price (£200). This would have meant that participants would have had to make a greater change to their valuation in order to remain loyal. However, this may only explain part of the loyal versus redistributive pattern and it may be that the valuations and choices given are formed in a different way cognitively, with some forming choices based on their values and other forming values based on their choice. This possibly also reflects the fact that some participants are valuing the outcome (or health state) compared with others valuing the intervention. This concept of what is being valued was discussed in Section 3.5.3 and although the decision was taken to ask for valuations on an intervention basis, it may be that individuals still value, in part, being in (or getting to) a health state. Although it can be argued that these are all valid

preferences in terms of welfare economics, it is important to understand these value formation behaviours in order to fully understand the preferences of individuals (Nord *et al.*, 2009).

The other aspect of the influence of price data that is interesting is the valuations of those that move to different choices as can be seen in Table 5.18. For example, if those who initially chose extraction and implant but then changed to extraction and gap are examined, it can be seen that the valuation (even despite knowing the price was £50) was £290, almost three times greater than the initial mean value for extraction and gap of £97.86. In economic terms, this may be interpreted as these participants having a high consumer surplus (difference between WTP and price to be paid), being at the top of the demand curve for dental treatment (Bergson, 1975). It is also possible that these are the participants with a high disposable income. Along with many other cells in the table where a similar phenomenon is exhibited, the fact that despite being made aware of price, valuation remained above this for some participants, suggests that WTP may reflect utility or true valuation of health rather than being a purely financial or budgetary measure. This diminishes the arguments of Diamond and Hausman (1994) who state that WTP valuations could be formed based on "informal cost-benefit analyses" which would not reflect preferences.

Another group can be observed that keep the same value even when they swap to a different option, for example those who initially chose RCT and then swapped to extraction and gap after discovering the real price had an initial mean valuation of £66.44 for RCT and then had a mean value of £66.27 for extraction and gap. This suggests that this group had a valuation to deal with the problem and perhaps were trying to get what they saw as the best treatment option for the value they attached to dealing with the problem. This perhaps suggests behaviour more similar to being a consumer (of a private good) rather than a patient consuming health. Another way of looking at this is again in terms of whether health states are being valued, as discussed earlier in this section and in detail in Sections 3.5.2 and 3.5.3. The group who are apparently valuing "dealing with the problem" may actually be valuing getting out of a health state, with those who do not follow this pattern either valuing getting into a health state or valuing the intervention itself as was postulated earlier in this section.

Taking these different groups and patterns as a whole, it may be that for some participants value is calculated on the basis of dealing with the problem, where the final outcome and process are less important (i.e. valuing getting out of health state). For others, value may be attached to the way the problem is dealt with (process utility) with the final outcome (i.e. valuing getting in a health state) and procedure (i.e. valuing the intervention) mattering more. It is impossible to draw firm conclusions here based on the data available, but the area of value formation is clearly an important topic of future research, as also identified by Nord *et al.* (2009).

In terms of WTP validity, it is clear that taken across the whole sample, WTP values remain above actual NHS prices, which, as outlined above, suggests that health may really being valued rather than financial calculations made. This is a positive finding in terms of the validity of WTP. Additionally, it can be seen that after the prices are revealed, valuations both go up and down, as well as remaining constant. This study therefore provides no evidence to support the hypothesis that WTP always over-values true preference (Arrow *et al.*, 1993), even suggesting that WTP may under-value true preference, again a positive finding for WTP. However, the fact that WTP is not constant after prices are revealed suggests that it is not always valuing preference fully. Further analysis will be important in understanding the validity of WTP in this respect. This finding does, however, reinforce the need for continued refining of WTP methodology, particularly in terms of making scenarios as realistic as possible.

6.7 Conclusions from Molar Tooth Study

This final section of the chapter draws out the strands developed in this discussion into some conclusions, classified into recommendations and consequences for WTP methodology, for dental policy makers and for dentists working with their patients.

6.7.1 Consequences for WTP methodology

As discussed in Section 6.6, the variety of behaviours observed, particularly when comparing choices and valuations before and after the price was revealed, suggests that choices and valuations are formed in a number of different ways by different individuals. It is difficult to assign these different behaviours to different groups using the data available here and impossible to understand the cognitive processes in forming

these valuations. In fact, it may be that there are different value-forming processes in different individuals but these lead to the same behaviour. This will probably, in part, be due to underdevelopment of the scenarios used (which is discussed in Section 10.3.3). However, even given the variation introduced by underdevelopment of the scenario, the area of value formation is likely to be highly complex. In previous work, two different sets of concepts may be playing a role (Baker *et al.*, 2008). Firstly, the individual may make a purely budgetary or financial calculation without taking health into account or alternatively, the individual may express a valuation of health reflecting utility. The second consideration, as discussed extensively in Sections 3.5.2, 3.5.3 and 6.6, is that individuals may value either a health state (either getting in or out of one) or an intervention.

Evidently, understanding these processes is important in further achieving the aims of the study, to understand the factors affecting choice and valuation, but perhaps more importantly, understanding of value-forming processes is vital for a greater understanding of WTP and how it links with utility and welfare economic theory as well as how it can be applied. Indeed, it is important to further understand these value-forming processes in order to fully evaluate the validity of WTP as a monetary measure of preference as value formation based on financial calculations would mean WTP was not truly valid in terms of reflecting utility (Diamond and Hausman, 1994). It is likely that value-forming process may differ depending on the good being questioned, so as well as need for further research, probably of a qualitative nature, about value forming in WTP generally, it will be important to look at this in the specific area of oral health, if the measure is to be used in this context.

Whilst any such research progresses, it will be important for researchers using WTP to be clear about whether health states or interventions are being valued when designing studies, collecting and interpreting data and publishing results (Nord *et al.*, 2009). Clear justifications will be needed for the approach taken as well as evidence of thinking about how participants may have arrived at their valuations. The concerns relating to value formation may well be lessened if whole programmes are valued rather than personal health states or interventions, but this approach in turn brings its own problems, and so is not a universal answer.

An extra point of note for WTP methodology is that despite the part-whole experiment being inconclusive due to a lack of power, there is a suggestion that as the precision of the estimate increases (with larger sample sizes), embedding bias does not appear to be a great problem, which is a positive finding for WTP in terms of its reliability and validity, and reflects previous findings (Carson *et al.*, 2001).

In short, it has been shown the WTP can be used for valuing treatment options for a non-vital molar, and the data can be useful for both policy makers and dentists working with their patients. These data not only have face validity, but a series of experiments have suggested validity in terms of at least some of the individuals forming values in terms of health. However, it is clear that there are a number of value-forming processes being used, and if the validity of WTP is to be fully understood, these processes will require further investigation.

6.7.2 Consequences for dental policy

In terms of findings relevant to policy makers, this section will first address potential differences between demand (in terms of the valuations elicited) and need defined on a purely clinical basis. The impact of this discrepancy as well as the variation in valuations on policy will then be discussed, followed by the need for cost benefit analysis. Finally, the effect of government intervention on the market and on valuations will be discussed, focussing particularly on implants as an intervention outside of the NHS market.

Firstly, it is clear that there is demand for all of the treatment options considered here and considerable strength of preference where the median or mean values of the sample are used. In particular, there is a strong case for RCT and implants when direction and strength of preference are taken together. For the NHS, this demand could be seen as a requirement to offer these treatments, but any such policy decision would have to be taken in light of the affordability of such a decision and the actual need. It is likely, for implants in particular, that a decision to offer these would not be affordable for the NHS, especially when the need could be satisfied with cheaper (if less preferred options). It is difficult to define the need for these treatments (as illustrated by one study looking at need for partial dentures (Graham *et al.*, 2006)), but if patient preferences are

ignored for a moment and natural unit type measures are used to define health instead, it is likely that avoiding a molar tooth gap with a root canal treated tooth or replacing a gap with an implant would both lead to very similar increases in "health" measured in these terms. It is interesting that health as measured in patient preference (utility) and using clinical indicators should be so different, perhaps reflecting the broader sense of health that utility encompasses. In a study that compared dentists and patients views of perceived need, which may reflect clinical versus preference based need, a difference was noted as postulated here (Lundegren *et al.*, 2004).

In addition to the potential discrepancy between demand and need, the high variability in valuations poses a difficult problem for any policy maker whether they be setting policy for a third party, insurance-based provider or the NHS (Eddy, 1991). To simplify this discussion, the context of the NHS will be taken, although these points apply equally in other systems. The simple question is how the system should be designed to take into account those with both low and high valuations. In the NHS, all participants are paying into the system (in terms of taxation) and so someone with a low valuation may regard it as unfair if individuals with a high valuation are catered for. Similarly, if a system is designed to cater for those with a low valuation (by providing low levels of treatment), the individual with a high valuation may see this as unfair, as their legitimate demands are not being catered for. In a democratic system, it could be argued that the system should be designed to provide treatments which satisfy the median valuation, but this is difficult when the distribution is skewed to the left with a long tail to the right, as those with very high valuations at the end of the tail, may be severely disadvantaged by this approach. However, the system must provide a sensible, affordable level of care, and so the approach taken may be to say that those who do have very high valuations can seek their care elsewhere, for example privately if we are looking at the context of an NHS system. However, this approach would probably introduce equity issues (Donaldson and Gerard, 2005), as some of those with high valuations may not be able to afford what they value. It should be noted here that in any system, it is likely that affordability (or efficiency) will be the first factor considered before the demand in terms of preference, and this is certainly true in NHS dentistry, where efficiency not patient preference is the main influence on policy (Holmes *et al.*,

2009). This is a difficult philosophical debate, but given the large variation in valuation, a debate that must be engaged with by policy makers.

The issues addressed above are relatively high level decisions about the size of the system provided, or allocative efficiency questions at a health sector level (should dentistry have a larger system or budget at the expense of other areas of healthcare). Whatever level is set will influence what treatments are available. However, the decision about precisely which treatments are included in a dental system once a budget has been set poses a different set of questions. There will be some philosophical questions to address about what it is felt is correct to be provided, especially in a publicly funded system, but these decisions could also be informed by cost-benefit analyses (Donaldson and Shackley, 1997a). The data presented in this Molar Tooth Study are an example of the data that could be used in such a cost benefit analysis. The analysis in this example would look at long term effectiveness data, long term costs and use the data presented here to define which of the treatment options would be the most efficient in dealing with a non-vital molar tooth. It is obvious that applying WTP to other dental interventions or health states would provide the necessary data for other cost benefit analyses.

Finally in this section, it is useful to reflect on the influence of government intervention on the market and valuations. It appears that intervention in the UK dental market by the government (in the form of NHS subsidised and controlled dentistry) is having a clear effect on the market, as would be predicted (Donaldson and Gerard, 2005). This is obvious from these data in terms of the differences in valuations between treatments available in the NHS system (RCTs, extractions, dentures and bridges) and the treatment option not available (implants), and the behaviour of patients after real prices are revealed.

Without intervention in the dental market, it is possible that the valuations for all treatment options would be much higher, but because patients are used to lower prices (which may be the result of subsidy and national government set prices) for most of dentistry, their valuations are lower (although it is the case that in any market it would be expected that (possibly large) numbers of people would express a value below the

market rate (Donaldson and Gerard, 2005)). However, this is a good result for patients, with prices for healthcare kept low, offering both patients and commissioners value for money. It is likely that these lower valuations even have an effect on the non-regulated private market, with dentists unable to charge higher prices because of the lowered population valuations (Donaldson and Gerard, 2005). It is possible that as there is no direct NHS comparison, there has been less effect on the unregulated price for implants and so this may explain the large discrepancy between the potentially depressed valuation and price seen in this study. It may also explain why so many patients had to change from their preferred treatment option of implants once the real prices were imposed. This probably reflects what is actually happening in the market, with many patients unable or unwilling to pay the price for their preferred option of implants. It may be that if implant prices fall, there would be a dramatic increase in take up (Watzek, 2006).

A comprehensive cost-benefit analysis, looking over an extended time period at a whole population, would be required to answer the question of whether there is any net benefit arising from implants. However, a simple comparison using these figures suggests that the median valuation (£250) for implants is much less than the current price (approximately £1500 using the figures obtained for this study), suggesting that there would be no net benefit. So, for NHS policy makers, it seems that at current prices and valuations, implants, uniquely amongst the options studied here, should not be offered on the NHS system, as is current policy.

6.7.3 Consequences for dentists and patients

As with policy makers, perhaps the most striking aspect of the data relevant to dentists working with their patients is the high variability in valuation of oral health and the influences on their choices. The importance of both of these characteristics of the populations dentists are serving lies in properly informed and truly shared decision making. This is recognised as an important component of professional practice (General Dental Council, 2005), and something all dentists are encouraged to incorporate into their own practice. Indeed, properly informed decision making is necessary for valid consent to be obtained for treatment.

It is clear that valuation of oral health varies greatly, but perhaps more importantly, is difficult to predict. Therefore dentists are encouraged not to prejudge patients' likely valuations based on their oral health, but instead to discuss these concepts with their patients. Understanding individuals' preferences will allow dentists to make better decisions with their patients (Mulley, 1990).

In terms of treatment preferences, it is clear that one of the major influences is previous experience of treatment. Therefore when engaged in shared decision making dentist are encouraged to discuss previous experience with their patients. The data also reinforce the necessity for in depth explanations of treatments unfamiliar to the patient, in order to have properly informed decision making.

Chapter 7. Prevention Study: Method

7.1 Introduction

In common with the molar tooth study (Chapter 4), the literature review in Chapters 1, 2 and 3 developed the argument that patient preferences are fundamental to a deeper understanding of oral health decision making at both a patient and population level and are also a vital part of planning and commissioning services, concluding that the most appropriate way of measuring patient preferences in oral health is using monetary valuation, specifically WTP. This Prevention Study addresses Aims 1 and 2 in conjunction with the Molar Tooth Study and addresses Aims 5, 6 and 7 by itself. The methods for the study are described in this chapter.

This study was built around one WTP experiment, conducted in private primary care dental practices. As this study involved a complex participant pathway, this is outlined briefly here before the detailed methodology is described. Firstly, before their dental appointment, consenting participants completed a questionnaire including demographic and dental details and a WTP scenario concerning a new preventive varnish to reduce the risk of caries. The WTP scenario varied by payment vehicle, with the vehicle reflecting both the participant's typical payment arrangements and a random allocation where some participants were randomised into two groups and given different vehicles.

The participants then saw the dentist, who assessed their risk of caries and therefore their eligibility within the trial regulations to use the new varnish. If participants were at risk, they were then offered the varnish initially at one price and then if they did not accept at this price, at a lower price (those accepting at the higher price were told after commencing treatment that they would be paying the lower price). This was a real offer and patients actually made payments and were provided with the treatment allowing testing of hypothetical (or stated) versus actual (or revealed) preference.

In this chapter, the sample, setting and recruitment will first be described, followed by the design and administration of the questionnaire, including the interventions being studied. The method for elicitation of revealed preference will follow this, concluding with an outline of the data analysis plan.

7.2 Sample and setting

7.2.1 Sample

The study intervention was aimed at those at risk of root caries, a condition rare in young people, therefore the population of interest was all adults of 40 years or older in the study practices (in Freiburg in Germany and the North East England). As a result of the setting (described in 7.2.2.), the sample was limited to private patients attending 9 practices during the study period. In terms of inclusion criteria for participants completing the questionnaire, all patients over 40 attending the practices in the questionnaire period who consented to complete the questionnaire and who could understand it were included. There were no other exclusion criteria for the questionnaire arm.

For completion of the revealed preference experiment and enrolment into the treatment arm, there were specific inclusion and exclusion criteria, mainly related to being eligible to have the intervention, under clinical trial regulations. The criteria (Figure 7.1) are designed to select adults who are at increased risk of root caries.

Inclusion Criteria
40 years of age and older
Dentate in both arches
At risk of dental caries in the future on the basis of the following risk factors: history of caries in the past 2 years requiring active treatment (restoration/lesion specific prevention) AND one of : gum recession of 1mm or greater on any tooth limited salivary flow multiple medication use ongoing periodontal disease removable partial denture wearer
Willing and able to provide informed consent
A practice patient registered under private arrangements
Not participating in another study
Exclusion Criteria
Pregnant or planning to become pregnant in the next 12 months
Nursing mother
Allergic to any of the ingredients of Prevora (chlorhexidine diacetate, Sumatra benzoin, alcohol, ammonio methacrylate copolymer Type B, triethyl citrate)
Patients who received in the last 3 days before study treatment any fluoride gel or directly before treatment any oil-based prophylactic
Investigator discretion that the participant will not complete the study's activities
Participating in another study

Figure 7. 1 Inclusion and Exclusion Criteria for real WTP and treatment arms

Given the paucity of similar studies using WTP in healthcare and dentistry or even more specifically, prevention, it was difficult to determine sample size in advance of the study. Additionally, as the intervention was being offered under clinical trial regulations, strict criteria had to be used in terms of eligibility including only asking WTP from those over the age of 40, and recruiting for a limited time period. There were additional criteria that patients had to fulfil in order to be offered the actual treatment, and therefore the number of participants in which revealed and stated preference could be compared was recognised from the outset to be limited.

The comparison of revealed versus stated preference was the element of the study with the largest sample size requirements. It was therefore decided to try and maximise numbers recruited within the limits presented logistically, with the likelihood that sufficient power would not be obtained for a conclusive answer for the particular objective of comparing stated versus revealed preference, rather informing the design of future studies.

7.2.2 Setting

The study was carried out in 5 primary care dental practices offering the Denplan scheme in the North East of England UK and 4 private primary care dental practices in Freiburg in Germany. Denplan is a UK based private company which runs a capitation-based private dental scheme. In this scheme, primary care practices offer patients routine dental care in return for a monthly payment. The payment is set based on a banding applied by risk of treatment need. In return for this, the dentist receives a capitation fee for each patient, and provides treatment as required. In addition a more basic scheme is offered "Denplan Essentials" where the capitation fees (much lower) only cover examinations and basic periodontal treatment with patients paying for any intervention required. The practices often also offer fee per item private dentistry, outwith the Denplan system. The German dental practices all operated in a mixed market with patients paying either through statutory (government) insurance schemes, private insurance schemes or out of pocket.

In England, all practices in the geographical area were invited to participate by letter by Denplan. In Germany, several practices known to the research team to be willing research partners were asked to participate. In each country, all practices who volunteered were accepted.

7.3 Recruitment – Questionnaire arm

The participant pathway through the study is shown in Figure 7.2, which includes both recruitment as discussed in this section, and data collection as discussed in Section 7.4.

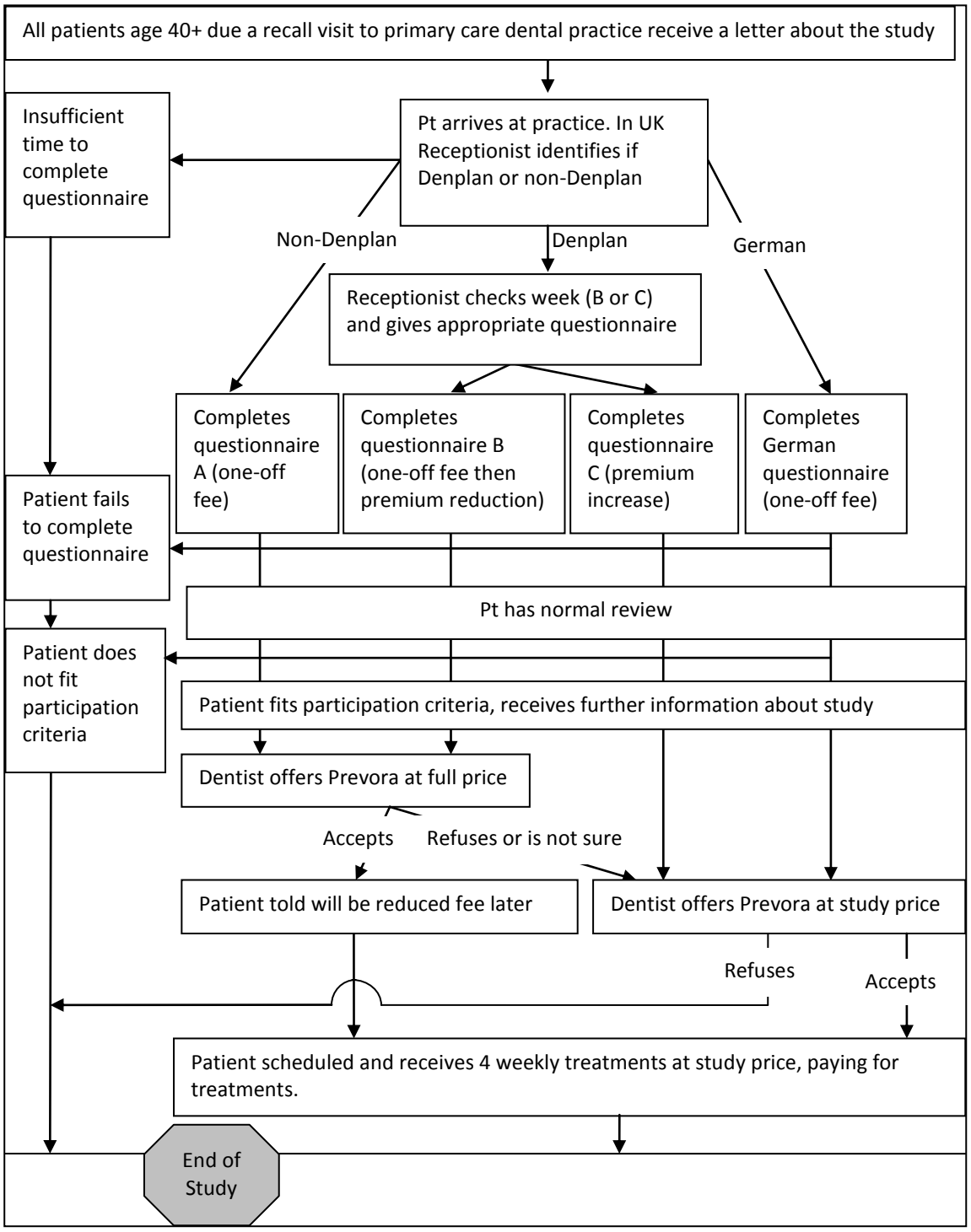

Figure 7. 2 Participant pathway through Prevention Study

All patients 40 years or older and due an appointment during the recruitment and questionnaire period were sent a letter outlining the intervention and the study in advance of their appointment. These letters included a reply slip which the patient could complete to indicate their consent to complete a questionnaire and for the dentist to discuss the treatment and the study further with them. Patients who had not received a

letter (e.g. they had made an urgent appointment on the day directly by telephone) were given this information on attendance at the dental clinic, where time permitted.

On arrival at the dental practice for their appointment, all adult patients aged 40 years and over were reminded by the receptionist that the study was taking place in the dental practice and asked for their completed reply slip or to complete one. Those consenting, by completing a reply slip, were asked to complete a questionnaire in the waiting room where there was sufficient time before their appointment time.

Patients then had their normal examination, during which, the dentist assessed compliance with participation criteria for the real WTP and treatment arm. If the patient met the inclusion criteria the dentist informed them of the disease risk and reminded them verbally that the new preventive product was available through the practice, as well as providing written information on the study.

The dentist then informed the participant of the full price of the application of the product to them (based on the full economic cost to the practice i.e. cost of product and cost of providing the service in the practice (staffing and overhead costs)), with the actual price "package" offered and used matching the scenario given in the WTP questionnaire, and asked them to consider whether they would wish to receive the treatment. Where patients were unsure or refused at the full price, they were informed of the trial price (cost of professional application only, not including the product cost). The decision of the patient and the price level accepted at were recorded on the questionnaire or in the Case Report Form (CRF).

Participants agreeing at either price then continued on to have a full course of the study medication applied, with various requirements relating to the clinical trial nature of this part of the study. This part of the study is not relevant to the thesis and hence the detailed protocol for application is not reported here. For those participants accepting at the full price, they were later informed that the actual price would be the trial price, and so all participants only paid the trial price.

7.4 Data collection

7.4.1 Questionnaire design

Several basic demographic questions were included in the questionnaire (Appendix E) such as gender and age in years. The final demographic question, on income was based on best practice from the Office of National Statistics (Office for National Statistics, 2007a; Office for National Statistics, 2009). Income bands were based on these guidelines but this was problematic as most data collected by ONS does not follow their own recommendation on bandings.

There were also several questions concerning previous dental experience including frequency of dental attendance, payment for dental care, experience of restorations, self-assessment of perceived risk and risk factors for root caries. The next set of questions related to dental knowledge, and these were included at the request of the sponsors of the research for market research purposes. Finally, there was a set of questions relating to experience of chlorhexidine use and allergic history to satisfy the safety requirements of the clinical trial being conducted.

7.4.2 Willingness to pay scenario

In this study, there was only one intervention and the preference was to have it or not. The intervention, as described in the literature review, was for caries prevention in the form of a new product, called Prevora. Prevora is an antibacterial tooth coating applied by the dental professional to all the teeth of the patient who is at risk of dental caries. The coating is applied in two layers: firstly, a high concentration (10%) of chlorhexidine to the tooth surface; secondly an aqueous acrylic dispersion which serves to temporarily protect the bonded chlorhexidine from abrasion and washing away in order to prolong its effect so that the chlorhexidine remains at bactericidal levels for 2-3 days (CHX Technologies, 2004). The treatment regimen consists of weekly treatments (4) in the first month, followed by a single reapplication every 6 months until the patient is no longer at risk of caries.

Although not approved at the time of the study for administration in the UK or Germany, it was approved in Ireland for the reduction of tooth decay in permanent teeth

and in Canada for the reduction of root caries in adults at high risk of dental caries. In this study, therefore, it was used under clinical trial regulations.

<table>
<tr><td colspan="3">We would like you think about how much you would be willing to pay for this new treatment to give us an idea of how useful you think the treatment would be. When you are thinking about this, we do not want you to think about how much you guess it would cost but just what value you put on the treatment yourself.

The treatment is a preventive treatment of tooth decay at the gum line which is an antibacterial coating painted on your teeth and is clear, temporary, simple and painless. This is done in four weekly appointments of 20 minutes and a further 20 minute appointment after 6 months.

To give you an idea of how effective it is, for those patients at risk of this disease, the treatment will reduce your risk of root decay, and therefore needing a filling by 40%</td></tr>
<tr><td rowspan="12">Now we would like you to imagine that you have to pay for the new treatment. We want you to think about how much you would be willing to pay as a one-off fee for this one set of treatments (5 applications, distributed over 6 months). It is important for you to think about the amount of money you can afford fort his treatment.

Consider the single amounts of money in order down the right column and tick if you would pay that much or make a cross if you wouldn't. After the first cross you don't have to go down the column any further but can continue with the next question, question No. 16</td><td>£0</td><td></td></tr>
<tr><td>£5</td><td></td></tr>
<tr><td>£10</td><td></td></tr>
<tr><td>£20</td><td></td></tr>
<tr><td>£30</td><td></td></tr>
<tr><td>£40</td><td></td></tr>
<tr><td>£50</td><td></td></tr>
<tr><td>£60</td><td></td></tr>
<tr><td>£70</td><td></td></tr>
<tr><td>£80</td><td></td></tr>
<tr><td>£100</td><td></td></tr>
<tr><td>£120+</td><td></td></tr>
<tr><td></td><td rowspan="2"></td></tr>
<tr><td colspan="2">For more than £120 insert the maximum amount you would pay here:</td></tr>
</table>

Figure 7. 3 Excerpt from WTP questionnaire showing scenario information and WTP task

7.4.3 Willingness to pay elicitation

In the questionnaire (Appendix E), administered prior to seeing the dentist, the Prevora treatment was explained in detail including the reduction in risk of caries over the next year, as shown in Figure 7.3. Then the participant was asked to go down a list of several increasing options of price thinking about each one individually and putting a tick if they were willing to pay and a cross if they were not. Once they had put one cross, the participant did not need to carry on down the list, as their maximum WTP had been reached and so all of the further options would elicit the answer "no." This is also illustrated in Figure 7.3.

7.4.4 Payment vehicle

The payment vehicle was varied depending on the participant's usual payment method and also to allow an experiment on payment vehicles. For those patients in Germany, the payment vehicle used was a one-off fee outwith any insurance scheme the patient participated in. In England, three different payment vehicles were used. The three scenarios were:

- A one-off fee (Questionnaire A) (for those on the Denplan Essentials scheme and not included in the Denplan scheme at all and therefore with no possibility of payment band changes) (analogous to the German vehicle although in a different payment system context)

- A one-off fee and the monthly capitation payment band would subsequently reduce to reflect the preventive nature (and therefore reduced caries risk) of the product (Questionnaire B),

- An increase in band to include application of the product as a covered item (Questionnaire C)

Questionnaire A was given to all non-Denplan patients and Denplan Essentials patients. Questionnaire B and C were allocated to Denplan in a block fashion, so that one was used in the first 2 weeks and the other in the 2nd 2-week block. Different practices started with different questionnaires to eliminate ordering effect (Table 7.1). Practices were informed of the order before the commencement of the study.

Practice	**Start questionnaire**	**Denplan monthly band charges (£)**					**Full Prevora Charge (£)**	**Trial Prevora Charge (£)**
		A	B	C	D	E		
UK1	N/A (A only)						248	188
UK2	B	12.49	17.79	20.95	30.4	36.00	300	240
UK3	N/A (A only)						184	124
UK4	C	12.52	18.12	22.49	30.26	36.87	168	108
UK5	C	12.10	17.95	21.05	29.06	38.06	204	144
All German practices (1-4)	N/A	N/A					N/A	70.53 (€100)

Table 7. 1 Prevora charges and Denplan bands by practice

7.4.5 Administration of questionnaire

Provided that patients consented to participating in the questionnaire arm and had completed the relevant paperwork outlined in the recruitment section, the receptionist allocated the patient a study number. They then handed the appropriate questionnaire, including a study number, to the patient by identifying whether they were a private non-Denplan/Denplan Essentials patient (Questionnaire A), or Denplan payer. For Denplan payers, the two questionnaires were offered on a crossover design as described in the payment vehicle section and so either questionnaire B or C were offered. There was no further advice or explanation available on the questionnaire or the WTP task. The questionnaire was then placed in a sealed envelope with only the study number on it.

7.4.6 Revealed preference

Participants then saw the dentists and if they were eligible for treatment (see Section 7.2.1) they were then asked if they wished to have the treatment, paying as per the payment vehicle in the questionnaire they had answered. This allowed validation of the WTP questionnaire through examination of whether each individual's WTP stated before seeing the dentist would have predicted whether they would have said 'yes' or 'no' to the treatment at the practice cost (addressing one of the methodological aims) i.e. whether revealed preference matched stated preference.

To add extra sensitivity to the revealed preference data, the yes/no question was offered at two levels: firstly, at the price the practice would charge if the product was not part of a trial (cost of product and professional fee for application); where patients were unsure or refused at this price, they were informed of the price being charged in the study (professional fee for application only; in a clinical trial in the UK participants generally only pay for the professional fees associated with application, not for the study medication itself). This was not the case with payment vehicle C in the UK or in Germany where having two levels of payment would have been logistically impossible given Denplan and German insurance systems. In these cases only a study price was offered.

Different prices were used at different practices based on their own fee scales and Denplan band prices which are set individually for each practice (Table 7.1). In

Germany, all of the practices agreed on one fee (€100 or £70.53), as the fee had to be seen as a surcharge in terms of the systems in place. The eligibility and acceptance were recorded on the case report forms which also included a study number so that the revealed preference element could be matched with stated preference and questionnaire details later.

7.4.7 Piloting

Questionnaires were piloted with various staff at Newcastle University working in a variety of roles and at a range of income levels and minor changes to wording and layout were carried out following this piloting.

7.4.8 Research team training

The study relied on dentists, hygienists, practice managers and receptionists of the various practices to carry out various roles. Therefore all staff involved in the study attended a one day training event which covered the dental and economic background to the study, the protocol and administration of the study, the study intervention and Good Clinical Practice (GCP) training. In addition to this, further training was carried out at each practice on 2 separate occasions, firstly to reinforce GCP and intervention related training and secondly on the first day of recruitment and questionnaire distribution, to ensure full comprehension of the patient pathways and paperwork requirements.

7.5 Data analysis

7.5.1 Data input and validation

Data were coded directly onto questionnaire script (Appendix E) and were then inputted by one researcher in the UK (the author of this thesis) and one researcher in Germany into Microsoft Excel (2007). Validation consisted of performing rationality and consistency tests on the whole sample.

7.5.2 Descriptive analysis

Descriptive data analysis consisted of means with standard deviations along with medians and quartiles for WTP data, broken down by payment vehicle. In addition, each of these was broken down by practice, demographic and dental factors. Finally, comparisons of stated (questionnaire) and revealed (real payment) WTP were made, in

particular looking at groups who paid more than would be predicted, those who would have been predicted to have paid for the treatment but didn't and those who behaved as predicted. Additionally, where possible, German and UK data were compared.

7.5.3 Econometric modelling

In order to understand fully how the dental and demographic factors influenced both direction (treatment choice) and strength of preference (WTP), econometric analysis was carried out. This consisted of tobit regression models for WTP for the intervention based on the demographic and dental history data collected. Each model was selected based on backwards elimination and best subsets regression. In each case AIC, BIC and pseudo R^2 fit statistics were used to compare models to enable selection of the best fitting model, with BIC being the key statistic used, as discussed in Section 4.4.3.

7.6 Ethical approval and governance

Ethical approval was sought through the NHS National Research Ethics Service and the application was approved by the Southampton & South West Hampshire Research Ethics Committee A Committee. This particular committee was used, despite its remoteness from the study location, due to its proximity to Denplan headquarters and its experience of dealing with the, relatively rare, situation of a study in private dentistry involving actual payments by participants. In addition, the study was approved by the Medicines and Healthcare Regulatory Authority (MHRA) and Bundesinstitut für Arzneimittel und Medizinprodukte (BfArM) for UK and German clinical trial purposes respectively. The funder of the study and developer of the Prevora acted as the sponsor, with the protocol being developed with their input. Due to contractual arrangements, Denplan acted as principal investigators although the design, training, administration and analysis of the study were conducted by the author of the thesis and supervisory and advisory team from Newcastle University.

Chapter 8. Prevention Study: Results

8.1 Introduction

The Prevention Study asked participants to value a new varnish to prevent root caries. Three different payment vehicles were used depending on the current payment method of the participant, with some random allocation of patients within this. All the participants who completed this questionnaire-based valuation were then screened, and those eligible for the varnish (at risk of root caries) were offered this at practice (full) prices and then at study price if they refused at full price. Those accepting went ahead and had the treatment and made real payments for it. The results section opens with a description of the sample in terms of numbers screened, offering and accepting treatment. Next the demographic and dental details are presented alongside population data where available. Then WTP data are presented broken down by payment vehicle. Econometric models relating to the WTP are also presented in this section. Finally, data relating to expected versus observed behaviour (or stated versus revealed preference) are presented.

A final note, necessary in this preface to the results, is that data were collected in 2 countries, the UK and Germany and monetary figures were therefore obtained in both UK pounds and Euros. For the purposes of this thesis, all of the figures in Euros have been converted into UK pounds using a rate of Euro = £0.70532, which was the rate used by Her Majesty's Revenue and Customs in the UK on 31st March 2008, when the German data collection was in progress (Her Majesty's Revenue and Customs, 2008).

8.2 Sample numbers

Nine dental practices took part in the study, 5 in the UK and 4 in Germany. In total, across all 9 practices, 167 participants completed questionnaires and were therefore screened with 134 of these being eligible for treatment. The number actually going on to have and pay for the treatment was 86 (64%) of those eligible. Table 8.1 shows the numbers screened, eligible and accepting or refusing treatment broken down by site.

	UK Practice 1	UK Practice 2	UK Practice 3	UK Practice 4	UK Practice 5	German Practice 1	German Practice 2	German Practice 3	German Practice 4	UK Total	German Total	Combined Total
Completed questionnaire/ Screened (n)	20	23	5	9	29	22	39	12	8	86	81	167
Eligible for treatment (n (% of sample))	17 (85)	19 (83)	1 (20)	8 (89)	10 (34)	22 (100)	39 (100)	10 (83)	8 (100)	55 (64)	79 (98)	134 (80)
Accepted treatment at full price (n (% of ***those eligible***))	10 (59)	11 (58)	0 (0)	8 (100)	4 (40)	15 (68)	14 (36)	9 (90)	8 (100)	33 (60)	46 (58)	79 (59)
Accepted treatment at study price (n (% of ***those eligible***))	4 (24)	3 (16)	0 (0)	0 (0)	0 (0)	-	-	-	-	7 (13)	-	7 (5)
Refused treatment at actual and study price (n (% of ***those eligible***))	3 (18)	5 (26)	1 (100)	0 (0)	6 (60)	7 (32)	25 (64)	1 (10)	0 (0)	15 (27)	33 (42)	48 (36)

Table 8. 1 Recruitment numbers and numbers eligible and accepting treatment by practice

8.3 Demographic and dental details

The basic demographics and dental history of this sample are given in Tables 8.2-8.10 alongside the figures for the population of Germany (more localized data were not available) and the North East Strategic Health Authority (or other similar areas in the UK).

Throughout the whole of the results and discussion, the sample will be split into sub-samples by the type of questionnaire the participants answered, which varied by the payment vehicle, which is how the tables in this section will be broken down. The four sub-samples are:

- UK questionnaire A where the payment vehicle was a one-off fee (n=30 or 17.96% of the whole sample)

- UK questionnaire B where the payment vehicle was a one-off fee plus a decrease in monthly capitation amount subsequently (n=23 or 13.77% of the whole sample)

- UK questionnaire C (payment vehicle was an increase in monthly capitation fee) (n=33 or 19.76% of the whole sample)

- German questionnaire (payment vehicle was a one-off fee on top of patients' usual insurance payments). (n=81 or 48.50% of the whole sample)

The only dental experience data not included in the tables is usual dental payment method, as this in part was the determining factor for which questionnaire each participant was assigned. All of those completing UK questionnaires B and C, were, by definition, full Denplan (private capitation) payers. Of those completing questionnaire A, 30% (n=9) were private fee per item payers with the remaining 70% (n=21) being Denplan payers (on the Denplan Essentials scheme where basic costs of examinations and routine periodontal treatment only are covered). In Germany, 84% (n=68) had most costs covered by statutory insurance, 12% (n=10) paid mainly via private insurance, with only 1% (n=1) paying mainly on a fee per item basis (with 2% (n=2) not responding to this question).

Age band (years)	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	NE England Population (% of 45 years +)*	German Questionnaire (%) n=81	German Population (% of 40 years +)	Whole Sample (%) n=177
40-50	33	35	5	47	35	55	30
51-60	27	59	50		36		39
61-70	23	6	18	14	13	45	15
71+	17	0	27	39	16		16

Table 8. 2 Proportions by age band and questionnaire completed including North East England (NE) (Office for National Statistics, 2007b) and German (Statistisches Bundesamt Deutschland, 2008) population data *= bands for this column are 45-59, 60-64, 65+

Gender	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	NE Population (45 yrs +) (%)	German Questionnaire (%) n=81	German Population (all ages) (%)	Whole Sample (%) n=177
Female	55	65	68	53	70	51	66
Male	45	35	32	47	30	49	34

Table 8. 3 Proportions by gender and questionnaire including North East England (NE) (Office for National Statistics, 2007b) and German (Statistisches Bundesamt Deutschland, 2008) population data

Yearly gross household income	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	NE Population (all years) (%)
<£5200	0	0	0	2
<£10400	0	4	6	15
<£15600	10	13	6	18
<£20800	3	13	24	14
<£26000	13	4	3	11
<£31200	7	4	6	7
<£36400	13	22	12	8
<£52000	10	9	15	13
>£52000	30	22	9	12
Not stated	13	9	18	

Table 8. 4 Proportions by yearly gross household income bands and questionnaire including North East England (NE) population data (Department for Work and Pensions, 2008)

Income	German sample (%) n=81	German Population (projection) (%)*
≤£7053	0	9
≤£10580	0	11
≤£14106	1	6
≤£17633	1	15
≤£21160	6	14
≤£28213	1	17
≤£35266	2	
≤£42319	0	15
>£42319	2	13
Not stated	85	

Table 8. 5 Proportions by yearly gross income bands (converted from € to £) for German sample and German population projections (*note that only net household income is available and bands are only approximately equal to those used in the study). (Statistisches Bundesamt Deutschland, 2008)

Frequency of dental visits	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	England population (all ages) (%)*	German Questionnaire (%) n=81	Whole sample (%) n=177
Only with problems	0	0	0	27	1	<1
Once every few years	0	0	0	10	0	0
Once a year	10	0	3	61	15	10
More than once a year	90	100	97		81	89
Not stated	0	0	0.00	0	2	1

Table 8. 6 Proportions by self reported dental attendance frequency and questionnaire including population figures for Northern and Yorkshire region of England (N&Y) (Kelly *et al.*, 2000) (German data not available) *2% had never been to the dentist

Restorations in last 2 years	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	German Questionnaire (%) n=81	Whole sample (%) n=177
None	20	43	36	20	26
1-2	57	52	58	53	54
3 or more	20	0	3	21	14
No response	3	4	3	6	5

Table 8. 7 Proportions by numbers of restorations in the last 2 years and questionnaire (no relevant population figures could be obtained)

Informed that have:	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	German Questionnaire (%) n=81	Whole sample (%) n=177
Recession	60	39	51	51	51
Dry mouth	0	4	9	5	5
Gum Disease	3	39	9	33	24

Table 8. 8 Proportions of sample informed of the presence of various carious risk factors by questionnaire (no relevant population figures could be obtained)

Number of medications taken daily	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	German Questionnaire (%) n=81	Whole sample (%) n=177
None	50	43	55	41	46
1-2	33	30	18	40	33
3 or more	13	26	27	20	21

Table 8. 9 Proportions by self-reported number of medications taken daily and questionnaire (no relevant population figures could be obtained)

Perceived risk of requiring caries treatment in next year	UK Questionnaire A (%) n=30	UK Questionnaire B (%) n=23	UK Questionnaire C (%) n=33	German Questionnaire (%) n=81	Whole sample (%) n=177
Zero/Very Low	43	22	33	26	30
Less than 50%	17	43	27	31	30
About 50%	20	22	18	19	19
More than 50%	7	9	6	7	7
No response	13	4	15	17	14

Table 8. 10 Proportions by self-reported risk of needing treatment for caries in next year and questionnaire (no relevant population figures could be obtained)

8.4 Willingness to pay

There were a number of participants who either stated their WTP as zero or did not complete the WTP question within the questionnaire. In the absence of follow up questions, it was decided that those who put zero were to be included in calculations as true zeros and that those who did not complete the question would be counted as protest responses and therefore not included in the calculations. The proportion of protest responses for those answering questionnaire A was 7% (n=2), questionnaire B was 4% (n=1), questionnaire C was 10% (n=3) and the German questionnaire was 5% (n=4). Mean WTP data excluding protest responses are presented in Table 8.11, broken down by practice and country.

	Mean WTP (Standard deviation) (£)									
	UK Practice 1 n=20	**UK Practice 2 n=23**	**UK Practice 3 n=5**	**UK Practice 4 n=9**	**UK Practice 5 n=29**	**German Practice 1 n=22**	**German Practice 2 n=39**	**German Practice 3 n=22**	**German Practice 4 n=8**	**Total**
Questionnaire A (one-off fee)	121.10 (81.5)	-	64.00 (33.6)	120.00 (n/a)	70.00 (17.3)	-	-	-	-	105.40 (72.5)
Questionnaire B (one-off fee then decrease in monthly payment)	-	57.86 (34.90)	-	-	50.00 (33.4)	-	-	-	-	55.00 (33.77)
Questionnaire C (increase in monthly fee) *N.B. These are monthly amounts*	-	6.14 (3.89)	-	2.33 (1.63)	5.65 (6.94)	-	-	-	-	5.10 (5.67)
German questionnaire (one-off fee)	-	-	-	-	-	102.62 (58.63)	84.27 (55.02)	114.13 (64.48)	82.88 (33.24)	93.16 (55.86)

Table 8. 11 Mean WTP and standard deviation by practice

Table 8.11 shows that there is a large variance in WTP in all practices and this reflects individual preferences but there are also large differences between practices, suggesting either a different demographic or a different dental expectation of the "customers" of these practices. Table 8.11 also illustrates some of the differences between payment vehicles. It can be seen comparing Questionnaire A (UK based) and the German questionnaire (the same payment vehicle) that one-off fee figures are broadly similar in both countries but a Mann-Whitney U test fails to reject the null hypothesis that they are the same (p=0.727). When an extra incentive is added (decrease in monthly payment band) in questionnaire B, the mean WTP in the form of a one-off fee actually fell markedly, with a Mann Whitney U test rejecting the null hypothesis that they are same (p=0.006). The sub-sample completing this questionnaire (B) were paying for the dental treatment in a different way (full Denplan coverage) to A (not Denplan payers). This will be explored further in Sections 9.3 and 9.4.

Questionnaire C results are not directly comparable with other WTP questionnaire data as the payment vehicle is based on a monthly amount rather than a one-off fee. However, with the mean figure at £5.10, it is interesting to note that it would take 20 months to pay the same amount of money as the mean one-off fee, although this does not take into account any time preference or discounting on this figure.

8.4.1 Econometric modelling

Tobit models were constructed for WTP using the demographic and dental history variables as predictors. For this modelling, only participants who completed questionnaire A or the German questionnaire were included, as these were the simplest

payment vehicles (one off fee) and the data from the two sub-samples could be combined (compared to the other two sub-samples which could not).

Two scenarios were used. Firstly, high and low income were included as possible variables. This was logical given the important theoretical link between income (as a measure of ability to pay) and WTP. The disadvantage of this approach, however, was that the sample size was restricted due to the number of participants who refused to answer income questions and would therefore not be included in the models. Therefore, the 2nd approach was to exclude income variables from the models.

The first model including income variables is given in Table 8.12, with significant factors of taking daily medications, high income and being UK based all increasing WTP. The model (n=37) has a likelihood ratio of chi^2 of 25.19 ($p<0.0001$) with a pseudo R^2 of 0.0619. The BIC figure is 269.900, compared to a value of 288.977 for a model with all variables included.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Takes daily medications (ref no medications)	50.38	15.77	3.19	0.003	18.33−82.42
High income (ref medium income)	103.68	20.11	5.15	0.000	62.80−144.56
UK based (ref Germany)	38.20	18.17	2.10	0.043	1.26-75.15
Constant	-28.95	25.97	-1.11	0.273	-81.74−23.84
Sigma	47.61	5.62			36.18−59.03

Table 8. 12 Tobit regression of WTP for intervention

The second model excluding income variables is given in Table 8.13, with the only factors remaining after backwards stepwise elimination being “takes daily medications”. The model (n=105) has a likelihood ratio of chi^2 of 4.74 ($p<0.05$) with a pseudo R^2 of 0.0041. The BIC figure is 672.669, compared to a value of 698.338 for a model with all variables included.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Takes daily medications (ref no medications)	25.91	11.78	2.20	0.030	2.56−49.27
Constant	81.10	8.98	9.03	0.000	63.28−98.91
Sigma	59.48	4.13			51.29−67.68

Table 8. 13 Tobit regression of WTP for intervention excluding income

8.5 Stated versus revealed preference

One of the methodological experiments undertaken in this study was the comparison of stated preference (WTP elicited in the survey) with revealed preference (revealed when the participant decided to pay for and have the treatment in question). The price that the participant had to pay can be thought of as having two components, the price for the material and the price for the labour and practice running costs of the dentist, which is unique to the practice. In the UK, as the intervention was being provided as part of a clinical trial, it was not possible to charge the patient for the product element of the price. Therefore, participants were firstly offered the product at the "full" price (product and practice costs combined) and if they accepted at this price, this was recorded and later on they were informed they would only have to pay the "actual" price (practice costs only). If participants initially refused at the full price, they were then offered the treatment at actual price and acceptance was recorded. This gave 2 levels of observation for revealed preference.

This 2 level approach was not undertaken for those completing questionnaire C (monthly band increase) or those in Germany due to the complexities of pricing for the practice.

The stated preference valuation allows behaviour in terms of revealed preference to be predicted, such that those with a stated preference higher than the full price would be expected to accept at this price, those with a stated preference between the actual price and full price would be expected to accept at the actual price, and those with a stated preference lower than the actual price would be expected to refuse completely. The next section examines this expected behaviour versus observed behaviour (revealed preference).

8.5.1 Overall results

The results across the whole sample for expected versus observed behaviour are shown in Table 8.14. The observed behaviour of participants falling in boxes in the grey shaded diagonal matched the expected behaviour based on their stated WTP levels. Where participants fell above and right of this line, their stated WTP was lower than the price they accepted at, or stated preference underestimated revealed preference. Where participants fell below or left of the line, their stated WTP was higher than the price they refused at, or stated preference overestimated.

Table 8.14 shows that behaviour was correctly predicted in 55% of cases (WTP was above the price accepted, but not higher than the next highest price available or WTP was lower than the lowest price and participant refused), with stated preference underestimating revealed preference in 30% of cases (WTP was lower than the price paid), leaving stated preference overestimating revealed preference in 16% of cases (WTP was higher than price paid or participant refused at all prices despite having a WTP value larger than one of the prices).

However, the reality is more complex than this, as payment vehicles may have an effect. As already described in the econometric modelling section, the payment vehicles in questionnaires B and C are complex, sample sizes were small and behaviour was unpredictable and inexplicable in terms of WTP values, and so these groups are excluded. Behaviour in the German and UK questionnaire A groups differed and so these will be explored separately in the next two sections.

	WTP>Full price n (%)	Full Price>WTP>Actual Price n (%)	WTP<Actual Price n (%)
Accepted at full price	42 (33)	2 (2)	31 (24)
Accepted at actual price	0 (0)	2 (2)	5 (4)
Refused	20 (16)	0 (0)	26 (20)

Table 8. 14 3x3 cross table showing observed behaviour and WTP levels (predictor of behaviour) for whole sample. Absolute numbers are the main figures with percentage of whole sample in brackets. Grey shaded boxes are where expected behaviour matched observed behaviour.

8.5.2 Questionnaire A: One-off fee

Table 8.15 shows the expected versus observed behaviour for the sub-sample who completed questionnaire A, thus making their payment vehicle in both stated and revealed situations a simple one-off fee. It can be seen that for 50% of the sample observed behaviour matched expected behaviour, but that for the other 50% of the sample (the remainder, lying above and right of the grey shaded diagonal), stated preference underestimated revealed preference with the participants' stated WTP values being below the price but with them still paying this and having the treatment.

	WTP>Full price n (%)	Full Price>WTP>Actual Price n (%)	WTP<Actual Price n (%)
Accepted at full price	3 (14)	2 (9)	7 (32)
Accepted at actual price	0 (0)	2 (9)	2 (9)
Refused	0 (0)	0 (0)	6 (27)

Table 8. 15 3x3 cross table showing observed behaviour and WTP levels (predictor of behaviour) for sub-sample completing questionnaire A. Absolute numbers are the main figures with percentage of whole sample in brackets. Grey shaded boxes are where expected behaviour matched observed behaviour.

8.5.3 German questionnaire: One-off fee

Table 8.16 shows the expected versus observed behaviour for the sub-sample who completed the German questionnaire, thus making their payment a one-off fee, and therefore comparable with questionnaire A. The extra sensitivity of another observed behaviour level (full price) is lost, it can be seen that there is large variation in expected behaviour versus predicted behaviour. 63 % of the sample behaved as predicted, with 14% paying for the product despite having a WTP less than the price, and 22% who had a WTP greater than the price but then refused to pay. The total does not add up to 100% because of rounding errors. This is in contrast to the comparable questionnaire where no participants refused to pay when they were predicted to pay.

	WTP>Actual price n (%)	WTP<Actual Price n (%)
Accepted at full price	34 (44)	11 (14)
Refused	17 (22)	15 (19)

Table 8. 16 2x2 cross table showing observed behaviour and WTP levels (predictor of behaviour) for sub-sample completing German questionnaire. Absolute numbers are the main figures with percentage of whole sample in brackets. Grey shaded boxes are where expected behaviour matched observed behaviour.

Chapter 9. Prevention Study: Discussion

9.1 Introduction

In this chapter, the results of the Prevention Study presented in Chapter 8 will be discussed in detail. Initially in Section 9.2, the methodology and the robustness of the data will be reviewed. This will be followed by a discussion of the strength of preference in terms of the WTP data in Section 9.3. Subsequently issues arising from the experiments concerning payment vehicles and stated versus revealed preference will be discussed in Sections 9.4 and 9.5 respectively. As with the Molar Tooth Study, the chapter will close in Section 9.6 by presenting the conclusions that can be drawn for WTP methodology, for dental policy makers and for dentists and their patients. It is worth again noting at this point that these discussions will be further developed in Chapter 10 alongside the arguments developed in the Molar Tooth Study (presented in Chapter 6), to give a holistic view of the discussion themes across the whole thesis.

9.2 Review of data

In this first section of the chapter some of the methodological issues in this study will be addressed, followed by discussions about the representativeness of the data and problems concerning the sample size. These arguments allow an understanding of the robustness of the data, specifically that the data cannot be used conclusively but emerging issues can be tentatively shown that would require further investigation.

9.2.1 Methodological issues

In commencing this discussion of the methodological issues, it must be remembered that this study was commercially funded and sponsored by the manufacturer of the new preventive product. Although the independence of the research team was completely protected in terms of the methodological design of the economic aspects of the study and collecting and analysing the data, the protocol for the clinical trial elements (not reported in detail in this thesis) was developed by the funder and the protocol for the economic parts of the study which form the empirical work in this thesis had to interface with the existing trial protocol. This led to some methodological restrictions in the economic aspects of the study. Some of the methodological constraints and resultant issues are described in this section.

In contrast to the Molar Tooth Study where interviews were conducted on-site by the researcher, the stated preference elicitation was conducted in primary care, administered by the staff of the primary care dental practices and with participants asked to complete questionnaires with no one available on-site to help to complete the task. All members of practice staff involved attended a training day and had further on-site training from the study monitor. Also, the principal researcher (the author) was present on the first day of recruitment at each practice. However, practice teams reported that it was difficult administering the study whilst also trying to run the practice as normal. These types of problems have been reported in other studies in primary care dental research (Hichens *et al.*, 2005). In this study, the difficulties led to several of the problems noted below.

Firstly, practices were asked to give out questionnaires on a consecutive basis to all patients aged 40 and over attending the practice, providing they had read the pre-study information, had sufficient time and consented to take part. However, upon reviewing the number of questionnaires handed out, it is obvious that this did not happen. For example, there were very few questionnaires completed in total, there were several dates when multiple questionnaires were handed out and other dates when no questionnaires were given out and the hand-out rate of questionnaires generally decreased as the study progressed.

This probable lack of consecutive recruitment obviously leads to the problem of small sample sizes which will be discussed below, but more importantly leaves the study open to selection bias (Petrie *et al.*, 2002). In particular, receptionists or practice managers (who were responsible for giving out questionnaires) may have only given out questionnaires to patients they knew well (biasing the sample to regular attendees and those with greater treatment experience) or to particular groups who they thought may respond better to the questionnaire which may introduce other demographic biases.

The other concern with the unsupervised nature of the study was the completion rate of questionnaires and in particular income and WTP questions. For example, in the income questions, 85% of German respondents did not provide an answer, with 14% of UK respondents not providing an answer. This contrasts with a non-response rate of 4% in

the interview-based Molar Tooth Study. For WTP, 5% of German respondents did not provide any answer, with 7% of UK respondents not providing any answer. Note that for the purposes of this study, in the absence of follow up questions those providing no response were counted as protest zeros and those providing a valuation of £0 by ticking the box by £0 were counted as true zeros. It is interesting that the response rates should be so different in Germany and the UK for the income questions, perhaps indicating a cultural difference in responding to these types of question. Interestingly, although many of the German respondents failed to provide an income answer, they were still happy to give WTP valuations. It can be assumed however, that where practicalities allow, an interview based elicitation is preferable to a questionnaire, as recommended by the NOAA report (Arrow *et al.*, 1993).

Aside from the issues of primary care based research, there are two further potential methodological problems that must be highlighted. The first is that to fulfil the aims of the thesis relating to methodological issues, in this case, studying the payment vehicle, the sample was split into four groups, leaving four smaller sub-samples with incomparable data. This creates additional problems with statistical power, in that any power that the study has is divided by four. This may not have been such a problem had truly consecutive recruitment occurred, but as it did not, this has left very small groups for analysis. This problem of carrying out methodological experiments alongside collecting WTP data to answer policy questions is one that must be thought through carefully at the design stage of any WTP experiment. This concern is also taken up by Carson (2001), who recommends, for example, that tests of sensitivity should be avoided and efforts should instead by focussed on maximising sample sizes.

The final issue is one relating to the WTP scenario design, in that a range of payments must be specified where a bidding card elicitation format is used. This has been shown to introduce range bias (Whynes *et al.*, 2004) and this is one of the disadvantages of this particular elicitation format. In this study, the amount to be actually charged was unknown at the time of developing the WTP scenario, and subsequently the range was set too low, with the actual price towards the top of the range. It is interesting to note that many of the responses were towards the top of the range with some participants opting to use the additional "specify value" option after the top of the range. This

perhaps indicates that respondents were not overly constrained by the range and so range bias was probably minimal in this study. It is probably reasonable to conclude that the range was not too great an issue.

9.2.2 Representativeness

Having a consecutive sample was the only practical way of recruiting in this study and having a representative sample was never the aim. Additionally, the study was conducted in wholly private practices in order to allow the aim of comparing hypothetical valuations with revealed preference to be studied (therefore requiring an environment where patients paid for treatment). This also satisfied commercial (funder imposed) requirements for the study to be conducted in this context and logistical and ethics committee requirements, as it would have been impossible to conduct such a study with an associated clinical trial in NHS practice. As a population, private dental attendees are not well defined with little data available on the demographics of this population. This makes any representativeness difficult to analyse and also makes calculating population weights impossible, therefore ruling out any weighting of the sample. As with the Molar Tooth Study, these results are not interpreted as if they are representative of any population, and absolute figures are not used; only patterns and trends in the data are analysed.

9.2.3 Sample sizes

As noted in Section 7.2.1, it was difficult to calculate sample size requirements for this study given the lack of previous data. It was agreed that the question in the study requiring the greatest power was the stated versus revealed preference difference. Additionally, as described in the Section 9.2.1, the division of the sample into sub-groups for the payment vehicle section increased the sample size requirements beyond what may have been required in a simple comparison of stated versus revealed preference. As with the Molar Tooth Study, the variance in the sample of WTP values was high. *Post-hoc* calculations suggest that, for example, in the questionnaire A sub-group, to detect a mean difference of £10, the sample size required would be 1104. Obviously, with the largest sub-sample being less than 100, the required sample was not going to be attained.

With the lack of power in conjunction with some of the methodological challenges described in this section, this study is inconclusive. Many of the areas discussed are therefore preliminary only and suggest areas for further investigation, which will be outlined in detail.

9.3 WTP valuations

The WTP values are difficult to interpret in the light of the different payment vehicles used, leading to small sub-samples effectively valuing different goods. However, perhaps the easiest to interpret are the German and UK questionnaire A sub-samples who were both valuing the product in terms of a one-off fee. It can be seen in Table 8.11 that the mean WTP was £105.40 for the UK and £93.16 for Germany, although as described in Section 9.2.2, these absolute figures are of limited value if used in isolation. In terms of comparing these values to existing data, in the most comparable study, high risk adolescents valuing a complete preventive programme in Sweden gave remarkable similar values of approximately £125 (conversion from Swedish Krona) (Oscarson *et al.*, 2007).

As with the Molar Tooth Study, the standard deviations are high being 72.50 and 55.86 for the UK and Germany respectively. However, the SDs are not as high as those seen in the Molar Tooth Study (for example, a SD of 108.61 around a mean of £97.86 for extraction only or a SD of 991.46 around a mean of £372.79 for RCT). This may reflect less divergence of valuation in the Prevention Study. However, it may also reflect the elicitation method with a smaller range presented to the participants and with the range being entirely transparent (compared to the shuffled card method used in the Molar Tooth Study, where the range is not clear). In one experiment (Rowe *et al.*, 1996), range bias was found where the upper end of the range of a payment was card was truncated, as could have happened in this study. However, if comparisons with the Molar Tooth Study are ignored, it can be seen that the SDs are still high, again reflecting a large variance in valuations in the sample.

The results indicate that there is a substantial valuation attached to prevention. In the case of this new intervention, it would seem that the mean valuations do not outweigh the probable costs of the products. However, if the valuations of around £100 are taken

to be reflections of valuations of caries prevention more generally (rather than specifically the intervention itself), there are many caries prevention interventions which would cost less than this (Kallestal *et al.*, 1997; Arrow, 2000). This suggests that for a health system such as the NHS, even if the longer term potential cost savings in terms of avoided treatment are ignored, it is worthwhile investing in prevention. Although this may mean that there is an initial financial outlay for the service, which introduces affordability issues, these figures suggest that many would be willing to contribute in the form of co-payments, although whether these figures can be transferred from a private to public system has not been tested. The tentative conclusion from these data then is that although the NHS should not invest in this particular product, there is a strong case for other, less expensive preventive regimes to made available on the system and also be funded by the system, rather than relying on co-payments, although this would probably be feasible.

Although the different payment vehicles will be explored in the next section, the German and UK questionnaire A are essentially the same payment vehicle and are therefore compared here. Firstly, the mean value in Germany is slightly (although not statistically significantly) lower than in the UK. Given the lack of statistical significance, this may purely be a sampling error. However, if this does reflect a genuinely smaller value, this may be a reflection of cultural differences in the value of oral health, or perhaps, more likely, the effect that market intervention has on valuation. It should also be noted that the sub-samples from Germany and the UK are slightly different in terms of how they usually pay for their dental treatment in that almost all of the German sample (96%) were insured for dental treatment compared with only 70% of the UK sample (and for this 70% only examinations and basic periodontal procedures were included in their insurance). The lower valuation in Germany may therefore be due to moral hazard (Grytten, 2005), in this case a perception for some participants that their insurance should cover some or all of the cost of the intervention, or a feeling that they have already paid for dentistry in terms of their monthly contribution, and are therefore unable or unwilling to contribute more. Although there is no statistical difference between the German and UK questionnaire A sub-samples, when the econometric modelling was carried out (Tables 8.12 and 8.13), which will be discussed in the next section (9.4), the German versus UK variable was significant as a factor in the model

which included income (although this was with a small sample size) but was removed in the elimination when income variables were deliberately excluded to increase sample size. It is difficult to interpret this finding in the light of the two models and the problems with the small size in the first. This is one area where further work is required.

In terms of the econometric modelling (Tables 8.12 and 8.13), to simplify the modelling and interpretation, only German and UK questionnaire A data were included. Due to the low response rate to income questions, two models were built, one where income variables were included as potential variables (as would have been preferred) but which therefore had a very low sample size, and one where income variables were excluded and so did not take these important variables into account but therefore had a much larger sample size.

Whilst bearing the issues around the modelling in mind, it is interesting that taking daily medications increases WTP in both models. It is difficult to explain this variable having an effect on valuation of oral health and it may simply be an erroneous finding due to the circumstances of the study. However, there are several possible explanations. Firstly, self-assessed health has an effect on utility values for health (Taube, 1989), so it may be that if self-assessed health is influenced by requiring daily medications, an individual may have greater utility values for health interventions in general and this may also have an effect on oral health. Additionally, participants may have been aware of links between some medications and increased risks of caries (Peker *et al.*, 2008), although this is not shown in the modelling, with self perceived risk not featuring in either model. Finally, participants who are already taking medications may be less averse to trying another product, and in reverse, those who do not take medications anyway, may fear that starting with one, albeit preventive intervention, may spoil their "perfect" health record. The influence of medication on valuation is an interesting area requiring further investigation.

When income is considered in the, albeit small sample size, model, the findings are similar to the Molar Tooth Study in that low income does not seem to influence valuation but high income does increase WTP. This fits with the possible explanation that disposable income is the important determinant in oral health valuation.

Finally, in the model including income, being in the UK sample increases WTP. This has been discussed in detail earlier in this section.

In general, however, it can be concluded that values for prevention are highly variable and that they are relatively unpredictable, with few factors featuring in the models. This is not surprising when other valuations of prevention are taken into account, where a range of different factors have been shown to influence valuations with likely explanatory factors found to be non-predictive (Oscarson *et al.*, 2007; Tianviwat *et al.*, 2008a)

9.4 Payment vehicles

The payment vehicle experiments were those that suffered most from a lack of power due to sample sizes, and in particular, sub-samples for questionnaires A, B and C are especially small (30, 23 and 33 participants respectively), and therefore the conclusions drawn in this section, in particular, must be interpreted with caution. Nevertheless, the payment vehicle experiment shows some of the most interesting results across the whole Prevention Study, and the scope for further study here is great.

Firstly, comparing the means, it can be seen from Table 8.11 that questionnaire A has the highest mean at £105, followed by the German questionnaire at £93 (not significantly different), and then questionnaire B at £55 (significantly different from A). Questionnaire C involved a monthly insurance contribution increase and the mean was £5. Although this figure is not comparable with the others, the value can be multiplied by 12 to £60 if the assumption that a year is the appropriate time frame for this to be viewed over (this was implied in the scenario participants faced).

The German questionnaire and UK questionnaire A have already been compared in the previous section, as these are actually the same payment vehicle, despite having a different health care system context. The most interesting comparison is questionnaire A and B, where both use a one-off fee vehicle but for B an added incentive of a reduction in monthly band is offered. It is therefore initially surprising that the mean WTP for B is almost half that of A, given that this should be worth more. Indeed, if the financial calculations are performed with a one year horizon (the scenario was framed in terms of one year reduction in risk), the behaviour of some of the sub-sample (giving

lower valuations) can be seen as particularly irrational: unfortunately, individual level band data was not collected, but assuming each of the participants answering questionnaire B was in the middle band at their practice, the mean decrease in payments would have been £3.14 per month. If this is seen over a 12 month period, the yearly decrease would have been £37.48. Several participants were willing to pay smaller amounts that £37.48 to save this same amount; this was irrational behaviour. Even for those who were willing to pay more than £37.48, the valuations seems low when compared to those answering questionnaire A who had a mean WTP of £105.

There are at least three possible explanations why the valuation should be lower for B than A. Firstly, those answering questionnaire B have a comprehensive dental insurance whereas those answering A either have a limited dental insurance (70%) or pay out of their pocket (30%). Therefore those answering questionnaire B may have an expectation that their insurance would cover the cost of the intervention (this moral hazard has already been encountered as a possible explanation for the differences between Germany and questionnaire A) (Grytten, 2005) and also may have less idea of the market value of such an intervention, if they are unused to paying for dental treatments outright. Secondly, the payment vehicle is relatively complex combining both a one-off, short term fee and a monthly, long term change in insurance payments on top of the complexities of reduction of risk in health terms, and this may have confused participants (anecdotal discussions with dentists involved with the study suggest this was a common problem that participants had). Finally, for either sampling reasons or possibly as a characteristic of a group who have already chosen comprehensive insurance, it may be that those in group B, are not carrying out a valuation of the health benefits but are merely making financial calculations (Baker *et al.*, 2008), thereby invalidating WTP (Diamond and Hausman, 1994). This question of how values are formed has already been discussed in terms of the data from the Molar Tooth Study, and this aspect of the Prevention Study provides additional data addressing the problem. The overall conclusions in terms of how WTP values are being formed and therefore how valid WTP is as a measure of health benefit will be drawn in Chapter 10.

Finally, in this section, the results from questionnaire C are considered, where participants were asked to value the intervention in terms of how much extra per month

they would be willing to pay in insurance payments. If the time horizon of 12 months is taken, the mean increase over one year would be £60. This is comparable with those in Group B who had a mean of £55, albeit with an incentive of a decrease in monthly payment. This again is perhaps surprising, in terms of the value for group B being lower than expected when compared with group C, especially given that the samples both have the same method of dental payment (comprehensive insurance). This weakens the argument put forward when comparing group B with group A that the low value for group B could be due to the participants in this group expecting their insurance to cover the cost or not knowing current market prices, as this would also be true for group C, and we would therefore expect C to be lower than B. Instead, the arguments that those in group B (and also C) form their values differently or that they are confused by the monthly banding system are strengthened.

There is an inference from these data that some of the payment vehicles may be too complex. This leaves a difficult question for policy makers who face the choice between simpler payment systems which are understandable and may increase the uptake of prevention, or more complex systems, which might be more sensitive to the differing needs of different patients and possibly fairer in terms of the financial burden on the patient (depending partly on how equity is defined in any given system). This debate is already occurring in NHS dentistry; one of the criticisms of the pre-2006 system was the complexity of patient charges and one of the criticisms of the post-2006 system is that patient charges have been over-simplified and therefore may not be fair (House of Commons Health Committee, 2008). It is therefore difficult but important to find a satisfactory compromise between these 2 solutions. The data presented here suggests that policy makers should err on the side of a simpler system, although this does not reflect the increasing complexity of other markets such as energy pricing or mobile phone tariffs, which it seems consumers are generally able to cope with (Nelson, 2002).

The findings related to payment vehicles are broadly in line with those in the only other study comparing payment vehicles in oral health (Matthews *et al.*, 2002), as discussed in Section 3.5.2. In that study, WTP for an anaesthetic gel was $2 median increase in monthly insurance premiums compared to $10 or $20 as a one-off fee depending on the sub-sample by dental experience. These differences of magnitude are comparable with

the findings in the study being discussed. With the low samples sizes, it is impossible to draw firm conclusions, but this is an area that is of great interest and warrants further investigation. If the influence of payment vehicle can be understood properly, this would allow policy makers to offer prevention using the payment vehicle that is going to maximise valuation and increase the uptake, which should be an important aim of any health care system. Indeed, if different groups responded differently to different vehicles it would be possible to target prevention at different groups using different payment vehicles.

9.5 Revealed versus stated preference

In this section, the comparison between stated preference (in terms of WTP expressed in the questionnaires) and revealed preference (in terms of take up of and payment for the actual intervention) will be dealt with. As stated in Section 7.4.6, at each UK practice the intervention was offered to participants who had completed a questionnaire and were eligible for the treatment at the full price and then, if they refused, at the actual price (reduced for the study). All participants paid the actual price, but this was only revealed to those accepting at the full price after agreement had been confirmed. In Germany only one price was offered. It would therefore be expected in the UK that those who had a stated WTP greater than the full price would accept at this price, that those who had a stated WTP lower than the actual price would refuse outright (refuse at both prices), and that those who had a stated WTP between the full and actual prices would accept at the actual price. In Germany, the simpler situation exists that where stated WTP was greater than the actual price the participant would be expected to accept, otherwise, they would be expected to refuse.

For questionnaires B and C the sample sizes are small and the payment vehicle is complex, therefore only questionnaire A and the German questionnaire will be considered. It can be seen from Table 8.15, that for questionnaire A, all participants behaved as expected, accepted when a refusal was expected or accepted at the higher price level when the lower was expected. In Table 8.16, it can be seen that the full range of possible behaviours was seen in the German sample with some participants behaving as expected, some participants accepting when a refusal was expected and some participants refusing when an acceptance was expected.

This suggests in all cases in the UK and in some cases in Germany that stated WTP either accurately estimates or underestimates actual valuations for this intervention. This is a perhaps surprising result with many of the critics of WTP expecting WTP to overestimate value due to its hypothetical nature with this concern being noted in the NOAA report (Arrow *et al.*, 1993). This study, however, reflects similar results to one of the only other empirical tests in health (Bryan and Jowett, 2010).

The reasons for this underestimation are more difficult to resolve with the data available. It is notable that the revealed decision was made only after a consultation and discussion with a dentist, and there may be an element of supplier-induced demand (possibly reflecting true need or possibly not), which is increasing valuations. This supplier-induced demand has previously been shown in dentistry (Birch, 1988; Naegele *et al.*, 2010). This is also supported by the practice level data, with valuations (Table 8.11) and take up rates (Table 8.1) varying hugely by practice. In Germany, some participants did not accept treatment when this would have been expected from the stated valuations, whereas this particular pattern of stated WTP overestimating revealed preference was not seen in the UK. This may be an artefact of the relatively small sample sizes, or may suggest a genuine difference. Again, it is difficult to determine reasons for this difference if it is real, but it may be that there is less scope for supplier-induced demand.

9.6 Conclusions

This final section of the chapter draws out the strands developed in this discussion into some conclusions classified into consequences for WTP methodology, for dental policy makers and for dentists working with their patients. Given the methodological issues identified in Section 9.2, the conclusions drawn are tentative and there will be a strong emphasis on areas that require further investigation.

9.6.1 Consequences and questions for WTP

Although there were several methodological flaws, the study has provided useful initial data, which has been used to begin to address some important policy questions. Other areas that could be addressed with more robust data have also been addressed in this discussion. The possibility of eliciting such data and how it could be used, have

therefore been illustrated, in part addressing the first objective of this thesis to use WTP in two dental settings. The methodological difficulties have highlighted issues that the design of future studies will need to take into account and in this respect alone, the study adds useful information to the current knowledge. These methodological lessons will be outlined next followed by first two key questions that are posed by the study in terms of WTP use.

The most important finding, in terms of methodological issues, was the sample size requirement. Firstly, the variance in the study was very large, and assuming this will be similar for other areas of oral health, and probably many areas of general health too, sample size requirements will be large whatever questions are addressed. Bearing this in mind, it will be important not to be over ambitious in terms of conducting multiple simultaneous experiments which split the sample into smaller potential non-comparable groups. This was a major issue in the current study.

The other key methodological issues apply not only to WTP studies but in fact, much research carried out in health care. There has been an increasing trend to carry out research in primary care particularly in oral health (where the majority of activity is primary care based), in order to satisfy the requirement that the research is more applicable to the context that the findings are likely to be used in (Clarkson, 2005). This is, of course, a laudable aim. However, this study has highlighted some of the issues with carrying out research in primary care, and if this is to be done, careful training of the staff involved, careful monitoring and simple administrative designs are all important elements that researchers will have to pay close attention to, as also noted by Hopper *et al.* (2008). It may be that for more complex studies, in order to fully ensure robust research, a researcher would need to be on-site full time, as suggested by Hichens *et al.*(2005).

It has therefore been shown that WTP can be used for valuing prevention in oral health, but that there are several methodological issues that need to be carefully addressed. If these issues are taken into account and similar studies are conducted with robust designs, the data could be useful for both policy makers and dentists working with their patients. In short, none of the methodological difficulties presented here are impossible

to deal with, either through robust design, or after more methodological research, and so the methodology is viable.

As with the Molar Tooth Study, one of the key questions emerging from this data is how individuals form WTP valuations. In particular, this prevention study has highlighted the dichotomy between financial calculations and health valuation, as defined by Baker *et al.* (2008). The different valuations for different payment vehicle could be explained by this difference in value-forming processes. It will be important to understand which of the two processes plays the more important role not only in order to inform policy making, as will be described in Section 9.6.2, but perhaps more importantly to fully understand the validity of WTP as a preference-based measure for health (Diamond and Hausman, 1994).

The other key question posed by the data is whether WTP under- or over-estimates actual preference. As discussed in Section 3.4.3.5, the theoretical viewpoint from some critics is that WTP will over-estimate true preference given the hypothetical nature of the valuation (Arrow *et al.*, 1993) and there is very little empirical data to refute this viewpoint, although one other study in health has found that WTP may actually under-estimate revealed preference (Bryan and Jowett, 2010). This prevention study broadly supports this existing empirical data, again finding that in many cases WTP under-estimates revealed preference, although the findings in this study are viewed with caution in the light of the methodological issues. These data do however reinforce the need to investigate this question in health with further robust experiments. If WTP is to be used further in oral health, as is suggested throughout this thesis, it will be important to address this question in the context of oral health specifically.

9.6.2 Consequences and questions for dental policy

In terms of findings of relevance to policy makers, this section will outline how the uptake of prevention can be increased, before going on to address what the valuations mean in terms of providing preventive interventions and the need for cost-benefit analysis. Finally the implications of the large variation in values will be discussed.

Given that increasing the uptake of prevention is likely to be an important aim for any healthcare system (Steele, 2009) for ethical reasons of improving health, but also

possibly for efficiency and financial reasons, there are several important conclusions that may be drawn from this discussion. Firstly, it would seem that prevention is valued lower where a more complex system is introduced, such as adjusting monthly payment bands. Therefore, to increase the uptake of prevention, it may be helpful to keep systems relatively simple and incentives, if too complex, may actually work in the opposite way and discourage take up (although this must be weighed against the possibility of reducing equity through an over-simplified patient charges system (Milsom *et al.*, 2008)). Additionally, for some individuals and perhaps particularly those in insurance-based systems, the decision to take up a preventive intervention may be based on financial calculations rather than a valuation of health (Grignon *et al.*, 2010). Marketing and pricing of preventive interventions should therefore take this into account.

Perhaps most importantly, it seems that the dentist-patient relationship is important in the uptake of prevention, in the form of supplier-induced demand. Therefore population based approaches to prevention would have to be carefully thought out to minimise any disadvantage of not using the positive benefits of the dentist-patient relationship.

As with the Molar Tooth Study, there is a great deal of variation in the valuations seen in this sample and this may well replicate the variation in the population, although it is more difficult to draw this conclusion in this study compared to the more robust Molar Tooth Study. If anything, the elicitation method may have artificially depressed the variance. If the variation truly is great, as is suggested, then designing dental systems which encourage the whole population to take up prevention will be difficult, but all the more important to do robustly if this is one of the aims of the system. It may be that in publicly funded systems, making prevention available for all regardless of personal valuation of oral health is a key area for using public funds (as suggested for the NHS system in the latest review (Steele, 2009)). However, others may argue that this is imposing decision makers' values on individuals, and that those who have low values for oral health should make their own choices about whether their own funds should be used for prevention. One possible solution to this dilemma is to argue that if policy makers do believe prevention should be increased, then one of the aims of a health system should be to increase individuals' values of prevention, something currently

being discussed in UK policy terms in the latest white paper (Department of Health, 2010b). These arguments raise philosophical and ethical issues, and this discussion will be expanded on, with the addition of data from the Molar Tooth Study, in Section 10.4.3. If, however, it is agreed that a system should try and increase valuations, these data suggest that dentists themselves working on an individual basis with patients may be a promising route for doing this.

Whatever is decided about increasing the uptake of prevention, allocative efficiency questions will always need to be addressed (Donaldson and Shackley, 1997a), such as how much prevention should be funded by the service and a cost-benefit analysis using the type of data produced here (although more representative of the population being served) would be invaluable in the decision making process. This would be one of the key uses of the type of data that this study has shown it is possible to elicit. In addition to the data elicited here on a personal level, WTP valuations of programmes, as discussed in Section 3.5.6, would also be of great use in this type of analysis.

The values elicited here show a substantial valuation of prevention, although not substantial enough to justify the cost of the intervention being studied. If the values are seen as valuations of prevention more generically rather than for the specific intervention studied here, it can be seen that less expensive interventions are valued by the public at greater levels than their cost, and so should be provided. The sample here consisted of private patients, but if the figures are transferable to the NHS, it suggests that prevention should be available on the NHS and if costs of individual interventions were known, it would be possible to determine which interventions should be funded. All of this assumes affordability for the NHS, although should it be the case that the costs cannot be met, there is evidence here that patients would accept co-payments for prevention.

This study therefore suggests that uptake of prevention varies with complexity of system, different incentives and different levels of supplier-induced demand and further investigation all of these influences is a key research area. It has been shown that appropriately designed WTP studies could, in part at least, address some of these issues. Additional research, possibly using qualitative methods, would also contribute to this

debate, as well as to the understanding of how WTP values are formed, an area already identified in the Molar Tooth Study as an important question for future research.

9.6.3 Consequences and questions for dentists

The majority of the consequences from the Prevention Study concern policy makers or WTP methodology. However, one important emerging conclusion for dentists working with their patients is the importance of supplier-induced demand. The study suggests that this is an important determinant of uptake of prevention, and therefore dentists need to be aware of this when taking decisions with their patients. Firstly, in order to practice ethically, it is important not to create demand where there is no need (General Dental Council, 2005), which may not be done deliberately, but if supplier-induced demand is as important as this study begins to suggest, could be easily done.

Secondly, where there is a need for prevention, the dentist must be aware that they can have the influence which may be necessary to facilitate the uptake of prevention with related health benefits and it may even be that health benefits outside of oral health could be influenced by a dentist, with the potential for dentists creating demand for prevention for non-oral health diseases. This approach has already been suggested (Binnie, 2008), based on the fact that individuals are more likely to see dentists regularly than other health care professionals, but this study suggests that there may be additional benefits in terms of uptake.

This study begins to suggest the importance of supplier-induced demand but it is not conclusive and so another carefully designed experiment would be necessary to explore this area more conclusively. Additionally, it is not clear what elements are influencing the strength of the supplier-induced demand, if it exists at all, and so further experiments to draw out important factors in supplier-induced demand, perhaps using discrete choice experiment methodology or again drawing on qualitative methods, are recommended.

Chapter 10. General discussion

10.1 Introduction

This final chapter will draw together conclusions, themes and emerging questions from both of the studies in the thesis, to give an overall indication of the knowledge contributed by the thesis. The division of conclusions will be similar to those in Sections 6.7 and 9.6 with implications for WTP methodology, dental policy makers and dentists working with their patients. However, in this chapter, implications for WTP methodology will be broken down into general and oral health specific sections. Policy implications for oral health and then implications for dentists will be addressed in the next two sections. The final two chapters (11 and 12) will then look at how each of the seven aims of the thesis have been addressed, and the future research agenda emerging from the thesis.

10.2 General WTP methodological implications

Aside from the implications of the results for oral health discussed in subsequent sections, the thesis, in using WTP in an area of healthcare where it has not often been applied before, has identified some important findings for WTP methodology in general.

10.2.1 Validity of WTP as a valuation of health

Perhaps the most interesting finding relates to the validity of WTP as a measure of valuation of health. Both studies yield evidence which suggests that two distinct value-forming processes occur in different individuals. Some individuals do appear to be genuinely valuing health in some form, whereas for others, the value seems to be based entirely on financial and budgetary calculations, not reflecting preference for health at all. This process of "mental accounting" was identified in multiple studies reviewed by Baker *et al.* (2008). In this thesis, this process was suggested by both the influence of real price elements of the Molar Tooth Study and the payment vehicle experiments in the Prevention Study.

Additionally, it is unclear whether individuals are valuing processes (interventions) or health states (either getting out of one or into another). To interpret the data fully, it is important to understand this. Although the data collected appear to suggest a variety of

valuation formation processes are used, it is difficult to be conclusive about precisely how these processes are working given the nature of data collected. Although not specifically comparing intervention versus health state valuation, a previous review of WTP studies in healthcare showed that a majority were valuing health products rather than the benefit produced by such products (Olsen and Smith, 2001). Other studies assessing how values are formed mainly relate to programme-based valuations and truly public goods and are therefore not very relevant to this thesis or the setting of oral health more generally (Baker *et al.*, 2008). To answer these questions definitively, it will be necessary to investigate these areas qualitatively.

10.2.2 Hypothetical bias

One major theoretical criticism of WTP is that as it is based on a hypothetical scenario, participants would have a tendency to overstate WTP and that WTP may therefore over-estimate preference (Arrow *et al.*, 1993). Little empirical research has been performed in healthcare investigating this issue due to the difficulties of designing a study where stated preference can be compared with revealed preference (Bryan and Jowett, 2010), but oral health is one area of health (where participants are already used to paying for care) that lends itself well to investigating this. The Prevention Study directly compared stated and revealed preference, and although the results must be interpreted with caution, it was seen that in many cases WTP under-estimated revealed preference. Although the Molar Tooth Study did not allow a direct comparison with revealed preference, recording preferences and valuations following exposure to real prices (albeit still hypothetically) allowed some insight into values that were probably closer to revealed preference than the initial stated WTP. Again, this study also found that in many cases, preference had been understated by initial WTP elicitation. In both studies, the behaviour observed and changes between stated and revealed preference were complex, and again this area warrants further investigation. However, the data in the thesis do not provide any evidence to support the hypothesis that WTP will underestimate preference. Indeed the data infer that the opposite may well be the case.

10.2.3 Part-whole bias

The other methodological experiment conducted related to part-whole valuation, a measure of WTP reliability, and to some extent validity (Arrow *et al.*, 1993; Olsen *et*

al., 2004). For reasons explored in Chapter 6, the data presented is not conclusive, but the initial findings suggest that part-whole bias may not be a particular problem, again a positive finding for WTP.

10.3 Using WTP in oral health

Firstly, both studies have shown that WTP can be used successfully in the dental examples chosen. Some important problems have been addressed using the WTP values elicited and these will be summarised in Section 10.4. In other areas, it has been illustrated how other questions could be answered using WTP values, even if these have not been addressed directly in this thesis. Following on from the arguments developed in Chapters 1 to 3, the thesis has shown that WTP is a viable alternative to health state utility measurement, and so given the arguments against the use of health state utility measurement in oral health, WTP is recommended as the preferred preference-based measure for oral health. This reflects previous conclusions in reviews of the use of preference-based measures in oral health (Matthews *et al.*, 1999b; Birch and Ismail, 2002). However, the thesis has also highlighted some issues with WTP measurement in oral health.

10.3.1 Primary care based research in oral health

Both of the studies were conducted in a primary care setting. This decision was based on the fact that, in the UK, the majority of dental care is delivered in this setting (Steele, 2009). The target population was users of the service in this setting and so recruiting in practices was the most logical and practical method. In reality, this proved to be an ideal situation for the Molar Tooth Study, where the researcher was present on-site, but led to some difficulties in the Prevention Study including increased levels of missing data due to non-completion of questionnaires, selection bias in recruitment and low sample sizes. The difference from the Molar Tooth Study was that the Prevention Study was being administered by dental practice staff without the support of a researcher. The results of the Prevention Study have therefore been interpreted tentatively. It can be seen by contrasting these two studies, that although primary care can be a good source of research participants, if a researcher is not to be present, any study will have to be carefully designed to minimise the impact on practice staff as well as making the study easy for staff to administer when they are doing this alongside running a busy practice.

Indeed, if the study is complex, it is probably desirable to have a full time dedicated researcher or member of staff present to administer the study when collecting key data. A similar conclusion was reached in a review of the administration of two practice based studies in orthodontics (Hichens *et al.*, 2005). Although the need for training of general dental practitioners involved in primary care research has been widely recognised (Clarkson, 2005; Crawford, 2005; Hopper *et al.*, 2008), this additional need for a dedicated member of staff or researcher has been little discussed in the literature.

10.3.2 Variance and sample sizes

A large variance in valuations was found in both studies (although less so in the Prevention Study). This finding is of great interest and relevance in its own right and has implications for policy makers and dentists (discussed in Sections 10.4 and 10.5). However, the large variance, which is likely to be replicated across other oral health valuations, also has methodological implications in terms of the need for large sample sizes. Both studies suffered to some degree from lack of power due to low sample sizes. Additionally, these requirements must be borne in mind if the sample is to be split in any way for experiments. The Prevention Study in particular suffered from this effect, whereas in the Molar Tooth Study, only the part-whole valuations experiment suffered from a lack of power. Of course, large sample sizes carry a cost in resource terms for research and so given the need for large numbers, it will be imperative to identify areas of oral health where WTP valuations are of high priority.

10.3.3 Scenario development

The development of good scenarios has been identified as a key factor in achieving accurate WTP elicitation (Olsen and Smith, 2001; Smith, 2003). In both studies, the scenarios could have been developed further and this is one of the key improvements that could be made to either study. Specifically, the molar tooth scenario could have included more information on the process of each possible intervention and the likely success rates, long term complications and likely options upon eventual failure in addition to the use of more consistent clinical photographs (See Appendix B). The prevention scenario could have explained the potential effect of the new intervention more clearly (presentation of percentage chances has previously been identified as a difficult conceptual challenge). In the molar tooth case, this may have led to more full

valuation of process utility and a more realistic valuation overall with longer term implications being fully considered. This potentially could have led to different directions of preference and possibly a reduction in strength of preference (lower WTP values). In the case of prevention it is difficult to know how strength of preference would be affected as individuals may have either under or overestimated the actual efficacy of the intervention.

Where scenarios are not fully developed it has been suggested (Smith, 2003) that individuals make assumptions about the missing information, often using personal experience, which means that each individual is valuing a different scenario. This reduces the validity of the values elicited. Full scenario development could involve the use of previous patients describing their experiences, drawing more fully on existing data in the literature (presented in an accessible way) and using focus groups to develop the scenarios. Although this may present a considerable extra demand on resources, this is likely to be a very worthwhile investment with good scenarios being a vital aspect of robust elicitation scenarios. In the two studies forming the empirical section of the thesis, better scenario development is one of the key improvements that could be made.

10.3.4 Valuation of interventions, health states and programmes

One question that remains unresolved is whether personal health states, personal interventions or population level programmes should be valued in oral health. The case was made for personal intervention valuation in Sections 3.5.2 and 3.5.3 as a way of minimising hypothetical and embedding bias, as well as being conceptually easier for respondents and including process utility. However, it is seems that even when respondents are asked to value specific interventions as was the case in both studies, some still value getting into or out of health states, as is exemplified by the variety of behaviours observed when participants were presented with real prices in the Molar Tooth Study. Although all could be seen as valid valuations of what is being presented (within the limits of the scenario design as described in the Section 10.3.3), interpreting and using the results where individuals within a sample have valued the scenario based on different concepts may be difficult. If population programmes were valued, this confusion may be reduced or even eliminated (Olsen and Smith, 2001).

An additional factor in the choice over what to value is how oral health can be compared to other areas of health care and to what extent this is necessary. If these comparisons are being made, or indeed if resource allocation decisions are being made at this level, population programme valuations may well be necessary.

The concerns highlight the potential need to define some key dental states, such as the point at which a prosthesis becomes necessary for function, and valuing these states would provide the large building blocks of a framework of value for the whole dentition. Indeed the concept of a minimum functional dentition (21 teeth) has been defined (Kayser, 1989) and there has even been some limited work looking at the utility value of such a state (Nassani *et al.*, 2005). Individual interventions could then be added into this framework of important oral health states as steps between the larger blocks. It may be that health state utilities would be the best method for eliciting values for the large states and WTP for the individual interventions. This would link WTP and health state utilities. This is comparable to a major programme of research being conducted across health more generally, in the whole of Europe, which is attempting to define the value of QALY using WTP (EuroVaQ Project Partners, 2010). A research programme to link health states with intervention values in oral health would be large and difficult and quite possibly culturally sensitive (although cultural sensitivity was not found between Germany and the UK in the Prevention Study in this thesis, the difference between the values in this thesis and Leung and McGrath (2010) for implants is large), but one which would be very valuable.

10.3.5 The influence of patient charges

One of the concerns about using WTP in oral health, where there are substantial patient charges, compared to other areas of health in the UK that are free at the point of delivery, was that valuations would be influenced by knowledge of patient charges whether NHS or private. This would be an anchoring effect, and would vary by an individual's experience of paying for treatment. There is strong evidence for anchoring effects, even when arbitrary reference points are used (Kahneman *et al.*, 1999) and so in the contexts in this thesis, where previous knowledge of prices would give far from arbitrary reference points, a large anchoring effect would be expected. Although there is some evidence of anchoring from the influence of real price experiment in the Molar

Tooth Study, particularly when implants (only available in the private market) and other interventions (available in the NHS system) are compared, the diversity of behaviours, valuations and most of all the consistency of valuations (some of which were already very divergent from the price) after revealing the prices suggest that this is not a major problem. This is a positive finding in terms of using WTP in oral health.

10.4 Dental policy implications

The need for preference-based measures in oral health was outlined in detail in Chapters 1 to 3. However, this need has been further reinforced and in some cases exemplified through both of the studies undertaken. In particular, it has been discussed how the values obtained in both studies could be used in cost benefit analyses to address both technical and allocative efficiency questions. However, it has also been shown that preference-based measures in these two examples can help in addressing questions such as how best to increase the uptake of prevention and how to implement better, more fully informed shared decision making. It is obvious that in many other areas of oral health, preference-based measures could inform decision making through their use in CBAs as well as helping to address other issues, as has been shown in these two examples.

10.4.1 Services for a population with large variance in valuations

The most striking finding in both studies was the high variability in valuation of oral health whether in terms of treatment or prevention, with the variance being unpredictable. This may, in part, have been due to inadequate scenario development but is likely to reflect significant variance, even if smaller than that found here. Where variance is low with small confidence intervals around the mean (or median) valuation, decisions as to whether or not to fund the intervention being valued can be taken with some confidence. However, where valuations are more divergent across a population, it becomes inappropriate to use the mean (or median) as a value upon which to base allocative decisions. The distribution then becomes very important, and the Molar Tooth study found the expected left skewed distribution. This then leaves difficult decisions to be made about how health care systems should be designed to cater for individuals with very divergent valuations (Eddy, 1991). Such a dilemma is noted in the recent review of NHS dentistry (Steele, 2009).

Some might argue that any system should cater for those with the highest valuations, thereby also covering the expectations of those with lower valuations, but in reality, especially in publicly funded systems, this approach is unlikely to be affordable at a system level and those with low valuations may not agree with subsidising those with high valuations through their taxation. If the alternative of implementing a system which only caters to those with low valuations is implemented, those with higher valuations would be forced to look elsewhere for interventions that they would deem to be valuable but were not covered by the system. For example, in a publicly funded system, those with high valuations would have to seek treatment in the private sector. This may be problematic if there is no viable alternative, and those with high valuations might expect what they value to be available in a system that they are contributing taxes to. It would also be problematic if, as found in this thesis, those with high values had a full range of abilities to pay, meaning that some could not afford what they valued, a major equity concern (Donaldson and Gerard, 2005).

In reality, in publicly funded or mixed oral health care systems, demand is likely to be managed through the user co-payment system in some way. The values obtained could be used very crudely to set prices and this would manage some of the demand. The risk with this simple approach is one of equity, in that there will be some individuals who cannot afford interventions that they value highly (Donaldson and Gerard, 2005), in a similar situation described in the previous paragraph. Therefore, a more complex payment system is required. This is already done in some respects in the current NHS dental system, through the use of exemptions from payment for low income groups. However, this is a relatively basic system and may not fully address the inequities. Values and analysis of influencing factors such as those presented in this thesis, could form the basis for the design of more sophisticated co-payment systems which would address inequities whilst managing the large variance in valuation of oral health.

An adjunct to such a system where a limited service is available, would be the option for those who choose to seek more comprehensive treatment outside of the system (in the NHS example, those seeking treatment privately) to have an opt-out of the element of taxation which pays for the system. This opt-out brings its own problems including,

again, a major equity concern (van Doorslaer *et al.*, 1999), however, and it is not within the remit of this discussion to discuss different health care systems in detail.

10.4.2 Allocative decisions for oral health related treatments

Whichever system is used to deliver oral health care, it is necessary to make decisions about what to offer in the system (allocative decisions), and preference-based measures used in CBAs are vital to informing these decisions (Donaldson and Shackley, 1997a). These CBAs should, ideally, be comprehensive, looking at all costs and benefits, both direct and indirect, over a long time horizon. Conducting this level of CBA for the two dental examples used is beyond the scope of this thesis and using the values obtained in this way would be one of the future areas for further research. However, taking the example of treatment options for a molar tooth, it can be seen, in the context of the sample in the Molar Tooth Study, that there is demand for all of the five options considered, but that there is particularly strong demand (where both direction and strength of preference are combined) for implants and RCT. However, if the prices of these two interventions are considered in what could be viewed as a very simple CBA, the benefit (in terms of mean WTP) outweighs the cost of RCT but in the case of implants, the cost far outweighs the benefit. However, it must be remembered that these two treatments may not be comparable considering that the markets for both have been manipulated. It may therefore be inappropriate to use current prices as the cost values and if this was done, sensitivity analysis would have to be used in a broad way. However, there is strong case, based on this simplistic assessment, for RCT to be provided in the NHS system, and for implants to be excluded.

10.4.3 Individuals' versus policy makers' and dentists' valuations

Often, policy makers and professionals will have strong views on what should or should not be funded in a system, irrespective of individuals' valuations. Where individuals' valuations do not conform to these views, difficult decisions need to be made. The Prevention Study is an example of such an area, and so this conflict and possible solutions are discussed in this sub-section.

It is likely that policy makers and dentists would want any healthcare system to include prevention, and indeed in the review of NHS dentistry, prevention is regarded as one of

the most worthy elements of the system for funding (after emergency care and public health) (Steele, 2009). The reasons for this are that: prevention is likely to save costs in the long term by reducing treatment need later; that prevention can be seen as a key element in ensuring health where health is defined in wide terms, such as the WHO definition, detailed in Section 3.1.2. Therefore, it is in the interests of policy makers and professionals to ensure that prevention in whatever form is funded in a system, and also to maximise uptake.

However, for those who have low values of oral health and in particular prevention, there may be only a small uptake of preventive services. The Prevention Study illustrated that a number of individuals had very low values for the intervention offered, and so there may be a proportion of the population who would not agree with funding high levels of prevention in a system they are contributing to and who may not take up prevention based on their low valuations.

This leads to the question of how much a policy maker should be concerned by and act to change this situation. The viewpoint could be taken that if an individual has a low value for oral health that it is their own decision not to access prevention, leaving the individual to act in their own best interest. However, the policy maker could also decide that they should intervene on behalf of the individual and encourage what the policy maker believes is in the individual's best interests (perhaps on the basis that individuals do not know what is in their best interest and may be influenced by marketing strategies aimed at encouraging unhealthy behaviours). This may be done by altering the system by which prevention is offered to make it more attractive to the individual (lowering the barriers to uptake to a level which fits with their low valuation). However, this approach is not always affordable and so an alternative, more fundamental approach would be to attempt to increase the individual's valuations. This is a practice engaged in by those with a commercial interest (Ellis and Jacobs, 1977), such as toothpaste manufacturers who rely on sophisticated advertising and marketing campaigns, which it could be argued are attempting to alter individuals' valuations. Both studies showed that dentists can have a major influence on valuations and this may be one possible way of altering valuations (which is almost certainly already being done at an informal individual level). Whether individuals are the best judge of their own behaviour or not, and

whether policy makers should attempt to influence valuations is a philosophical argument based on political ideologies, but is a debate that policy makers need to engage in.

The UK government are currently engaging in such a debate, with the publication of a white paper on public health (Department of Health, 2010b). In this paper, the government makes it clear that although it recognises the need to intervene in order to improve (public) health, it will always try and minimise the level of intervention. The paper draws on a pre-existing "intervention ladder" (Hepple, 2007) and states that government will try and intervene at the levels of "enabling choice" or "guiding choice" rather than legislating to restrict or remove choice. The "guiding choice" option is split into three levels of increasing amounts of intervention from guiding choice through changing the default to having incentives to having disincentives. The preferred approach is referred to as "nudging" although the white paper does not specify any particular ways of doing this. Influencing health values, however, as discussed above, might be one such approach.

Whichever decision is made, the preference-based data and influencing factors will help in various ways, for example: in predicting levels of uptake of prevention; determining the levels of subsidy that would be required for prevention in order to get whatever level of take up is deemed satisfactory; in determining who valuation alteration attempts should be aimed at and how this would best be done.

10.5 Implications for dentists

Although the majority of implications from the data in both studies apply to policy makers, there are also common themes from both studies that are of relevance to dentists engaged in decision making with their patients. The WTP data show some of the factors in decision making that dentists should be aware of in order to undertake properly informed, shared decision making. Population level WTP data are therefore of use to individual dentists as well as policy makers.

Perhaps the most striking aspect from both studies, although not a surprising finding, is the influence that dentists have on decision making. This is most obvious from the Prevention Study, where dentists are the most likely influence for the increased uptake

of the intervention above what would be expected from the stated WTP data. This phenomenon of supplier-induced demand is not a new concept (Birch, 1988; Naegele *et al.*, 2010), but it has been clearly demonstrated here. The influence of the dentist is also shown in the Molar Tooth Study, with previous dental experience being the main explanatory variable in choice of treatment options. Dentists should therefore be aware of the influence that they and previous experience at their own hands could have on shared decision making (as many, if not all, likely already are). It would be easy to abuse this, even if accidentally, and therefore not have fully informed, truly shared decision making (Mulley, 2009).

It may be that as the number of population level studies of WTP in oral health grow, and understanding of how individuals' valuations influence behaviour increases, that the principles of collecting WTP values for individual patients could be employed by dentists to inform treatment planning in terms of shared decision making with patients. This use of WTP has already been suggested in the field of oncology (Hofstatter, 2010). If this were the case, dentists would have to be careful to separate this entirely from price setting mechanisms and make it explicit to patients that WTP values would not be used to set price, rather as a decision aid.

Chapter 11: Conclusions

The discussions in Chapters 6, 9 and 10 have addressed all seven of the aims of the thesis, and in this chapter the conclusions will be laid out in terms of how they have addressed each of the aims in turn.

11.1 Aim 1

To use WTP in two examples of oral health choices (the preservation or loss of a non-vital molar tooth and the uptake or refusal of a caries prevention product)

WTP has been used successfully in the two dental examples provided, and its use has illuminated a number of issues surrounding these two examples as well as a number of issues surrounding the use of WTP in oral health and more generally. Examples of allocative decisions that could be taken based on the WTP values elicited have been described.

11.2 Aim 2

To investigate factors affecting oral health choices and WTP (for the two dental examples)

Factors affecting choice and WTP for treatment options were investigated using econometric modelling. In the Molar Tooth Study, the factors affecting choice were mainly related to previous treatment experience, an important finding for dentists involved in shared decision making. In both studies, it was found that there was a great deal of variance in WTP, and even though some of this may have been due to inadequate scenario development it is likely the variance was still considerable and was difficult to predict based on the factors used for modelling. However, being female (Molar Tooth Study), taking daily medications (Prevention Study) and having a high income (both studies) increased WTP. In both studies, the factors which did not affect choice or WTP were perhaps the more significant findings, with a number of demographic factors excluded from the models. These findings will be important to inform policy decisions as well as being of importance to dentists making decisions at individual levels. One important finding is that it is emerging that values are formed using a variety of processes and it is unclear what these processes are. This is an important area for future research.

11.3 Aim 3

To investigate part versus whole bias in the dental setting

Due to sample size issues, there was insufficient power to address this aim of the study fully. However, preliminary findings suggest that part versus whole (or embedding) bias may not be a large issue in the dental setting. This is a positive finding for WTP use.

11.4 Aim 4

To investigate the influence of actual price on WTP valuations

The experiment concerning influence of actual price on WTP valuations yielded very interesting data, with a full range of behaviours exhibited with participants both changing preferred treatment options and keeping the same option and participants increasing, decreasing and keeping the same valuations. One of the concerns regarding using WTP in the dental setting was that valuations would be based on knowledge of real prices, but these data suggest this is not a major concern.

11.5 Aim 5

To investigate the influence of payment vehicle on WTP and actual payment for preventive products

In pursuit of this aim, a number of methodological problems were encountered. These included sample size issues and supervision of research in primary care settings and these have already been described. These findings will inform future WTP studies. The data available suggest that payment vehicle does have an important influence on WTP valuations, with vehicles that include an adjustment to monthly insurance payments creating unexpected behaviour, with the possibility that moral hazard and confusion may be the causes. This will require further investigation.

11.6 Aim 6

To investigate the difference in stated versus revealed preference (hypothetical bias) in oral health

In the Prevention Study, it appears that in many cases stated preference under-estimates revealed preference, a finding that is in contrast to theoretical concerns that stated preference over-estimates revealed preference. This possible finding is reinforced by

data from the influence of real price experiments in the Molar Tooth Study. However, this area also will require further investigation.

11.7 Aim 7

To investigate differences in the value of prevention between two countries (the UK and Germany)

The WTP values for the two different countries (using only the Questionnaire A sub-sample from the UK to ensure comparability) are not statistically different, although the value is slightly lower in Germany, although the sample was small.

There was a difference, however, when hypothetical versus real behaviour is compared. Although in the UK (questionnaire A) all participants paid for treatment at or above their stated WTP, with none refusing treatment, in Germany a number of the sample refused treatment at a price below their WTP. It is difficult to determine a reason for this from the data presented in this study.

Chapter 12: Future research agenda

Although areas for future research have been highlighted throughout Chapters 10 and 11 and also in Chapters 6 and 9, these ideas will all be brought together in this final chapter to form an agenda for future research in this area.

12.1 Use of values in cost-benefit analysis

Firstly, in terms of using the values produced, the next step is to incorporate the values elicited in cost benefit analyses, particularly in the case of the Molar Tooth Study, where there is already a debate over the allocative efficiency question (Felton, 2005; Trope, 2005; Zitzmann *et al.*, 2009) and the values elicited in the study are robust. This would be a relatively simple project and one of direct relevance to commissioners. To increase the relevance, it may be possible to use the values in programme budgeting/marginal analysis process, which has been suggested as one of the ideal ways of taking commissioning decisions in dentistry (Holmes *et al.*, 2009).

12.2 Valuing other interventions and oral health states

Naturally, one of the next steps from the thesis is to look at other areas of oral healthcare and elicit WTP values for these, using the lessons learned in this thesis to ensure robust methodology and thorough scenario development. Although different interventions could be valued, as has been done in this thesis, it may be useful to take a broader view of health and begin to try to define and then value some dental health states as outlined in Section 3.5.3, which would aid in broader policy decisions. For example, if values could be elicited to avoid being edentulous (having no teeth), to avoid losing one tooth from a full dentition and various points between, it may be possible to highlight at which points in the lifetime of a dentition particularly expensive interventions might be genuinely beneficial.

12.3 Value formation

Perhaps one of the most important questions arising from this thesis is how values are formed. There has been little work in this field (Baker *et al.*, 2008), and none in the context of oral health. The results presented in the thesis suggest that a variety of processes are used, but it is not clear which are used by which individuals and in what circumstances. This is obviously important in terms of understanding preferences for

oral health, but is also important for WTP more generally, as this would illuminate the validity of WTP as a measure of health preference. The methodology most suited to addressing this question would be a qualitative approach alongside a WTP experiment. This work is vital and probably the most pressing item on the future research agenda arising from this thesis.

12.4 Individuals' versus policy makers' and dentists' valuations

As discussed in Section 10.4.3, one of the most difficult decisions for policy makers and dentists is where population values do not reflect the priorities and aims that they feel the system should have. One potentially important piece of research would be to take some appropriate interventions and ask individuals, policy makers and dentists for WTP values (bearing in mind that policy makers and dentists would also have personal valuations given their likely status as dental patients also). The differences between the groups could then be quantified, showing how much of an issue this really is for a series of different interventions. This would probably be most successfully done if programmes rather than personal interventions were to be valued as this is the level at which these decisions are made.

12.5 Other areas of research

Other areas of interest to dental policy makers and dentists that remain inconclusive from these studies, and therefore would benefit from further investigation, are the role of supplier-induced demand in dentistry and the role of different payment vehicles in the uptake of preventive care. Areas of interest to WTP methodology and again not definitively addressed in these studies include part versus whole valuation, although a large body evidence is already available, outside of oral health and revealed versus stated preference, an area where the context of oral health is a good basis for experiments. Finally, some of the influences on choices and WTP such as taking medications, previous experience of dental treatment and high income may merit further investigation.

Appendix A. Molar Tooth Study questionnaire and interview script

Study Code: ☐☐☐

Measuring Preferences for Dental States
Measurement of willingness to pay to save a tooth

Instructions

Thank you for agreeing to take part in this research. As already explained this will involve a short questionnaire for you to fill out and then an interview.

First of all please fill in your details here. These will be kept separate from the rest of the information you give us, so that this remains anonymous and they will only be used in the unlikely event that we would need to contact you in the future.

Please print in block capitals.

First Name …….
Family Name/Surname …….
Date of Birth …/…/……

Address ……..
……..
……..
……..
Postcode …….. ……

The next three pages form the questionnaire. Please complete this by circling the numbers or entering values in the boxes. When you have finished this, please hand it to the interviewer.

Remember, all of the information on this questionnaire will be kept strictly confidential.

However, before you start the questionnaire, please detach this sheet and place in the envelope and reseal the envelope.

	Centre No: P		Study No:	
1	How old are you?			years
2	What gender are you (please circle correct number):		Male	1
			Female	2
3	What is your postcode :			
4	What is your household's income before any deductions for National Insurance, Income Tax etc.? You should include all sources of income including wages, pensions, benefits, interest on savings, and rent paid to you.	WEEKLY OR	YEARLY	
		£0-£99	£0-£5199	1
		£100-£199	£5200-£10399	2
		£200-£299	£10400-£15599	3
		£300-£399	£15600-£20799	4
		£400-£499	£20800-£25999	5
		£500-£599	£26000-£31199	6
		£600-£699	£31200-£36399	7
		£700-£999	£36400-£51999	8
		£1000+	£52000+	9
5	What is the highest level qualification you have attained?		GCSE (D-G), CSE grade 2-5, SCE O Grades D-E/Standard Grades 4-7, Scottish National Qualifications (Access level), SCOTVEC National Certificate Modules NVQ (level 1), GNVQ (Foundn), BTEC (Intro level)	1
			GCSE (A-C)/GCE O-level passes, CSE grade 1 SCE O Grades A-C / Standard Grades 1-3, Scottish National Qualifications (Intermediate), School Certificate / Matriculation NVQ (level 2), GNVQ (Intm), BTEC (1st level)	2
			GCE 'A'-level, AS Level, SCE Higher Grades A-C, Scottish National Qualifications (Higher) NVQ (level 3), GNVQ (Adv), BTEC (National level)	3
			First degree, eg BSc, BA, MA at first degree level NVQ (level 4), BTEC (Prof level), HND/HNC	4
			Higher degree, eg MSc, MA, MBA, PGCE, PhD NVQ (level 5), BTEC (Adv prof level)	5
			None of these/Not sure	6
6	The following questions refer to your current main job, or (if you are not working now) to your last main job.			
6A	Do (did) you work as an employee or are (were) you self-employed?		Employee	1
			Self-employed with employees	2
			Self-employed / freelance	3

		without employees (go to 6D)	
6B	*For employees:* indicate below how many people work (worked) for your employer at the place where you work (worked). *For self-employed:* indicate below how many people you employ (employed) and go to 6D when you have completed this question.	1-24	1
		25+	2
6C	Do (did) you supervise any other employees?	YES	1
		NO	2
6D	Please choose one option to show which best describes the sort of work you do. (If you are not working now, please choose a number to show what you did in your last job).	**Modern and traditional professional occupations** *such as:* teacher, nurse, physiotherapist, social worker, welfare officer, artist, musician, police officer (sergeant or above), software designer, accountant, solicitor, medical practitioner, scientist, civil / mechanical engineer	1
		Clerical and intermediate occupations *such as:* secretary, personal assistant, clerical worker, office clerk, call centre agent, nursing auxiliary, nursery nurse	2
		Senior managers or administrators (usually responsible for planning, organising and co-ordinating work and for finance) *such as:* finance manager, chief executive	3
		Technical and craft occupations *such as:* motor mechanic, fitter, inspector, plumber, printer, tool maker, electrician, gardener, train driver	4
		Routine and semi-routine manual and service occupations *such as:* HGV driver, van driver, cleaner, porter, packer, sewing machinist, messenger, labourer, waiter / waitress, bar staff, postal worker, machine operative, security guard, caretaker, farm worker, catering assistant, receptionist, sales assistant	5

		Middle or junior managers *such as:* office manager, retail manager, bank manager, restaurant manager, warehouse manager, publican			6
7	How often do you usually visit the dentist?	Regular check ups			1
		Occasional check ups			2
		Only when you're having trouble			3
8	What is the ***main*** way you pay for your dental care?	Out of my own pocket (NHS)			1
		Out of my own pocket (Private)			2
		I am exempt and the NHS pays			3
		With private insurance/Denplan			4
9	Your dental experience. Please circle when you last had the following dental treatments:		In the last 2 years	Longer ago than 2 years	Never
9A		Scale and polish	1	2	3
9B		Fillings	1	2	3
9C		Crowns	1	2	3
9D		Bridges	1	2	3
9E		Root Canal Work	1	2	3
9F		Extraction	1	2	3
9G		Dentures	1	2	3
10	Have you experienced dental pain bad enough to make you go to the dentist?	Never			1
		Longer ago than 2 years			2
		2 years to 6 months ago			3
		In the last 6 months			4
		Currently in pain			5
11	How many natural teeth do you have remaining?	Fewer than 10			1
		10-19			2
		20 or more			3
	Please now hand this to the interviewer.				

12	**Show CARD A and read out:** Now I want you to imagine that you have all of your adult teeth but that one back tooth (2nd from the back) is broken down and the nerve is dead. You are not in pain at the moment, but you are slowly getting an abscess on it and there has been a bit of discomfort in recent months. The dentist tells you that it is likely to become uncomfortable at some stage. You cannot see this tooth from the front when you smile but you do use it for chewing. There are two choices. Firstly you can keep the tooth by having a root canal treatment. This involves the dentist making a hole into the tooth to get to the nerve, cleaning the inside of the tooth, filling it and putting a metal crown (cap) on top. The other choice you have is to have the tooth extracted. There are various options following extraction including just leaving a gap, having a removable denture to replace the tooth, having a bridge (artificial tooth) fixed to teeth next to the gap, or an implant screwed into your jaw to support an artificial tooth. It is important to be aware that these options exist, but at the moment we are only interested in whether you would keep the tooth or extract it. We are not interested in exactly what you would do afterwards. Which would you prefer to have?		
	Root canal treatment	1	**GO TO 13**
	Extraction	2	**GO TO 14**
13	**Use set of cards V** **Read out:** Now, I have a set of cards with different amounts of money printed on them. I want you to consider each card individually and decide whether you would be willing to pay that amount for your preferred option, saving the tooth. When you are thinking about this, we do not want you to think about how much you guess it would cost or what you have paid in the past for similar treatment, but just what value you put on the treatment yourself. It is also important for you to consider this in terms of what you can afford, for some of the larger amounts this might require taking out a loan or something similar but as this is something that you could theoretically choose to do it should come into your consideration. Also, we should be absolutely clear, this is a theoretical exercise. We are doing this to see how you value treatment, so there is no question of it altering what you or anyone else might pay for dental treatment at the moment or in the future. Bearing this in mind, you should look at each card, and place it in one of these piles. If you would definitely not be willing to pay that much, you should place it here. If you would definitely be willing to pay that much,		

	place it here, and if you are not sure, place it here. **WHEN PARTICIPANT HAS PLACED ALL CARDS, IF ANY IN UNSURE PILE ASK:** Now that you have had chance to think a little more, do you want to reconsider any of the cards you were unsure about. **THEN CHECK LOWEST IN "WOULD NOT PAY" AND HIGHEST IN "WOULD PAY" PILES AND ENTER IN BOXES**		
13A	Highest **would** pay		**Continue at 13E**
13B	Lowest would **not** pay		
13C	If no cards for 13A **SHOW CARD D** and enter code		**Continue at 14**
13D	If 13C=H write summary of reason here:		
13E	**Read out:** Because there are only twenty cards, there are gaps between the amounts you had to decide about. You have chosen **(SAY AMOUNT 13A)** as the highest amount you would be willing to pay. Would you actually be prepared to pay any more or just **(SAY AMOUNT 13A)**? **Record amount here, recording amount 13A if this is still the maximum**		**Go to 20**

14	Open envelope for allocation to part or whole group		
	Whole	1	Go to 15
	Part	2	Go to 17

15	**Show card B** **READ OUT:** When you chose to have your tooth extracted, you may remember that I said there were several options about what to do afterwards. These were leaving a gap, having a removable denture to replace the tooth, having a bridge (artificial tooth) fixed to teeth next to the gap, or an implant screwed into your jaw to support an artificial tooth. Which would you prefer to have?		
	Leave gap	1	**Go to 16**
	Removable Denture	2	
	Fixed Bridge	3	
	Implant	4	

16	**Use set of Cards V** **Read out:** Now, I have a set of cards with different amounts of money printed on them. I want you to consider each card individually and decide whether you would be willing to pay that amount for your preferred option i.e. extraction and **(SAY ANSWER 15 HERE)**. When you are thinking about this, we do not want you to think about how much you guess it would cost or what you have paid in the past for

	similar treatment, but just what value you put on the treatment. It is also important for you to consider this in terms of what you can afford, for some of the larger amounts this might require taking out a loan or something similar but as this is something that you could theoretically choose to do it should come into your consideration. Also, we should be absolutely clear, this is a theoretical exercise. We are doing this to see how you value treatment, so there is no question of it altering what you or anyone else might pay for dental treatment at the moment or in the future. Bearing this in mind, you should look at each card, and place it in one of these piles. If you would definitely not be willing to pay that much, you should place it here. If you would definitely be willing to pay that much, place it here, and if you are not sure, place it here. **WHEN PARTICIPANT HAS PLACED ALL CARDS, IF ANY IN UNSURE PILE ASK:** Now that you have had chance to think a little more, do you want to reconsider any of the cards you were unsure about. **THEN CHECK LOWEST IN "WOULD NOT PAY" AND HIGHEST IN "WOULD PAY" PILES AND ENTER IN BOXES**	
16A	Highest **would** pay		**Continue at 16E**
16B	Lowest would **not** pay		
16C	If no cards for 16A **SHOW CARD D** and enter code		**Continue at 20**
16D	If 16C=H write summary of reason here:		
16E	**Read out:** Because there are only twenty cards, there are gaps between the amounts you had to decide about. You have chosen **(SAY AMOUNT 16A)** as the highest amount you would be willing to pay. Would you actually be prepared to pay any more or just **(SAY AMOUNT 16A)**? **Record amount here, recording amount 16A if this is still the maximum**		**Go to 20**
17	**Use set of Cards V** **Read out:** Now, I have a set of cards with different amounts of money printed on them. I want you to consider each card individually and decide whether you would be willing to pay that amount for your preferred option of extraction. We are only interested in what you would pay for the extraction at the moment NOT what you might want to do afterwards. When you are thinking about this, we do not want you to think about how much you guess it would cost or what you have paid in the past for similar treatment, but just what value you put on the treatment. It is also important for you to consider this in terms of what you can		

	afford, for some of the larger amounts this might require taking out a loan or something similar but as this is something that you could theoretically choose to do it should come into your consideration. Also, we should be absolutely clear, this is a theoretical exercise. We are doing this to see how you value treatment, so there is no question of it altering what you or anyone else might pay for dental treatment at the moment or in the future. Bearing this in mind, you should look at each card, and place it in one of these piles. If you would definitely not be willing to pay that much, you should place it here. If you would definitely be willing to pay that much, place it here, and if you are not sure, place it here. **WHEN PARTICIPANT HAS PLACED ALL CARDS, IF ANY IN UNSURE PILE ASK:** Now that you have had chance to think a little more, do you want to reconsider any of the cards you were unsure about. **THEN CHECK LOWEST IN "WOULD NOT PAY" AND HIGHEST IN "WOULD PAY" PILES AND ENTER IN BOXES**		
17A	Highest **would** pay		**Continue at 17E**
17B	Lowest would **not** pay		
17C	If no cards for 17A **SHOW CARD D** and enter code		**Continue at 18**
17D	If 17C=H write summary of reason here:		
17E	**Read out:** Because there are only twenty cards, there are gaps between the amounts you had to decide about. You have chosen **(SAY AMOUNT 17A)** as the highest amount you would be willing to pay. Would you actually be prepared to pay any more or just **(SAY AMOUNT 17A)**? **Record amount here, recording amount 17A if this is still the maximum**		**Continue at 18**
18	**Show card B** **READ OUT:** When you chose to have your tooth extracted, you may remember that I said there were several options about what to do afterwards. These were leaving a gap, having a removable denture to replace the tooth, having a bridge (artificial tooth) fixed to teeth next to the gap, or an implant screwed into your jaw to support an artificial tooth. Which would you prefer to have? Leave gap	1	**Go to 20**

	Removable Denture	2	**Go to 19**
	Fixed Bridge	3	
	Implant	4	

19	**Use set of cards V** **Read out:** As before we want to work out how much you would be willing to pay for this preferred option, using the cards in the same way as before. Again, don't think about how much you guess it would cost or what you have paid in the past for similar treatment, and consider it in terms of your actual income and savings. A reminder that we are doing this to see how you value treatment, so there is no question of it altering what you pay for dental treatment at the moment or in the future. **WHEN PARTICIPANT HAS PLACED ALL CARDS, IF ANY IN UNSURE PILE ASK:** Now that you have had chance to think a little more, do you want to reconsider any of the cards you were unsure about. **THEN CHECK LOWEST IN "WOULD NOT PAY" AND HIGHEST IN "WOULD PAY" PILES AND ENTER IN BOXES**		
19A	Highest **would** pay		**Continue at 19E**
19B	Lowest would **not** pay		
19C	If no cards for 19A **SHOW CARD D** and enter code		**Continue at 20**
19D	If 19C=H write summary of reason here:		
19E	**Read out:** Because there are only twenty cards, there are gaps between the amounts you had to decide about. You have chosen **(SAY AMOUNT 19A)** as the highest amount you would be willing to pay. Would you actually be prepared to pay any more or just **(SAY AMOUNT 19A)**? **Record amount here, recording amount 19A if this is still the maximum**		**Continue at 20**
20	**Show Card C** **READ OUT:** Imagine now that there is a minimum price for each of the options as follows: Root canal treatment + Crown **£200** Extraction + Leave Gap **£50** Extraction + Removable Denture **£200** Extraction + Fixed Bridge **£250** Extraction + Implant **£1500**		

	Which option do you now prefer?		
	Root canal treatment + Crown	**1**	**Go to 21 Use Cards W**
	Extraction + Leave Gap	**2**	**Go to 21 Use Cards X**
	Extraction + Removable Denture	**3**	**Go to 21 Use Cards W**
	Extraction + Fixed Bridge	**4**	**Go to 21 Use Cards Y**
	Extraction + Implant	**5**	**Go to 21 Use Cards Z**

21	**Read out:** We now want you to consider what you would be willing to pay for your latest preferred option rather than your less preferred options bearing in mind you can't pay less than the amount on the card. We will do this with the shuffled cards again, but in these cards the lowest value is the minimum above. Again, don't think about how much you guess it would cost or what you have paid in the past for similar treatment, and consider it in terms of your actual income and savings. A reminder that we are doing this to see how you value treatment, so there is no question of it altering what you pay for dental treatment at the moment. **WHEN PARTICIPANT HAS PLACED ALL CARDS, IF ANY IN UNSURE PILE ASK:** Now that you have had chance to think a little more, do you want to reconsider any of the cards you were unsure about. **THEN CHECK LOWEST IN "WOULD NOT PAY" AND HIGHEST IN "WOULD PAY" PILES AND ENTER IN BOXES**		
21A	Highest **would** pay		**Continue at 21E**
21B	Lowest would **not** pay		
21C	If no cards for 21A **SHOW CARD D** and enter code		**Continue at 22**
21D	If 21C=H write summary of reason here:		
21E	**Read out:** Because there are only twenty cards, there are gaps between the amounts you had to decide about. You have chosen **(SAY AMOUNT 21A)** as the highest amount you would be willing to pay. Would you		

	actually be prepared to pay any more or just **(SAY AMOUNT 21A)**? **Record amount here, recording amount 21A if this is still the maximum**		
			Continue at 22
22	**That is the end of the questions, thank you very much for your time.**		

Appendix B: Molar Tooth Study questionnaire cards and bidding cards

CARD A

Imagine that you have all of your adult teeth but that one bottom back tooth (2nd from the back) is broken down. You cannot see this tooth from the front when you smile but you do use it for chewing.

You are not in pain at the moment, but you are slowly getting an abscess on it and there has been a bit of discomfort in recent months. The dentist tells you that it is likely to become uncomfortable at some stage.

How the tooth looks in the mouth

The position of the tooth in the mouth (where there is a gap in this case)

There are two choices:

1. You can keep the tooth by having a root canal treatment. This involves the dentist making a hole into the tooth to get to the nerve, cleaning the inside of the tooth, filling it and putting a metal crown (cap) on top.	
2. You could have the tooth extracted. This would leave a gap. There are various options following extraction including leaving a gap, having a removable denture to replace the tooth, having a bridge (artificial tooth) fixed to teeth next to the gap, or an implant screwed into your jaw to support an artificial tooth.	

It is important to be aware that these options exist, but at the moment we are only interested in whether you would keep the tooth with a root canal treatment or extract it. We are not interested in what you would do afterwards.

Which would you prefer to have?

CARD B

There are several options after you have had a tooth extracted.
These are:

Leaving a gap	
Having a removable denture to replace the tooth	
Having a bridge (artificial tooth) fixed to teeth next to the gap	
Implant screwed into your jaw to support an artificial tooth	Implant screwed into the jaw  Then with an artificial tooth fixed on top 

Which would you prefer to have?

CARD C

The minimum cost of each of the treatments is as follows:

Root canal treatment + Crown	**£200**
Extraction + Leave Gap	**£50**
Extraction + Removable Denture	**£200**
Extraction + Fixed Bridge	**£250**
Extraction + Implant	**£1500**

CARD D

What is the reason that you are not willing to pay anything for this treatment?
Please tell the researcher which letter is closest to your reason:

A: This treatment is of no value to me

B: Other treatments are more valuable to me

C: Other groups in society should pay

D: Users should not have to pay

E: The health service should be more efficient

F: I can not afford it

G: I prefer other ways of paying

H: Other (please tell the researcher why)

DEFINITELY WOULD PAY
UNSURE
DEFINITELY WOULD NOT PAY

v £1	v £5	v £10	v £20	v £30
v £50	v £75	v £100	v £150	v £200
v £250	v £500	v £750	v £1000	v £1500
v £2000	v £3000	v £5000	v £10000	v £20000

£200	£225	£250	£300	£350
£400	£500	£600	£750	£1000
£1250	£1500	£1750	£2000	£2500
£3000	£4000	£5000	£10000	£20000

x £50	x £60	x £70	x £80	x £90
x £100	x £125	x £150	x £175	x £200
x £250	x £500	x £750	x £1000	x £1500
x £2000	x £3000	x £5000	x £10000	x £20000

£250	£275	£300	£325	£350
£400	£500	£600	£750	£1000
£1250	£1500	£1750	£2000	£2500
£3000	£4000	£5000	£10000	£20000

£1500	£1750	£2000	£2250	£2500
£2750	£3000	£3500	£4000	£4500
£5000	£6000	£7000	£8000	£9000
£10000	£15000	£20000	£25000	£30000

Appendix C: Molar Tooth Study glossary of terms

Glossary of terms

For use when participants require further clarification.

Q6

Out of my own pocket (NHS)
If you receive your work on the NHS, you will normally have to pay one of three amounts depending on the type of work done. These are £15.90, £43.60 and £194.00.

Out of my own pocket (Private)
If you receive your work privately, you may pay for it per item so you will pay so much for a filling, a different amount for a check up etc.

I am exempt and the NHS pays
If you fall into certain categories, you will receive NHS dental treatment free of charge. Usually this applies if you are:

- aged 18 and in full-time education
- pregnant or have had a baby in the previous 12 months
- getting, or your partner is getting, Income Support, income-based Jobseeker's Allowance or Pension Credit guarantee credit
- have the right to, or your name is on, a valid NHS tax credit exemption certificate
- have the right to full help under the NHS Low Income Scheme (i.e. you are named on a valid HC2 certificate).

With private insurance/Denplan
Some private dentists use a scheme where you pay a monthly contribution which covers certain types of dental treatment, so that you don't have to pay for these individually. You may still have to pay a set price for more expensive or complicated treatments.

Q7

Scale and polish
This is where the dentist or dental hygienist cleans your teeth by scraping the tartar off them, and cleaning them with a small brush and some paste.

Fillings
This is where holes in your teeth, usually caused by decay or pieces of your tooth or old fillings breaking off, are filled up with either a silver coloured metal (amalgam), or a tooth coloured material. This usually involves drilling the decay or old fillings away.

Crowns
This is where teeth that have a lot of decay or large pieces broken off have metal (usually gold coloured) or porcelain (tooth coloured) caps put over the top, to make them tooth shaped again, and to protect the remaining real tooth underneath. This usually involves drilling the tooth to make it the correct shape, taking moulds of your teeth and then cementing the cap into place at a separate appointment.

Bridges
This is where a missing tooth is replaced by an artificial tooth which is either stuck to a cap that fits over one or more of the adjacent teeth, or stuck to a metal wing which is glued onto the teeth next door. The artificial tooth is usually porcelain (tooth coloured) but can be made of metal. Usually this involves drilling adjacent teeth to make them the correct shape, taking moulds of your teeth and then cementing the bridge into place at a separate appointment. The artificial tooth is then permanently fixed into place.

Root Canal Work
This is where a tooth has died off and sometimes an abscess will have formed. The tooth is drilled to get deep into the middle of the root, where the living part (the nerve) is usually found. The dead nerve is then washed and scraped away and the empty space in the root is filled up. Usually the tooth will then have a large filling or crown (cap) placed over the top to protect the remaining tooth underneath.

Extraction
This is where a tooth is removed. The tooth is numbed up and the dentist loosens the tooth until it can be removed with pressure.

Dentures
These are artificial teeth (usually plastic) attached to a metal or plastic plate which fit around your existing teeth (if any) and gums. They can be taken out, for example for cleaning or at night.

Q11 onwards

Abscess
This is where an the infection from a dead tooth starts to spread out of the end of the tooth root. Usually, as well as painful toothache, the tooth becomes very painful to bite on. Sometimes, the gum next to the tooth will also swell up or start to leak pus.

Root canal treatment
This is where a tooth has died off and sometimes an abscess will have formed. First of all the tooth is number. Then the tooth is drilled to get deep into the middle of the root, where the living part (the nerve) is usually found. The dead nerve is then washed and scraped away and the empty space in the root is filled up. Usually the tooth will then have a large filling or crown (cap) placed over the top to protect the remaining tooth underneath. This will often take two or three appointments including the cap, some of which may last an hour or longer. There may be some discomfort for one or two days afterwards.

Metal crown
This is where teeth that have a lot of decay or large pieces broken off have metal (usually gold coloured) or porcelain (tooth coloured) caps put over the top, to make them tooth shaped again, and to protect the remaining real tooth underneath. For this scenario imagine that you can only have the metal (gold) cap. After numbing the tooth, this usually involves drilling the tooth to make it the correct shape, taking moulds of your teeth and then cementing the cap into place at a separate appointment. The timings are variable but the first appointment will often last an hour, with the second being shorter.

Extraction
This is where a tooth is removed. The tooth is numbed up and the dentist loosens the tooth until it can be removed with pressure. This typically takes around 20 minutes. There may be some discomfort for one or two days afterwards.

Leaving a gap
Where a gap is left, there is usually no problem with eating providing you have sufficient remaining teeth (as in this scenario). Sometimes the adjacent or opposite teeth (those that bite into the gap) will move around a very small amount into new positions.

Removable denture
These are artificial teeth (usually plastic) attached to a metal or plastic plate which fit around your existing teeth (if any) and gums. They can be taken out, for example for cleaning or at night. To replace a single tooth, as in this scenario, the plate would almost always be plastic. The denture might take 3 or 4 short visits to make and fit, and this would involve taking moulds of your teeth and adjusting mock up versions of the denture.

A bridge
This is where a missing tooth is replaced by an artificial tooth which is either stuck to a cap that fits over one or more of the adjacent teeth, or stuck to a metal wing which is glued onto the teeth next door. The artificial tooth is usually porcelain (tooth coloured) but can be made of metal. In this case imagine that you will be getting a tooth coloured replacement. Usually this involves drilling adjacent teeth to make them the correct shape, taking moulds of your teeth and then cementing the bridge into place at a separate appointment. The artificial tooth is then permanently fixed into place. The timings are variable but the first appointment will often last an hour, with the second being shorter.

An implant
This is where a missing tooth is replaced by screwing a metal (titanium) screw into your jaw bone and placing an artificial tooth (tooth coloured) on top of this screw where it comes through the gum. This involves minor surgery whilst you are awake with the gum being numbed, and then peeled back. The screw is then put in and the gum is closed with stitches. You would then wait 3-6 months, using a temporary bridge or denture in the meantime, after which time, you would need further minor surgery to uncover the screw. The artificial tooth is then made which involves making moulds of your teeth, and then fixed in place permanently. Although timings are variable, typically each of the four appointments (initial surgery, second surgery, making the crown, and fitting the crown) will take around an hour.

Appendix D: Analyses excluding outliers

In this appendix, analyses for the Molar Tooth Study excluding the outliers defined in Section 5.4 are presented. Firstly, the descriptive data is presented in Table E.1, the equivalent of Tables 5.14 and 5.15

Initial choice	Prosthetic replacement	Mean	SD	Min	Q1	Med	Q3	Max
Save tooth (RCT + crown)	N/A	237.56	261.14	0	80	165	250	2000
Extract tooth	None (leave gap)	82.20	61.61	0	40	60	100	250
	Removable denture	152.67	117.43	30	50	150	200	500
	Fixed partial denture	282.24	326.02	5	115	200	275	1500
	Implant	352.01	274.24	10	150	250	500	1250

Table E. 1 Descriptive statistics for WTP for preferred treatment option excluding outliers

Next the logistic model of initial choice of extraction (versus saving tooth) is presented in Table E.2, equivalent to Table 5.20. In this model (n=486) the likelihood ratio of chi^2 is 51.36 ($p<0.001$) with a pseudo R^2 of 0.076. The BIC figure is -2355.044.

Predictor	Odds Ratio	SE	Z	P	95% confidence interval
Low Socio Economic Status (Ref mid & high Socio-economic status)	1.94	0.37	3.43	0.001	1.32-2.83
Experience of crown (Ref no experience)	0.46	0.10	-3.69	0.000	0.31-0.70
Experience of RCT (Ref no experience)	0.58	0.13	-2.42	0.015	0.37-0.90
Experience of extraction (Ref no experience)	2.56	0.70	3.45	0.001	1.50-4.36

Table E. 2 Logistic regression model of initial choice between extraction (versus saving tooth) excluding outliers

The next model is the multinomial logistic model of initial choice, presented in Table E.3, equivalent to Table 5.21. In this model (n=486) the likelihood ratio of chi^2 is 52.20 ($p<0.001$) with a pseudo R^2 of 0.043. The BIC figure is -1710.765.

Predictor	Relative Risk Ratio	Standard Error	z	p	Confidence Interval
Base Case: Extract and leave gap					
RCT					
Experience of crown (Ref no experience)	2.26	0.61	2.99	0.003	1.32-3.85
Experience of RCT (Ref no experience)	2.26	0.72	2.57	0.010	1.21-4.21
Experience of extraction (Ref no experience)	0.23	0.10	-3.41	0.001	0.10-0.53
Extract and denture					
Experience of crown (Ref no experience)	0.28	0.23	-1.56	0.118	0.05-1.39
Experience of RCT (Ref no experience)	1.71	1.25	0.73	0.465	0.41-7.15
Experience of extraction (Ref no experience)	0.60	0.52	-0.60	0.551	0.11-3.24
Extract and bridge					
Experience of crown (Ref no experience)	0.87	0.38	-0.31	0.756	0.37-2.05
Experience of RCT (Ref no experience)	1.26	0.63	0.45	0.653	0.47-3.38
Experience of extraction (Ref no experience)	0.95	0.69	-0.07	0.941	0.23-3.92
Extract and implant					
Experience of crown (Ref no experience)	1.21	0.41	0.56	0.574	0.62-2.34
Experience of RCT (Ref no experience)	1.60	0.63	1.21	0.226	0.75-3.45
Experience of extraction (Ref no experience)	0.30	0.15	-2.45	0.014	0.12-0.79

Table E. 3 Multinomial logistic regression for all choices with extract and leave gap as baseline excluding outliers

Now the tobit models of WTP are presented starting with a model for the whole sample (WTP to deal with the problem) presented in Table E.4, equivalent to Table 5.22. In this model (n=467) the likelihood ratio of chi^2 is 25.18 ($p<0.001$) with a pseudo R^2 of 0.039. The BIC figure is 3602.255.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Low income (Ref middle and high income)	-10.89	28.13	-0.39	0.699	-66.17 – 44.40
High income (Ref low and middle income)	94.88	33.08	2.87	0.004	29.88 – 159.89
Low qualification level (Ref high level)	-68.93	26.04	-2.65	0.008	-120.11 – -17.75
Constant	258.84	23.05	11.23	0.000	213.53 – 304.15
/sigma	251.90	8.29			235.61 – 268.19

Table E. 4 Tobit model of WTP top deal with problem (whole sample) excluding outliers

The next tobit model deals with WTP only for the sub-sample choosing RCT as their preferred option and is presented in Table E.5 (equivalent to Table 5.23). In this model (n=252) the likelihood ratio of chi^2 is 9.08 ($p<0.05$) with a pseudo R^2 of 0.003. The BIC figure is 2098.061.

Predictor	Coef.	SE of coef.	t	p	95% confidence intervals
Low income (Ref middle and high income)	0.92	40.57	0.02	0.982	-78.98 – 80.81
High income (Ref low and middle income)	119.96	41.21	2.91	0.004	38.80 – 201.12
Constant	208.25	22.22	9.37	0.000	164.48 – 252.02
/sigma	259.69	11.69			236.67 – 282.71

Table E. 5 Tobit regression of WTP for RCT subsample excluding outliers

Table E.6 presents a tobit model for WTP only for the sub-sample choosing extract and leave a gap as their preferred option (equivalent to Table 5.24). In this model (n=85) the likelihood ratio of chi^2 is 7.34 ($p<0.1$) with a pseudo R^2 of 0.008. The BIC figure is 558.236.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Low income (Ref middle and high income)	-4.06	15.26	-0.27	0.791	-34.41 – 26.29
High income (Ref low and middle income)	12.39	21.09	0.59	0.558	-29.56 – 54.34
Low IMD (Ref high)	33.69	14.23	2.37	0.020	5.37 – 62.01
Constant	70.38	10.20	6.90	0.000	50.09 – 90.67
/sigma	61.31	4.82			51.73 – 70.89

Table E. 6 Tobit regression of WTP for extract and leave gap subsample excluding outliers

Table E.7 presents a tobit model for WTP only for the sub-sample choosing extract and implant as their preferred option (equivalent to Table 5.25). In this model (n=80) the likelihood ratio of chi^2 is 28.52 ($p<0.001$) with a pseudo R^2 of 0.0256. The BIC figure is 780.657.

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Low income (Ref middle and high income)	14.52	73.66	0.20	0.844	-132.33 – 161.36
High income (Ref low and middle income)	188.71	77.40	2.44	0.017	34.41 – 343.01
Low qualification level (Ref high level)	-74.89	58.23	-1.29	0.203	-190.96 – 41.19
Exempt from NHS payment (Ref not exempt)	-183.14	74.45	-2.46	0.016	-331.55 – 34.73
Experience of extraction (Ref no experience)	168.02	68.55	2.45	0.017	31. 37 – 304.67
Currently in pain (Ref not in pain)	163.33	79.14	2.06	0.043	5.57 – 321.09
Older than 65 years (Ref 65 years and younger)	-220.97	98.36	-2.25	0.028	-417.05 – 24.90
Low IMD (Ref high)	-124.27	71.94	-1.73	0.088	-267.68 – 19.14
Constant	329.08	78.06	4.22	0.000	173.46 – 484.69
/sigma	233.23	18.58			196.18 – 270.27

Table E. 7 Tobit regression of WTP for extract and implant subsample

Finally the Heckman model looking at WTP across the whole sample using an error term to control for sample selection by initial preference is presented in Table E.8 (equivalent to Table 5.26). In this model (n=473) the Wald chi^2 is 16.98 ($p<0.001$).

Predictor	Coef.	SE of coef.	t	p	95% confidence interval
Regression model for WTP including selection correction					
Low income (Ref middle and high income)	-33.36	38.09	-0.88	0.381	-108.02 – 41.29
High income (Ref low and middle income)	90.31	52.18	1.73	0.084	-11.96 – 192.58
Low qualification level (Ref high level)	-101.43	38.29	-2.65	0.008	-176.48 – -26.37
Constant	285.49	69.07	4.13	0.000	150.11 – 420.88
Probit selection model for extraction versus saving tooth					
Low Socio Economic Status (Ref mid & high Socio-economic status)	0.39	0.12	3.21	0.001	0.15 – 0.62
Experience of crown (Ref no experience)	-0.47	0.13	-3.64	0.000	-0.72 – -0.22
Experience of RCT (Ref no experience)	-0.37	0.14	-2.62	0.009	-0.65 – -0.094
Experience of extraction (Ref no experience)	0.59	0.17	3.49	0.000	0.26 – 0.92
Constant	-0.47	0.17	-2.84	0.004	-0.81 – -0.15
Mills Lambda	7.29	70.04	0.10	0.917	-130.00 – 144.58
Rho	0.030				
Sigma	242.27				

Table E. 8 Heckman selection model for WTP with selection for extracting versus saving the tooth excluding outliers

Appendix E: Prevention Study questionnaire

Patient questionnaire
We are investigating a new treatment to prevent dental decay and would like to get an impression of the people who would be interested in this and how it would be accepted by people with different dental experiences.

Please complete this short questionnaire and hand it to your dentist or nurse when you go into the surgery. Your answers will be treated confidentially and cannot be traced to you.

Firstly, we need information about your previous experience with dentists:			
1.	**How often do you go to the dentist (circle one number)?**	Only when I have a problem	1
		Once every few years	2
		Once a year	3
		More than once a year	4
2.	**How do you usually pay for your dental treatment (circle one number)?**	Denplan	1
		Other health insurance	2
		Out of my own pocket (Private)	3
		Other	4
3.	**During the last 2 years, have you had (circle one number)?**	no fillings	1
		1-2 fillings or crowns	2
		3 or more fillings/crowns	3
4.	**Has your dentist told you that you are suffering from any of the following problems (circle all appropriate numbers)?**	receeding gums	1
		reduced saliva flow	2
		gum diseases	3
5.	**How many medicines/drugs do you take every day (circle one number)?**	none	1
		less than 3	2
		3 or more	3
6.	**How likely do you think it is that you will need treatment due to dental decay during the next 12 months (circle one number)?**	zero/very low	1
		less than 50%	2
		about 50%	3
		more than 50%	4
Now we would like to know something about your general knowledge about dental health. Please tell us which of the following 3 statements are true or false:			
7.	*Dental decay is an infectious disease* **(circle one number)**	True	1
		False	2
8.	*Dental decay can be a risk factor for heart problems* **(circle one number)**	True	1
		False	2
9.	*A dry mouth is a risk factor for dental decay development* **(circle one number)**	True	1
		False	2
Next, please tell us some information that relates to whether you could use the new product:			
10.	Are you using any products containing chlorhexidine currently (e.g. Corsodyl products/Savlon creams)?	Yes	1
		No	2
		I'm not sure	3
11a.	Have you used any products containing chlorhexidine in the past (e.g. Corsodyl products/Savlon creams)?	Yes	1
		No	2
		I'm not sure	3
11b.	If yes, when did you last use them?	….. months/….. years ago	
12.	**If you have used chlorhexidine have you:** Had any problems with taste	Yes	1
		No	2
		I'm not sure	3
13.	**If you have used chlorhexidine have you:** Had any problems with saliva (dry mouth or excess saliva)	Yes	1
		No	2
		I'm not sure	3
14.	**If you have used chlorhexidine have you:** Had any other problems (please describe) ……		

Please turn the page…

QUESTIONNAIRE A – DENPLAN ESSENTIALS/ NON-DENPLAN

We would like you think about how much you would be willing to pay for this new treatment to give us an idea of how useful you think the treatment would be. When you are thinking about this, we do not want you to think about how much you guess it would cost but just what value you put on the treatment yourself.

The treatment is a preventive treatment of tooth decay at the gum line which is an antibacterial coating painted on your teeth and is clear, temporary, simple and painless. This is done in four weekly appointments of 20 minutes and a further 20 minute appointment after 6 months.

To give you an idea of how effective it is, for those patients at risk of this disease, the treatment will reduce your risk of root decay, and therefore needing a filling by 40%

15. Now we would like you to imagine that you have to pay for the new treatment. We want you to think about how much you would be willing to pay as a one-off fee for this one set of treatments (5 applications, distributed over 6 months). It is important for you to think about the amount of money you can afford fort his treatment.

Consider the single amounts of money in order down the right column and **tick if you would pay** that much or make a **cross if you wouldn't**. After the first cross you don't have to go down the column any further but can continue with the next question, question No. 16

£0	
£5	
£10	
£20	
£30	
£40	
£50	
£60	
£70	
£80	
£100	
£120+	

For more than £120 insert the maximum amount you would pay here:

Now we would like to know some more about you:

16. **How old are you:** ____ Years old

17. **Are you**:

Female	1
Male	2

18. **What is your HOUSEHOLD'S annual income before any deductions for Insurance, Tax etc.? You should include all sources of income including wages, pensions, benefits, interest on savings, and rent paid to you.**

Up to £ 5200	1
Up to £ 10 400	2
Up to £ 15 600	3
Up to £ 20 800	4
Up to £ 26 000	5
Up to £ 31 200	6
Up to £ 36 400	7
Up to £ 52 000	8
More than £ 52 000	9

*****PLEASE NOW PLACE YOUR COMPLETED QUESTIONNAIRE IN THE ENVELOPE PROVIDED AND SEAL IT.*****

Hand it to the dentist or nurse when you enter the surgery.

NOBODY AT THE PRACTICE WILL HAVE ACCESS TO YOUR QUESTIONNAIRE. Only independent researchers will open the envelope and you will be known to them only be an anonymous number.

QUESTIONNAIRE B – DENPLAN CARE

We would like you think about how much you would be willing to pay for this new treatment to give us an idea of how useful you think the treatment would be. When you are thinking about this, we do not want you to think about how much you guess it would cost but just what value you put on the treatment yourself.

The treatment is a preventive treatment of tooth decay at the gum line which is an antibacterial coating painted on your teeth and is clear, temporary, simple and painless. This is done in four weekly appointments of 20 minutes and a further 20 minute appointment after 6 months.

To give you an idea of how effective it is, for those patients at risk of this disease, the treatment will reduce your risk of root decay, and therefore needing a filling by 40%

15. Now we would like you to imagine that your Denplan payments would not cover this new treatment but that if you paid for it on a one-off basis, you would reduce by one Denplan payment band in 3 months time (the payment bands are shown on a separate sheet – ask the receptionist if you have not already been given one of these). We want you to think about how much you would be willing to pay as a one-off fee for this one set of treatments (5 applications, distributed over 6 months). It is important for you to think about the amount of money you can afford for this treatment.

Consider the single amounts of money in order down the right column and **tick if you would pay** that much or make a **cross if you wouldn't**. After the first cross you don't have to go down the column any further but can continue with the next question, question No. 16

For more than £120 insert the maximum amount you would pay here:

£0	
£5	
£10	
£20	
£30	
£40	
£50	
£60	
£70	
£80	
£100	
£120+	

Now we would like to know some more about you:

16. **How old are you:** ____ Years old

17. **Are you**:

Female	1
Male	2

18. **What is your HOUSEHOLD'S annual income before any deductions for Insurance, Tax etc.? You should include all sources of income including wages, pensions, benefits, interest on savings, and rent paid to you.**

Up to £ 5200	1
Up to £ 10 400	2
Up to £ 15 600	3
Up to £ 20 800	4
Up to £ 26 000	5
Up to £ 31 200	6
Up to £ 36 400	7
Up to £ 52 000	8
More than £ 52 000	9

*****PLEASE NOW PLACE YOUR COMPLETED QUESTIONNAIRE IN THE ENVELOPE PROVIDED AND SEAL IT.*****

Hand it to the dentist or nurse when you enter the surgery.

NOBODY AT THE PRACTICE WILL HAVE ACCESS TO YOUR QUESTIONNAIRE. Only independent researchers will open the envelope and you will be known to them only be an anonymous number.

QUESTIONNAIRE C – DENPLAN CARE

We would like you think about how much you would be willing to pay for this new treatment to give us an idea of how useful you think the treatment would be. When you are thinking about this, we do not want you to think about how much you guess it would cost but just what value you put on the treatment yourself.

The treatment is a preventive treatment of tooth decay at the gum line which is an antibacterial coating painted on your teeth and is clear, temporary, simple and painless. This is done in four weekly appointments of 20 minutes and a further 20 minute appointment after 6 months.

To give you an idea of how effective it is, for those patients at risk of this disease, the treatment will reduce your risk of root decay, and therefore needing a filling by 40%

15. Now we would like you to imagine that your Denplan payments could be adjusted to include this new treatment. We want you to think about how much you would be willing to pay for it in terms of an increase in your monthly payment (5 treatments, distributed over 6 months). It is important for you to think about the amount of money you can afford for this treatment.

Consider the single amounts of money in order down the right column and **tick if you would pay** that much extra per month or make a **cross if you wouldn't**. After the first cross you don't have to go down the column any further but can continue with the next question, question No. 16

£0	
£1	
£2	
£3	
£5	
£7	
£10	
£15	
£20	
£25	
£30	
£35+	

For more than £120 insert the maximum amount you would pay here:

Now we would like to know some more about you:

16. **How old are you:** ____ Years old

17. **Are you**:

Female	1
Male	2

18. **What is your HOUSEHOLD'S annual income before any deductions for Insurance, Tax etc.? You should include all sources of income including wages, pensions, benefits, interest on savings, and rent paid to you.**

Up to £ 5200	1
Up to £ 10 400	2
Up to £ 15 600	3
Up to £ 20 800	4
Up to £ 26 000	5
Up to £ 31 200	6
Up to £ 36 400	7
Up to £ 52 000	8
More than £ 52 000	9

*****PLEASE NOW PLACE YOUR COMPLETED QUESTIONNAIRE IN THE ENVELOPE PROVIDED AND SEAL IT.*****

Hand it to the dentist or nurse when you enter the surgery.

NOBODY AT THE PRACTICE WILL HAVE ACCESS TO YOUR QUESTIONNAIRE. Only independent researchers will open the envelope and you will be known to them only be an anonymous number.

References

Aadland D, Caplan AJ (2006). Cheap talk reconsidered: New evidence from CVM. *Journal of Economic Behavior & Organization* 60:562-578.

Aas JA, Griffen AL, Dardis SR, Lee AM, Olsen I, Dewhirst FE, *et al.* (2008). Bacteria of dental caries in primary and permanent teeth in children and young adults. *Journal of Clinical Microbiology* 46:1407-1417.

Abrams RA, Ayers CS, Petterson MV (1986). Quality assessment of dental restorations: a comparison by dentists and patients. *Community Dentistry and Oral Epidemiology* 14:317-319.

Adulyanon S, Sheiham A (1997). Oral impacts on daily performances. In: Measuring oral health and quality of life. G Slade editor. Chapel Hill: University of North Carolina, pp. 151-160.

American Dental Association (2006). Professionally applied topical fluoride: evidence-based clinical recommendations. *Journal of the American Dental Association* 137:1151-1159.

Anderson R, Thomas DW (2003). 'Toothache stories': a qualitative investigation of why and how people seek emergency dental care. *Community Dental Health* 20:106-111.

Antczak-Bouckoms AA, Weinstein MC (1987). Cost-effectiveness analysis of periodontal disease control. *Journal of Dental Research* 66:1630-1635.

Arrow K, Solow R, Leamer E, Portney P, Radner R, Schuman H (1993). Report of the NOAA Panel on Contingent Valuation. *Federal Register* 58:4601-4614.

Arrow P (2000). Cost minimisation analysis of two occlusal caries preventive programmes. *Community Dental Health* 17:85-91.

Atchison KA, Dolan TA (1990). Development of the Geriatric Oral Health Assessment Index. *Journal of Dental Education* 54:680-687.

Baelum V (2008). Caries management: technical solutions to biological problems or evidence-based care? *Journal of Oral Rehabilitation* 35:135-151.

Baker R, Robinson A, Smith R (2008). How do respondents explain WTP responses? A review of the qualitative evidence. *Journal of Socio-Economics* 37:1427-1442.

Baker SR (2007). Testing a Conceptual Model of Oral Health: a Structural Equation Modeling Approach. *Journal of Dental Research* 86:708-712.

Banting DW, Papas A, Clark DC, Proskin HM, Schultz M, Perry R (2000). The effectiveness of 10% chlorhexidine varnish treatment on dental caries incidence in adults with dry mouth. *Gerodontology* 17:67-76.

Barros PP, Martinez-Giralt X (2006). Models of negotiation and bargaining in health care. In: The Elgar Companion to Health Economics. AM Jones editor. Cheltenham: Edward Elgar, pp. 233-241.

Bateman I, Munro A, Rhodes B, Starmer C, Sugden R (1997). Does part-whole bias exist? An experimental investigation. *Economic Journal* 107:322-332.

Beazoglou T, Brown LJ, Heffley D (1993). Dental-Care Utilization over Time. *Social Science & Medicine* 37:1461-1472.

Bergenholtz G (1990). Pathogenic mechanisms in pulpal disease. *Journal of Endodontics* 16:98-101.

Bergson A (1975). A Note on Consumer's Surplus. *Journal of Economic Literature* 13:38-44.

Bhatti T, Rana Z, Grootendorst P (2007). Dental insurance, income and the use of dental care in Canada. *Journal of the Canadian Dental Association* 73:57.

Bhuridej P, Kuthy RA, Flach SD, Heller KE, Dawson DV, Kanellis MJ, *et al.* (2007). Four-Year Cost-Utility Analyses of Sealed and Nonsealed First Permanent Molars in Iowa Medicaid-Enrolled Children. *Journal of Public Health Dentistry* 67:191-198.

Binnie VI (2008). Addressing the topic of smoking cessation in a dental setting. *Periodontology 2000* 48:170-178.

Birch S (1986). Measuring dental health: improvements on the DMF index. *Community Dental Health* 3:303-311.

Birch S (1988). The identification of supplier-inducement in a fixed price system of health care provision : The case of dentistry in the United Kingdom. *Journal of Health Economics* 7:129-150.

Birch S, Gafni A, Markham B, Marriott M, Lewis D, Main P (1998). Health years equivalents as a measurement of preferences for dental interventions. *Community Dental Health* 15:233-242.

Birch S, Gafni A, O'Brien B (1999). Willingness to Pay and the Valuation of Programmes for the Prevention and Control of Influenza. *Pharmacoeconomics* 16:55-61.

Birch S, Ismail AI (2002). Patient preferences and the measurement of utilities in the evaluation of dental technologies. *Journal of Dental Research* 81:446-450.

Birch S, Sohn W, Ismail AI, Lepkowski JM, Belli RF (2004). Willingness to pay for dentin regeneration in a sample of dentate adults. *Community Dentistry and Oral Epidemiology* 32:210-216.

Bloomfield K (1992). Fundamental review of dental remuneration London: Department of Health.

British Dental Association (2006). Information Sheet 40: Average £/UDA amounts for GDS/PDS in England. London: British Dental Association.

Brooks R (1996). EuroQol: The current state of play. *Health Policy* 37:53-72.

Bryan S, Jowett S (2010). Hypothetical versus real preferences: results from an opportunistic field experiment. *Health Economics* 19:1502-1509.

Buckingham K (1993). A note on HYE (healthy years equivalent). *Journal of Health Economics* 12:301-309.

Burnham KP, Anderson DR (2004). Multimodel Inference. *Sociological Methods & Research* 33:261-304.

Carr AJ, Gibson B, Robinson PG (2001). Measuring quality of life: Is quality of life determined by expectations or experience? *British Medical Journal* 322:1240-1243.

Carson RT, Flores NE, Martin KM, Wright JL (1996). Contingent valuation and revealed preference methodologies: Comparing the estimates for quasi-public goods. *Land Economics* 72:80-99.

Carson RT, Flores NE, Meade NF (2001). Contingent valuation: Controversies and evidence. *Environmental & Resource Economics* 19:173-210.

Champ PA, Bishop RC (2006). Is Willingness to Pay for a Public Good Sensitive to the Elicitation Format? *Land Economics* 82:162-173.

Charles C, Gafni A, Whelan T (1997). Shared decision-making in the medical encounter: What does it mean? (or it takes at least two to tango). *Social Science & Medicine* 44:681-692.

Chestnutt IG, Davies L, Thomas DR (2009). Practitioners' perspectives and experiences of the new National Health Service dental contract. *British Dental Journal* 206:7.

Christie M (2007). An examination of the disparity between hypothetical and actual willingness to pay using the contingent valuation method: The case of red kite conservation in the United Kingdom. *Canadian Journal of Agricultural Economics* 55:159-169.

CHX Technologies (2004). Product Monograph: Prevora Stage 1. Toronto: CHX Technologies.

Clarkson J (2005). Experience of Clinical Trials in General Dental Practice. *Advances in Dental Research* 18:39-41.

Crawford F (2005). Clinical trials in dental primary care: what research methods have been used to produce reliable evidence? *British Dental Journal* 199:155-160.

Creugers NH, Mentink AG, Kayser AF (1993). An analysis of durability data on post and core restorations. *Journal of Dentistry* 21:281-284.

Culyer A, Wagstaff A (1993). QALYs (quality-adjusted life-years) versus HYEs (healthy years equivalents). *Journal of Health Economics* 12:311-323.

Cummings RG, Harrison GW, Rutstrom EE (1995). Homegrown values and hypothetical surveys - Is the dichotomous choice approach incentive-compatible *American Economic Review* 85:260-266.

Cummings RG, Taylor LO (1998). Does realism matter in contingent valuation surveys? *Land Economics* 74:203-215.

Cummings RO, Taylor LO (1999). Unbiased Value Estimates for Environmental Goods: A Cheap Talk Design for the Contingent Valuation Method. *American Economic Review* 89:649-665.

Cunningham SJ, Hunt NP (2000). Relationship between utility values and willingness to pay in patients undergoing orthognathic treatment. *Community Dental Health* 17:92-96.

Cunningham SJ, Sculpher M, Sassi F, Manca A (2003). A cost-utility analysis of patients undergoing orthognathic treatment for the management of dentofacial disharmony. *British Journal of Oral & Maxillofacial Surgery* 41:32-35.

Davies BJB, Macfarlane F (2010). Clinical decision making by dentists working in the NHS General Dental Services since April 2006. *British Dental Journal* 209:E17.

Department for Work and Pensions (2008). Family Resources Survey. Colchester, Essex: National Centre for Social Research and Office for National Statistics. .

Department of Health (1998). Personal dental services: guidance on establishing and running pilots London: The Stationery Office.

Department of Health (2000a). Modernising NHS dentistry : implementing the NHS plan. London: The Stationery Office.

Department of Health (2000b). The NHS Plan : a plan for investment: a plan for reform, Report No.: 0101481829. London: The Stationery Office.

Department of Health (2002). NHS Dentistry: Options for Change. London: The Stationery Office.

Department of Health (2005a). Meeting the Challenges of Oral Health for Older People: A Strategic Review. London: The Stationery Office.

Department of Health (2005b). Choosing Better Oral Health: An Oral Health Plan for England, Report No.: 4790. London: The Stationery Office.

Department of Health, British Association for the Study of Community Dentistry (2009). Delivering Better Oral Health: An evidence based toolkit for prevention. London: The Stationery Office.

Department of Health (2010a). Equity and excellence: Liberating the NHS, Report No.: Cm 7881. London: The Stationary Office.

Department of Health (2010b). Healthy Lives, Healthy People: Our strategy for public health in England. London: The Stationery Office.

Diamond PA, Hausman JA (1994). Contingent Valuation - Is Some Number Better Than No Number. *Journal of Economic Perspectives* 8:45-64.

Dixon S, Shackley P (1999). Estimating the benefits of community water fluoridation using the willingness-to-pay technique: results of a pilot study. *Community Dentistry & Oral Epidemiology* 27:124-129.

Donaldson C, Shackley P (1997a). Economic Evaluation. In: Oxford Textbook of Public Health. R Detels, WW Holland, J McEwen and GS Omenn editors. Oxford: Oxford University Press.

Donaldson C, Shackley P (1997b). Does "process utility" exist? A case study of willingness to pay for laparoscopic cholecystectomy. *Social Science & Medicine* 44:699-707.

Donaldson C, Jones AM, Mapp TJ, Olson JA (1998). Limited dependent variables in willingness to pay studies: applications in health care. *Applied Economics* 30:667-677.

Donaldson C (1999). Valuing the benefits of publicly-provided health care: does 'ability to pay' preclude the use of 'willingness to pay'? *Social Science and Medicine* 49:551-563.

Donaldson C (2001). Eliciting patients' values by use of 'willingness to pay': letting the theory drive the method. *Health Expectations* 4:180-188.

Donaldson C, Gerard K (2005). Economics of health care financing : the visible hand. 2nd ed. New York: Palgrave Macmillan.

Donaldson C, Mason H, Shackley P (2006). Contingent valuation in health care. In: The Elgar companion to Health Economics. A Jones editor. Cheltenham: Elgar.

Drummond MF, O'Brien BJ, Stoddart GL, Torrance GW (1997). Methods for the economic evaluation of health care programmes. 2nd ed. Oxford: Oxford University Press.

Dummer PMH (1998). The quality of root canal treatment provided by general dental practitioners working within the general dental services of England and Wales. Part 2. *Dental Profile (Journal of the Dental Practice Board of England and Wales)*:8-10.

Eddy DM (1991). The individual versus society - resolving the conflict *Journal of the American Medical Association* 265:2399-2406.

Ellis D, Jacobs L (1977). Marketing utilities: A new look. *Journal of the Academy of Marketing Science* 5:21-26.

Elwyn G, Edwards A, Kinnersley P (1999). Shared decision-making in primary care: the neglected second half of the consultation. *British Journal of General Practice* 49:477-482.

Emilson CG (1994). Potential efficacy of chlorhexidine against mutans Streptococci and human dental-caries. *Journal of Dental Research* 73:682-691.

Esfandiari S, Lund JP, Penrod JR, Savard A, Mark Thomason J, Feine JS (2009). Implant overdentures for edentulous elders: study of patient preference. *Gerodontology* 26:3-10.

Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR (2008). Accuracy of Cone Beam Computed Tomography and Panoramic and Periapical Radiography for Detection of Apical Periodontitis. *Journal of Endodontics* 34:273-279.

EuroVaQ Project Partners (2010). EuroVAQ Project Introduction. http://research.ncl.ac.uk/eurovaq/index.html Date Accessed:12th December 2010.

Feeny D, Torrance GW, Furlong WJ (1996). Health Utilities Index. In: Quality of Life and Pharmacoeconomics in Clinical Trials. Spilker B editor. Philadelphia: Lippincott-Raven.

Fejerskov O (1997). Concepts of dental caries and their consequences for understanding the disease. *Community Dentistry and Oral Epidemiology* 25:5-12.

Felton DA (2005). Implant or root canal therapy: a prosthodontist's view. *Journal of esthetic and restorative dentistry* 17:197-199.

Fyffe H, Kay E (1992). Assessment of dental health state utilities. *Community Dentistry and Oral Epidemiology* 20:269-273.

Fyffe HE, Deery C, Nugent Z, Nuttall NM, Pitts NB (1999). The reliability of two methods of utility assessment in dentistry. *Community Dental Health* 16:72-79.

Gafni A, Birch S, Mehrez A (1993). Economics, Health and Health Economics - Hyes Versus Qalys. *Journal of Health Economics* 12:325-339.

Gafni A, Birch S (1997). QALYs and HYEs spotting the differences. *Journal of Health Economics* 16:601-608.

Gelman A (2007). Struggles with survey weighting and regression modeling. *Statistical Science* 22:153-164.

General Dental Council (2005). Standards for Dental Professionals. London: General Dental Council.

Gold MR (1996). Cost-effectiveness in health and medicine: Oxford University Press New York.

Goldberg I, Roosen J (2007). Scope insensitivity in health risk reduction studies: A comparison of choice experiments and the contingent valuation method for valuing safer food. *Journal of Risk and Uncertainty* 34:123-144.

Gordon SM, Dionne RA (2004). The integration of clinical research into dental therapeutics: The role of the astute clinician. *Journal of the American Dental Association* 135:1537-1542.

Graham R, Mihaylov S, Jepson N, Allen PF, Bond S (2006). Determining 'need' for a Removable Partial Denture: a qualitative study of factors that influence dentist provision and patient use. *British Dental Journal* 200:155-158.

Grieve A, McAndrew R (1993). A radiographic study of post-retained crowns in patients attending a dental hospital. *British Dental Journal* 174:197-201.

Grignon M, Hurley J, Wang L, Allin S (2010). Inequity in a market-based health system: Evidence from Canada's dental sector. *Health Policy* 98:81-90.

Grossman M (1972). The demand for health : a theoretical and empirical investigation New York: National Bureau of Economic Research ; New York ; London : Distributed by Columbia University Press.

Grytten J (1990). How age influences expenditure for dental services in Norway. *Community Dentistry and Oral Epidemiology* 18:225-229.

Grytten J (2005). Models for financing dental services. A review. *Community Dental Health* 22:75-85.

Gujarati D (2003). Basic econometrics. 4th ed., International ed. ed. Boston: McGraw-Hill.

Guyatt GH, Feeny DH, Patrick DL (1993). Measuring Health-related Quality of Life. *Annals of Internal Medicine* 118:622-629.

Halstead JM, Lindsay BE, Brown CM (1991). Use of the Tobit-Model in Contingent Valuation - Experimental-Evidence from the Pemigewasset Wilderness Area. *Journal of Environmental Management* 33:79-89.

Harty FJ, Pitt Ford TR (2004). Harty's endodontics in clinical practice. 5th ed. Edinburgh: Wright.

Heberlein TA, Wilson MA, Bishop RC, Schaeffer NC (2005). Rethinking the scope test as a criterion for validity in contingent valuation. *Journal of Environmental Economics and Management* 50:1-22.

Hepple BA (2007). Public health : ethical issues London: Nuffield Council on Bioethics.

Her Majesty's Revenue and Customs (2008). Foreign Exchange Rates and Spot Rates. http://www.hmrc.gov.uk/exrate/index.htm Date Accessed:19th September 2010.

Hichens LPY, Sandy JR, Rowland HN, McNair AG, Clark S, Hills D, *et al.* (2005). Practical aspects to undertaking research in the primary care setting: experience from two studies. *Journal of Orthodontics* 32:262-268.

Hofstatter EW (2010). Understanding Patient Perspectives on Communication About the Cost of Cancer Care: A Review of the Literature. *Journal of Oncology Practice* 6:188-192.

Holmes RD, Bate A, Steele JG, Donaldson C (2009). Commissioning NHS dentistry in England: issues for decision-makers managing the new contract with finite resources. *Health Policy* 91:79-88.

Hopper L, Aspinall A, Mackie IC, Blinkhorn FA (2008). The views of dentists on their participation in a primary care-based research trial. *British Dental Journal* 205:4.

House of Commons Health Committee (2008). House of Commons Health Committee Report on Dental Services, Report No.: HC 289-I/II. London: The Stationary Office.

Inglehart MR, Bagramian RA (2002). Oral Health Related Quality of Life Chicago: Quintessence Books.

Ismail AI, Hasson H, Sohn W (2001). Dental caries in the second millennium. *Journal of Dental Education* 65:953-959.

Ismail AI, Sohn W, Tellez M, Amaya A, Sen A, Hasson H, *et al.* (2007). The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. *Community Dentistry and Oral Epidemiology* 35:170-178.

Jones-Lee MW, Hammerton M, Philips PR (1985). The Value of Safety - Results of a National Sample Survey. *Economic Journal* 95:49-72.

Jones-Lee MW (1989). The Economics of Safety and Physical Risk Oxford: Blackwell.

Kahneman D, Knetsch JL (1992). Valuing public goods: The purchase of moral satisfaction. *Journal of Environmental Economics and Management* 22:57-70.

Kahneman D, Ritov I, Schkade D (1999). Economic preferences or attitude expressions? An analysis of dollar responses to public issues. *Journal of Risk and Uncertainty* 19:203-235.

Kallestal C, Oscarson N, Holm AK (1997). Costs for prevention of dental caries in a group of Swedish teenagers. *Swedish Dental Journal* 21:193-197.

Kayser AF (1989). Shortened dental arch: a therapeutic concept in reduced dentitions and certain high-risk groups. *International Journal of Periodontics and Restorative Dentistry* 9:426-449.

Kelly M, Steele J, Nuttall N, Bradnock G, Morris J, Nunn J, *et al.* (2000). Adult Dental Health Survey: Oral Health in the United Kingdom 1998. London: The Stationery Office.

Kennedy CA (2002). Revealed preference valuation compared to contingent valuation: radon-induced lung cancer prevention. *Health Economics* 11:585-598.

Kidd EAM (2005). Essentials of dental caries. 3rd ed. Oxford: Oxford University Press.

King RS (1998). The dash for dentures: the turbulent introduction of NHS dentistry. *British Dental Journal* 185:14-18.

Kleinman ER, Harper PR, Gallagher JE (2009). Trends in NHS primary dental care for older people in England: implications for the future. *Gerodontology* 26:193-201.

Kvist T, Reit C (2002). The perceived benefit of endodontic retreatment. *International Endodontic Journal* 35:359-365.

Labelle RJ, Hurley JE (1992). Implications of basing health-care resource allocations on cost-utility analysis in the presence of externalities. *Journal of Health Economics* 11:259-277.

Laine C, Davidoff F (1996). Patient-Centered Medicine. *JAMA: The Journal of the American Medical Association* 275:152-156.

Landry CE, List JA (2007). Using ex ante approaches to obtain credible signals for value in contingent markets: Evidence from the field. *American Journal of Agricultural Economics* 89:420-429.

Leao A, Sheiham A (1995). Relation between clinical dental status and subjective impacts on daily living. *Journal of Dental Research* 74:1408-1413.

Leles CR, Martins RR, Silva ET, Nunes MF (2009). Discriminant analysis of patients' reasons for choosing or refusing treatments for partial edentulism. *Journal of Oral Rehabilitation* 36:909-915.

Leung KCM, McGrath CPJ (2010). Willingness to pay for implant therapy: a study of patient preference. *Clinical Oral Implants Research* 21:789-793.

Lindsey G (1994). Market-Models, Protest Bids, and Outliers in Contingent Valuation. *Journal of Water Resources Planning and Management* 120:121-129.

Locker D (1988). Measuring oral health: a conceptual framework. *Community Dent Health* 5:3-18.

Locker D, Slade G (1993). Oral health and the quality of life among older adults: the oral health impact profile. *Journal of the Canadian Dental Association* 59:830-844.

Lumley PJ, Lucarotti PSK, Burke FJT (2008). Ten-year outcome of root fillings in the General Dental Services in England and Wales. *International Endodontic Journal* 41:577-585.

Lundegren N, Axtelius B, Hakansson J, Akerman S (2004). Dental treatment need among 20 to 25-year-old Swedes: discrepancy between subjective and objective need. *Acta Odontologica Scandinavica* 62:91-96.

Marinho VC, Higgins JP, Logan S, Sheiham A (2002). Fluoride varnishes for preventing dental caries in children and adolescents. *Cochrane Database of Systematic Review* 3:CD002279.

Matthews D, Rocchi A, Gafni A (2002). Putting your money where your mouth is - Willingness to pay for dental gel. *Pharmacoeconomics* 20:245-255.

Matthews DC, Birch S, Gafni A, DiCenso A (1999a). Willingness to pay for periodontal therapy: development and testing of an instrument. *Journal of Public Health Dentistry* 59:44-51.

Matthews DC, Gafni A, Birch S (1999b). Preference based measurements in dentistry: a review of the literature and recommendations for research. *Community Dental Health* 16:5-11.

McColl E, Smith M, Whitworth J, Seccombe G, Steele J (1999). Barriers to improving endodontic care: the views of NHS practitioners. *British Dental Journal* 186:564-568.

McGlone P, Watt R, Sheiham A (2001). Evidence-based dentistry: an overview of the challenges in changing professional practice. *British Dental Journal* 190:636-639.

McGrath C, Bedi R (2001). An evaluation of a new measure of oral health related quality of life--OHQoL-UK(W). *Community Dental Health* 18:138-143.

McKinlay JB (1979). A case for refocusing upstream: the political economy of illness. In: Patients, physicians and illness. E.G. Jaco editor. New York Free Press.

Mehrez A, Gafni A (1989). Quality-Adjusted Life Years, Utility-Theory, and Healthy-Years Equivalents. *Medical Decision Making* 9:142-149.

Mehrez A, Gafni A (1993). Healthy-Years Equivalents Versus Quality-Adjusted Life Years - in Pursuit of Progress. *Medical Decision Making* 13:287-292.

Milsom KM, Threlfall A, Pine K, Tickle M, Blinkhorn AS, Kearney-Mitchell P (2008). The introduction of the new dental contract in England - a baseline qualitative assessment. *British Dental Journal* 204:59-62.

Mitchell RC, Carson RT (1988). Using Surveys to Value Public Goods: The Contingent Valuation Method Washington: Resources for the Future.

Mjor IA, Gordan VV, Abu-Hanna A, Gilbert GH (2005). Research in general dental practice. *Acta Odontologica Scandinavica* 63:1-9.

Muller F, Schimmel M (2007). Management of preventative care for an ageing population. *International Dental Journal* 57:215-220.

Mulley AG (1990). Supporting the Patients Role in Decision-Making. *Journal of Occupational and Environmental Medicine* 32:1227-1228.

Mulley AG (2009). Inconvenient truths about supplier induced demand and unwarranted variation in medical practice. *British Medical Journal* 339:-.

Murray JJ, Nunn JH, Steele JG (2003). The prevention of oral disease. 4th ed. Oxford: Oxford University Press.

Naegele ER, Cunha-Cruz J, Nadanovsky P (2010). Disparity between Dental Needs and Dental Treatment Provided. *Journal of Dental Research*.

Nassani MZ, Devlin H, McCord JF, Kay EJ (2005). The shortened dental arch - an assessment of patients' dental health state utility values. *International Dental Journal* 55:307-312.

Nassani MZ, Locker D, Elmesallati AA, Devlin H, Mohammadi TM, Hajizamani A, *et al.* (2009). Dental health state utility values associated with tooth loss in two contrasting cultures. *Journal of Oral Rehabilitation* 36:601-609.

National Health Service (Dental Charges) Amendment Regulations (2008). No. 547 England.

National Health Service (General Dental Services Contracts) Regulations (2005). UK.

Nelson W (2002). Practice papers all power to the consumer? Complexity and choice in consumers' lives. *Journal of Consumer Behaviour* 2:185-195.

Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K (2007). Outcome of primary root canal treatment: systematic review of the literature - Part 1. Effects of study characteristics on probability of success. *International Endodontic Journal* 40:921-939.

Ng YL, Mann V, Gulabivala K (2010). Tooth survival following non-surgical root canal treatment: a systematic review of the literature. *International Endodontic Journal* 43:171-189.

Nguyen L, Hakkinen U, Rosenqvist G (2005). Determinants of dental service utilization among adults--the case of Finland. *Health care management science* 8:335-345.

Nord E, Daniels N, Kamlet M (2009). QALYs: Some Challenges. *Value in Health* 12:S10-S15.

Nord E, Enge AU, Gundersen V (2010). Qalys: Is the Value of Treatment Proportional to the Size of the Health Gain? *Health Economics* 19:596-607.

Nunes JC, Boatwright P (2004). Incidental Prices and Their Effect on Willingness to Pay. *Journal of Marketing Research* 41:457-466.

Nunn J, Morris J, Pine C, Pitts NB, Bradnock G, Steele J (2000). The condition of teeth in the UK in 1998 and implications for the future. *British Dental Journal* 189:639-644.

O'Brien B, Gafni A (1996). When do the "dollars" make sense. *Medical Decision Making* 16:288-299.

Office for National Statistics (2001). 2001 Census: Standard Area Statistics (England and Wales). Manchester: ESRC/JISC Census Programme, Census Dissemination Unit, Mimas (University of Manchester).

Office for National Statistics (2007a). Statistics: Methodology and Quality. http://www.statistics.gov.uk/about/data/methodology/default.asp Date Accessed:9th June 2008.

Office for National Statistics (2007b). Regional Snapshot. http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=14161 Date Accessed:19th September 2007.

Office for National Statistics (2009). Harmonisation. http://www.ons.gov.uk/about-statistics/harmonisation/index.html Date Accessed:10th December 2009.

Office of Fair Trading (2003). The private dentistry market in the UK London: Office of Fair Trading.

Olsen J, Donaldson C (1998). Helicopters, hearts and hips: using willingness to pay to set priorities for public sector health care programmes. *Social Science and Medicine* 46:1-12.

Olsen J, Donaldson C, Shackley P (2005). Implicit versus explicit ranking: On inferring ordinal preferences for health care programmes based on differences in willingness-to-pay. *Journal of Health Economics* 24:990-996.

Olsen JA, Smith RD (2001). Theory versus practice: a review of willingness-to-pay in health and health care. *Health Economics* 10:39-52.

Olsen JA, Donaldson C, Pereira J (2004). The insensitivity of `willingness-to-pay' to the size of the good: New evidence for health care. *Journal of Economic Psychology* 25:445-460.

Oscarson N, Lindholm L, Kallestal C (2007). The value of caries preventive care among 19-year olds using the contingent valuation method within a cost-benefit approach. *Community Dentistry and Oral Epidemiology* 35:109-117.

Pedrazzi V, Oliveira-Neto JM, Sequeira P, Fedorowicz Z, Nasser M (2008). Hand and ultrasonic instrumentation for orthograde root canal treatment of permanent teeth. *Cochrane Database of Systematic Reviews* 4:CD006384.

Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR (1996). A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology* 49:1373-1379.

Peker I, Alkurt MT, Usalan G (2008). Clinical evaluation of medications on oral and dental health. *International Dental Journal* 58:218-222.

Pennington M, Vernazza CR, Shackley P, Armstrong NT, Whitworth JM, Steele JG (2009). Evaluation of the cost-effectiveness of root canal treatment using conventional approaches versus replacement with an implant. *International Endodontic Journal* 42 874-883.

Petersen PE, Yamamoto T (2005). Improving the oral health of older people: the approach of the WHO Global Oral Health Programme. *Community Dentistry and Oral Epidemiology* 33:81-92.

Petrie A, Bulman JS, Osborn JF (2002). Further statistics in dentistry - Part 1: Research designs 1. *British Dental Journal* 193:377-380.

Petrou S, Hockley C (2005). An investigation into the empirical validity of the EQ-5D and SF-6D based on hypothetical preferences in a general population. *Health Economics* 14:1169-1189.

Philips Z, Whynes DK, Avis M (2006). Testing the construct validity of willingness to pay valuations using objective information about risk and health benefit. *Health Economics* 15:195-204.

Pitts NB, Boyles J, Nugent ZJ, Thomas N, Pine CM (2007). The dental caries experience of 5-year-old children in Great Britain (2005/6). Surveys co-ordinated by the British Association for the Study of Community Dentistry. *Community Dental Health* 24:59-63.

Reit C, Kvist T (1998). Endodontic retreatment behaviour: the influence of disease concepts and personal values. *International Endodontic Journal* 31:358-363.

Richards D, Lawrence A (1995). Evidence Based Dentistry. *British Dental Journal* 179:270-273.

Rohlin M, Mileman PA (2000). Decision analysis in dentistry - the last 30 years. *Journal of Dentistry* 28:453-468.

Rosenberg W, Donald A (1995). Evidence Based Medicine - An approach to clinical probelm-solving. *British Medical Journal* 310:1122-1126.

Rosvall MD, Fields HW, Ziuchkovski J, Rosenstiel SF, Johnston WM (2009). Attractiveness, acceptability, and value of orthodontic appliances. *American Journal of Orthodontics and Dentofacial Orthopedics* 135.

Rowe RD, Schulze WE, Breffle WS (1996). A test for payment card biases. *Journal of Environmental Economics and Management* 31:178-185.

Ryan M, Scott DA, Donaldson C (2004). Valuing health care using willingness to pay: a comparison of the payment card and dichotomous choice methods. *Journal of Health Economics* 23:237-258.

Sackett DL, Rosenberg WMC, Gray JAM, Haynes RB, Richardson WS (1996). Evidence based medicine: What it is and what it isn't - It's about integrating individual clinical expertise and the best external evidence. *British Medical Journal* 312:71-72.

Salehrabi R, Rotstein I (2004). Endodontic treatment outcomes in a large patient population in the USA: an epidemiological study. *Journal of Endodontics* 30:846-850.

Saunders W, Saunders E, Sadiq J, Cruickshank E (1997). Technical standard of root canal treatment in an adult Scottish sub-population. *British Dental Journal* 182:382-386.

Schanschieff SG (1986). Report of the Committee of Enquiry into Unnecessary Dental Treatment London: The Stationery Office.

Shackley P, Donaldson C (2000). Willingness to pay for publicly-financed health care: how should we use the numbers? *Applied Economics* 32:2015-2021.

Sheiham A (2005). Oral health, general health and quality of life. *Bulletin of the World Health Organization* 83:644.

Simon E, Matee M (2001). Post-extraction complications seen at a referral dental clinic in Dar Es Salaam, Tanzanial. *International Dental Journal* 51:273-276.

Slade GD, Spencer AJ (1994). Development and evaluation of the Oral Health Impact Profile. *Community Dental Health* 11:3-11.

Smith RD (2003). Construction of the contingent valuation market in health care: a critical assessment. *Health Economics* 12:609-628.

Smith RD (2005). Sensitivity to scale in contingent valuation: the importance of the budget constraint. *Journal of Health Economics* 24:515-529.

Smith RD (2006). It's not just what you do, it's the way that you do it: the effect of different payment card formats and survey administration on willingness to pay for health gain. *Health Economics* 15:281-293.

Statistisches Bundesamt Deutschland (2008). Long Term Series: Population. http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/EN/Content/Statistics/TimeSeries/LongTermSeries/Population/Content100/lrbev01ga,templateId=renderPrint.psml Date Accessed:19th September 2010.

Steele JG, Treasure E, Pitts NB, Morris J, Bradnock G (2000). Total tooth loss in the United Kingdom in 1998 and implications for the future. *British Dental Journal* 189:598-603.

Steele JG (2009). NHS dental services in England: An independent review. London: Department of Health.

Taube PM (1989). An analysis of the influence of self-assessed health on expenditure in a complete demand system. *Journal of Economic Psychology* 10:101-116.

The NHS Information Centre (2007). Dental Earnings and Expenses, Great Britain, 2005-6. http://www.ic.nhs.uk/webfiles/publications/dentalearn/Dental%20Earnings%20and%20Expenses%20GB%202005-06%20DWG17rev6.pdf Date Accessed:29th November 2007.

The NHS Information Centre (2010). Adult Dental Health Survey 2009 – First Release. London: The NHS Information Centre.

Thierer T, Friedman B (2006). Preferences for oral health states in a US community-dwelling functionally impaired older adult population: 2000-2001. *Journal of Public Health Dentistry* 66:248-254.

Tianviwat S, Chongsuvivatwong V, Birch S (2008a). Prevention versus cure: Measuring parental preferences for sealants and fillings as treatments for childhood caries in Southern Thailand. *Health Policy* 86:64-71.

Tianviwat S, Chongsuvivatwong V, Birch S (2008b). Different dental care setting: Does income matter? *Health Economics* 17:109-118.

Tickle M, Milsom K, Qualtrough A, Blinkhorn F, Aggarwal VR (2008). The failure rate of NHS funded molar endodontic treatment delivered in general dental practice. *British Dental Journal* 204:6.

Tomlinson P, Treasure E (2006). Provision of prevention to adults in NHS dental practices and attitudes to prevention. *British Dental Journal* 200:393-397.

Torabinejad M, Anderson P, Bader J, Brown LJ, Chen LH, Goodacre CJ, *et al.* (2007). Outcomes of root canal treatment and restoration, implant-supported single crowns, fixed partial dentures, and extraction without replacement: A systematic review. *The Journal of Prosthetic Dentistry* 98:285-311.

Torrance GW, Boyle MH, Horwood SP (1982). Application of Multi-Attribute Utility-Theory to Measure Social Preferences for Health States. *Operations Research* 30:1043-1069.

Torrance GW (1986). Measurement of Health State Utilities for Economic Appraisal - a Review. *Journal of Health Economics* 5:1-30.

Trope M (2005). Implant or root canal therapy: an endodontist's view. *Journal of esthetic and restorative dentistry* 17:139-140.

van Doorslaer E, Wagstaff A, van der Burg H, Christiansen T, Citoni G, Di Biase R, *et al.* (1999). The redistributive effect of health care finance in twelve OECD countries. *Journal of Health Economics* 18:291-313.

vanRijkom HM, Truin GJ, vantHof MA (1996). A meta analysis of clinical studies on the caries inhibiting effect of chlorhexidine treatment. *Journal of Dental Research* 75:790-795.

Veall MR, Zimmermann KF (1996). Pseudo-R^2 Measures for some common limited dependent variable models. *Journal of Economic Surveys* 10:241-259.

Vernazza C, Heasman P, Gaunt F, Pennington M (in press). How to measure the cost-effectiveness of periodontal treatments. *Periodontology 2000* in press.

Von Neumann J, Morgenstern O (2007). Theory of games and economic behavior. 60th anniversary ed. Princeton, N.J. : Princeton University Press.

Vossler CA, McKee M (2006). Induced-value tests of contingent valuation elicitation mechanisms. *Environmental & Resource Economics* 35:137-168.

Walls AWG, Wilmot A (2002). How well can people count their own teeth? *Journal of Dental Research* 81:A434-A434.

Watzek G (2006). Oral implants - Quo vadis? *International Journal of Oral & Maxillofacial Implants* 21:831-832.

Whynes DK, Wolstenholme JL, Frew E, Whynes DK, Wolstenholme JL, Frew E (2004). Evidence of range bias in contingent valuation payment scales. *Health Economics* 13:183-190.

Williams A (1985). Economics of Coronary-Artery Bypass-Grafting. *British Medical Journal* 291:1507-1508.

Wilson IB, Cleary PD (1995). Linking Clinical-Variables with Health-Related Quality-of-Life - a Conceptual-Model of Patient Outcomes. *Jama-Journal of the American Medical Association* 273:59-65.

Wiser RH (2007). Using contingent valuation to explore willingness to pay for renewable energy: A comparison of collective and voluntary payment vehicles. *Ecological Economics* 62:419-432.

World Health Organization (1946). Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19 June - 22 July 1946; signed on 22 July 1946 by the representatives of 61 States *Official Records of the World Health Organization*:100.

World Health Organization (1980). International classification of impairments, disabilities and handicaps : a manual of classification relating to the consequences of the disease World Health Organisation: Geneva.

Wu MK, Shemesh H, Wesselink PR (2009). Limitations of previously published systematic reviews evaluating the outcome of endodontic treatment. *International Endodontic Journal* 42:656-666.

Xu ZM, Loomis J, Zhang ZQ, Hamamura K (2006). Evaluating the performance of different willingness to pay question formats for valuing environmental restoration in rural China. *Environment and Development Economics* 11:585-601.

Yoo SH, Kwak SJ, Kim TY (2000). Dealing with zero response data from contingent valuation surveys: application of least absolute deviations estimator. *Applied Economics Letters* 7:181-184.

Yule B (1993). Dental care in the NHS: reforms with teeth? *Health Policy* 25:63-80.

Zitzmann NU, Krastl G, Hecker H, Walter C, Weiger R (2009). Endodontics or implants? A review of decisive criteria and guidelines for single tooth restorations and full arch reconstructions. *International Endodontic Journal* 42:757-774.