Université de Montréal

Technology adoption among Canadian dentists

Par

Shahrokh Esfandiari

Département d'Administration de la santé

Faculté de Médecine

Mémoire présenté à la Faculté des études supérieures

en vue de l'obtention du grade de Maîtrise

en Évaluation des technologies de la santé

April 2008

Page d'identification du jury

Université de Montréal

Faculté de Médecine

Ce mémoire intitulée :

Technology adoption among Canadian dentists

présenté par :

Shahrokh Esfandiari

A été évalué par un jury composé des personnes suivantes :

Jean-Marc Brodeur
Président-rapporteur

Renaldo Battista
Directeur de recherche

Brigitte Côté
Membre du jury

Mémoire accepte le :.....

Summary

There is little evidence on technology adoption in dentistry. Dentists are the ones who purchase and provide the technology. The objective of this research was to gather information on the determinants of the rate of adoption of dental technologies among dental physicians. For this reason, a nation-wide cross-sectional survey was conducted among all licensed Canadian dentists to measure the adoption of general dental technologies.

Multivariate regression analysis on the data from this survey revealed that the dentist's specialty, whether they own their practice, the time elapsed since their graduation, and the source of information on dental technologies are significantly associated with the adoption of these technologies.

The results of this study inform all stakeholders at micro, meso and macro level on what types of clinicians are more likely to adopt technologies in oral health. This will ease formulating strategies on how to assemble the information about dental technologies and to improve the adoption process.

Key words: Health technology assessment – oral health – technology adoption – Dentists – health economic evaluation

Résumé

Il existe peu de données sur l'adoption des technologies en dentisterie. Les dentistes sont ceux qui achètent et qui utilisent la technologie. L'objectif de cette recherche est de recueillir de l'information sur les déterminants du taux d'adoption de technologies dentaire parmi les dentistes. Une enquête transversale à l'échelle nationale a été menée auprès de tous les dentistes canadiens licenciés, pour mesurer l'adoption des technologies dentaires

L'analyse de régression multivariée sur les données de ce sondage a révélé que selon la spécialisation des dentistes, selon s'ils sont propriétaires de leur pratique ou non; le temps écoulé depuis l'obtention de leur diplôme, et les sources d'information sur les technologies de l'art dentaire sont associés de manière significative à l'adoption de ces technologies.

Les résultats de cette étude informent sur les types de cliniciens qui sont le plus susceptibles d'adopter des technologies de la santé bucco-dentaire. Ceci facilitera la formulation de stratégies sur la façon de rassembler les informations sur les techniques dentaires et d'améliorer le processus d'adoption des nouvelles technologies.

Mots clés: évaluation des technologies de la santé - santé bucco-dentaire - adoption - technologie – dentistes - évaluation économique

TABLE OF CONTENTS

Acknowledgments

First, I would like to thank my supervisor, Dr. Renaldo Battista for taking me on as a trainee and for all the intellectual support he has given me throughout my MSc training and the thesis work. I would also like to express my gratitude to Dr. Jocelyne Feine for her enthusiastic support, and Dr. Reza Majdzadeh for his advice on statistical analysis throughout this thesis work. I would thank my parents for their unconditional love throughout my life.

Finally and most importantly, I am indebted to my wife, Dr. Azin Alborzi, for her strength, patience, tolerance and for carrying the extra weight of parental responsibilities throughout my research work, and to my beloved children Taara and Zacharia for constantly bringing joy and happiness to my life.

Section 1- Introduction

1.1 Adoption of new health technologies

The demand for health care services is rising in the face of resource limitations [1]. Thus, like any other good or service, there will never be a sufficient quantity of resources available to meet demand. This is the economic concept of scarcity, as these goods and services are in short supply and will always have a higher demand than what is available. Consequently, scarcity of financial, human and technological resources is the major cause of today's health problems. As a result, decisions must be made in the health care sector for the allocation of the goods and services that will result in the maximum total benefit for the members in the community. This is the concept of economic efficiency [2].

It is believed that the adoption of sophisticated and costly health technologies is the major driver of the growing cost of health care services [3-6] . As new technologies help patients to reduce morbidity and mortality, they pose a heavy financial pressure on already overwrought health systems. This threatens the financial sustainability of health systems and public health care budgets [7].

Some researchers advocate for the study of human behavior in assessing the adoption and utilization of technologies. The most comprehensive of these is the Triandis' Theory of Interpersonal Behavior [8] which encompasses many of the behavioral factors found in other models such as Theory of Planned Behavior [9] or the Technology Acceptance Model [10] by considering cultural, social, and moral factors that are not accounted for in other models. Most managers of health organizations name "Organizational" factors as the most important in user's acceptance of technology. Examples of these factors are reengineering, organizational structure, management quality, political and cultural processes [11]. Whereas some others think that "Group" factors, such as professional values and culture, and user satisfaction are important [12]. "Individual" factors are also named important in forming user's acceptance. Attitudes, user satisfaction, motivation, user involvement and participation are classified among these factors[13]. And the last of these factors are the Environmental level factors which include broad categories such as economic, government, technological, and cultural factors [14, 15]. However, most of these studies concentrate on the implementation process of technology rather than the adoption process. The important question in assessing the adoption of a specific technology is, "what kind of physicians adopts the technology?"

Health economists blame the rising costs of health care within the last two decades to the implementation of costly new technologies rather than increasing prices of existing technologies [16, 17]. Friedman in his study of "The rate of adoption of new procedures among physicians" discusses that the physician adaptability towards a new technology depends on the following criteria [18];

1) Specialties, even when controlling for other characteristics, differences in the rates of adoption of new procedures among specialty groups remain. Radiologists being the most closely tied to new equipments are leading with the highest rate of adopting of new procedures whereas obstetrics and gynecologists were found to have the lowest rate of adoption of new procedures.

2) Type of practice, on average physicians in solo practices adopt fewer new procedures than their counterparts in group practices do, including the hospitals.

3) Years of practice, he claims that the rate of adoption of new procedures by years of practice although of small magnitude is statistically significant. This results from two factors; a) older physicians are less interested in restructuring their methods of practice and b) the newer graduated physicians are likely to have received more recent training than their older counterparts.

4) Age of physicians; up to the age of approximately 50 years, age has an increasing impact on the number of new procedures adopted by physicians. Beyond that age, it has a decreasing effect.

5) Board certified physicians; tend to adopt more new procedures than physicians

who are not board certified.

On the other hand, Phelps in his review of "Diffusion of Information in Medical Care" in assessing the US medical market, states number of economic and psychological factors that might lead physicians in adopting a new technology [19]. These factors are;

1) Comparative profitability between the old and new treatment.

2) Physicians may gain some reputation value by being "out in front" on new treatments.

3) Physicians like others prefer to do new things when available to them, a trait that is captured in the idea of "Technological Imperative". This term stems from the belief that when a clinical intervention is possible and safe it should be undertaken without regard for its costs and benefits.

4) There is a lack of information about the effectiveness of medical technologies at the time when most of these technologies are already in use.

Hillman [20] in his comparative analysis of the adoption and diffusion of MRI and CT scan in the US, names two major factors in adopting high cost technologies. One is the "Attributes of Technology", which includes the time of introduction of technologies, the order they appear and their integrations into hospitals. The second is the set of "Environmental Factors" such as the

reimbursement policy that is known as a major determinant of the rate of diffusion, regulations at the time of adoption and market factors in which competition among hospitals for patients and how physicians may encourage the adoption play a role. Friedman [21] in his case study of Neonatal Intensive Care confirms his predecessors' findings in that the decision of a hospital to offer the technology is associated with teaching status, patients demand and market concentration of major competitors. Therefore, it is evident that the adoption of new innovative health technologies is a complex process that is contingent upon personal, institutional, economical and environmental variables. Unraveling this complexity requires detailed study of the adoptive behavior of those who decide to adopt and provide the technology in a pertinent setting in which the technology would be used.

1.2 Oral health in Canada versus other developed countries

Dental diseases are the fourth most expensive disease to treat in industrialized nations [22]. In 2000, the European Union spent a total of €54 billion on oral health care [23]. In the United States, spending on oral health care services, including the prevention and treatment of dental caries, reached a shocking $81.5 billion in 2004 [24]. However, this remarkable cost cruelly underestimates the real amount spent on oral disorders each year. On top of $81.5 billion, one must

consider the additional tens of billions of dollars required for direct medical care and indirect costs associated with severe early childhood caries, temporomandibular disorders, trigeminal neuralgia, cleft-lip and palate, oral and pharyngeal cancers, autoimmune diseases and injuries to the head and face. The costs continue to rise if one takes into account the resulting loss of productivity from the nearly 170 million hours of work lost each year due to dental diseases and dental visits [7]. Unfortunately, the dental literature does not provide specific estimates of the economic burden of oral diseases in industrialized countries. It has been shown upon evaluation that preventive programs targeted for the reduction of dental caries alone, have resulted in a substantial savings of the overall dental expenditures worldwide [22].

It is clear that oral health is a considerable economic activity in most developed countries [24]. During the 1990s, in Canada, oral health expenditures increased by 64% overall, from $4.13 billion to $6.77 billion. This rate of increase in oral health spending surpassed the rate of growth of inflation and total health expenditures, which rose by 18.4% and 47.1%, respectively, over the same time period. In terms of the direct economic costs of illnesses in Canada, oral health care expenditures in 1998 ($6.30 billion) exceeded those of mental disorders ($4.68 billion) to rank second to cardiovascular diseases ($6.82 billion) [25]. In the United States, oral health care spending grew to an astounding $81.5 billion in

2004. Consumption of oral health services has reached its highest point in history and will continue to increase as the demand for these services grows. In fact, the direct cost of oral health care in the United States is projected to reach $167.3 billion in 2015 [24]. In Canada, 2007 expenditures on dental services were forecasted to make up %6.2 or CN$9.8 billion of total health care expenditures [26].

In most developed countries oral health is a private market and public funds account for only %10-15 of total expenditures in oral health. This means that for the majority of the population oral health care services are out-of-pocket expenses. This is a major contributing factor to oral health disparities across population groups at all ages in Canada.

1.3 Oral health technology adoption in Canada

In an optimal hypothetical health care system, one would expect that new technologies after their proper assessments of safety with favorable cost-effectiveness ratio be rapidly adopted. The new technology would meet the equity and efficacy requirements and would be available to everyone in need. The truth is the adoption and diffusion of most technologies is not scientifically or socially optimal. As Deber and many others, shown costly health technologies

follow a recognized path of adoption [27]. The early adoption begins from large hospitals with much greater resources and highly trained staff to smaller ones. The inescapable fact about a publicly funded system like the Canadian health care system is the government involvement. Government is extensively implicated in financing and management of health services. In dealing with high cost technologies this involvement is much more apparent. In the Canadian health care system, provincial governments finance hospital care and manage the hospital organizations but they do not produce hospital care.

The truth remains that in Canada like most industrialized countries, oral health care is considered by the majority of the population as private care for which patients have to pay out of their pockets to receive the care. Therefore, the studied mechanisms for adopting new health technologies mentioned in section 1.1 of this chapter may or may not be applicable in oral health.

The aforementioned behavioral models enhance our knowledge on identification of barriers that can interfere with adoption processes, however, each of those models address specific theoretical problems out of particular disciplinary concerns. So the question still remains as to what are the determinants that affect the adoptive behavior of a health care professional?

With the present rapid advancement of knowledge and technology, clinicians are overwhelmed with innovative technologies. However, most clinicians have little knowledge about the effectiveness of these new products, nor do they understand how to assess these innovations. Unlike high medical technologies, such as MRI and CT scanners that require elaborate decision making schemes and funding resources by hospitals and governments, dental technologies are low to medium intensity technologies, in that their adoption does not require extensive discussions and meetings by corporate decision makers [28]. Individual dentists are the ones who decide, purchase and implement these technologies into their practices. Therefore, it is important to realize how dentists acquire new technologies in oral health and, more importantly, whether there are determinants that may contribute to their adoptive behavior of new technologies.

It is also known that physician's behavior is influenced by a number of factors in addition to patient outcomes. In effect, physicians seek to optimize personal gratification, and the benefits realized from being on the cutting edge may play a role in individuals' adoptive behavior by contributing to their personal satisfaction [19, 29].

Other personal characteristics may affect their likelihood of adopting new technologies. The effect of gender, age, training, expertise and the type of

practice as whether the physician practices alone or in association with other physicians, as well as the location of the practice (rural versus central regions) are well documented in the literature [9, 11, 28, 30, 31]. However, our search has revealed no reference in oral health which may have addressed the effect of these factors in oral health technology adoption. Therefore, we believe this research is the first of its kind in exploring the adoption of oral health technologies among dentists.

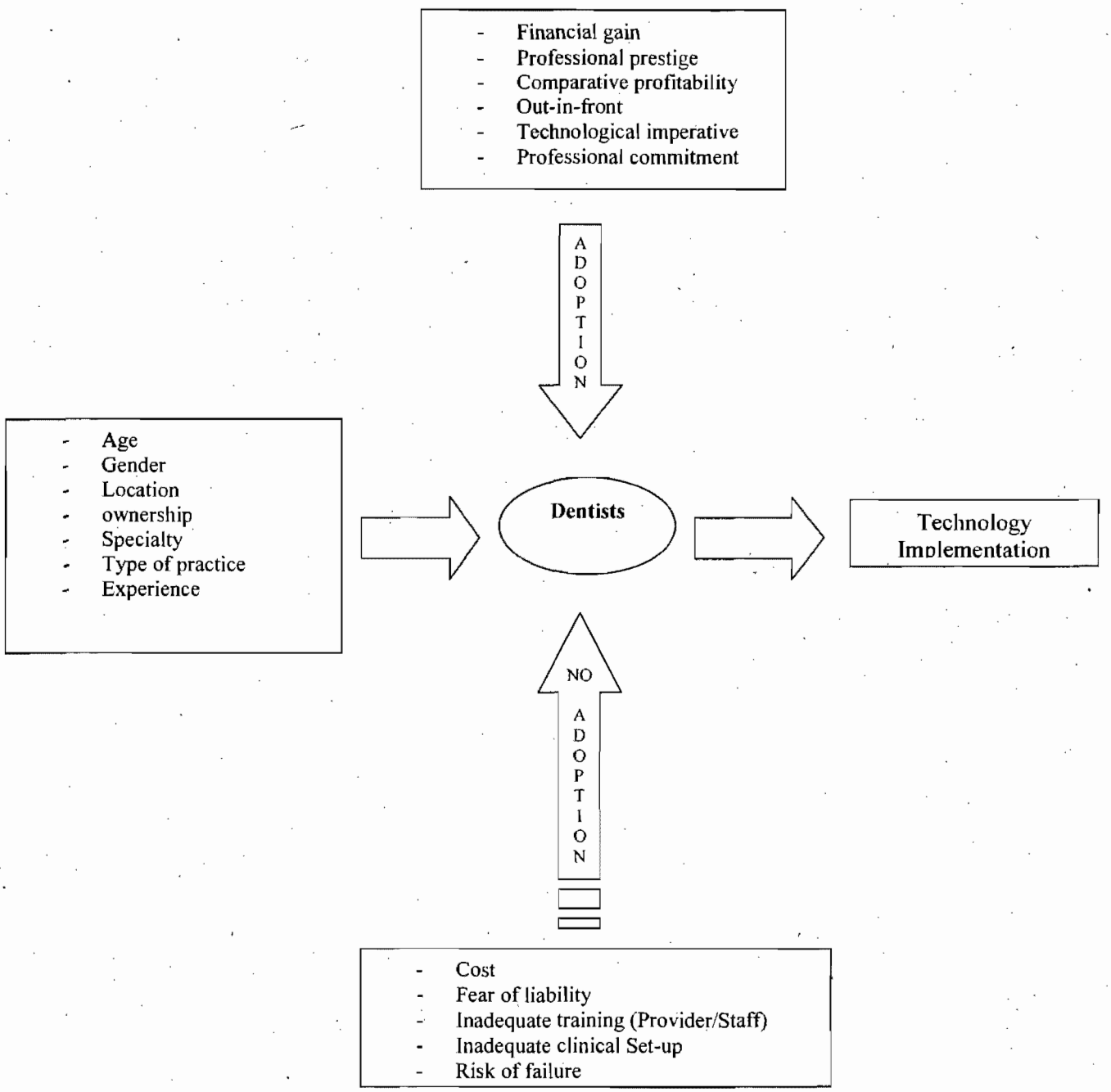
For this reason, we have decided to conduct a national survey to assess the rate of adoption and the factors that may play in the adoption of innovative oral health technologies. This will aid us in establishing the adoptive behavior of dentists in other private health systems where dentists play an important role in making decisions on the diffusion, adoption and implementation of a new technology.

We have also listed a set of barriers that are known to negatively affect physicians' adoptive behavior in choosing particular health technologies. The high cost of the technology, inadequate expertise and training, insufficient information about the safety and effectiveness of the technology, fear of liability, lack of patient demand, lack of proper clinical set-up, and lack of trained staff are among the plausible barriers in adopting health technologies. Some other studies suggest that the referral to other specialists and the fact that the same technology

is offered at other health facilities near by, may hinder the adoption of the technology.

We have carefully assessed the relevance of all the aforementioned factors and considered the elements that may affect the adoption of dental technologies by dentists (Fig. 1). We then designed our questionnaires based on the results of our personal interviews and consultation processes with other dentists.

Fig 1. Oral Health Technology Adoption



1.4 Oral health Technology Assessment (OHTA)

In oral health, like in any other medical field, limited infrastructure and resources hinder the provision of basic health services, let alone the oral health treatments, to low-income populations. Subsequently, oral health is often neglected, as over 90 percent of caries remains untreated in developing communities [32]. Knowing that oral diseases are the fourth most expensive to treat, managing these diseases poses a global health dilemma [33]. Therefore, affordable and feasible preventive strategies are needed to avoid the tremendous cost of dental caries treatment.

Considering the economical, social, industrial, ethical and legal importance of the provision of oral health in our community, it is surprising that there is still no established framework to use HTA to assess oral health technologies like other innovative health technologies. Oral health in Canada like most other industrialized countries is mainly private. Only those who receive social assistance and children in some regions are covered under a public dental health plans. The most recent example of this privatization in Canada was the lobbying of Québec dentists to stop treating children and social welfare recipients covered under the public health plan. In 2008, the general association of dental surgeons in Quebec has asked all his members to opt out of the public health plan due to the increase in operating cost. Therefore, the majority of the population will have

to pay for their dental treatments out of their pocket. In this private market, other than sporadic inspections by local regulatory associations, there is no accountability for the new dental technologies that avail themselves to dentists on a daily basis. One should also consider the impact that industry imposes on dentists

It is suggested that the decision making process would be much simpler in a private health care system than the publicly funded one. This may be the case, where most decisions are taken at the micro level. Dentists often are the ones who choose, adopt and implement the technology in their clinics. In this regard, one should also consider that dentists like their medical counterparts may be influenced by the medical and dental industry. Industry's promotional strategies to facilitate the adoption of new innovative technologies play an important role in their adoption.

In this privately funded health care, HTA will still have to consider the same factors that involve the diffusion of the technology with the exception that the decision-making environment is less chaotic. This is due to the fact that most decisions on the adoption of a dental technology are taken at micro level by dental providers.

There is now a call for the recognition of the importance of technology

assessment in oral health among industrialized countries [34, 35]. Up to now there is no official document that considers the use of HTA for assessing oral health technologies in Canada. For much the same reasons that medical technologies are rigorously assessed, oral health technologies need to also be evaluated. It seems that who pays for the technology makes the difference on how it is assessed.

Most so-called technology assessment studies in dentistry are focused on the clinical superiority of a particular technology or the economical evaluations, the bulk of which is under cost effectiveness studies [36]. The undisputable notion that the cost of a dental technology is crucially important in sustaining its provision tends to overshadow the importance of other aspects of the technology. The social, industrial, ethical and legal assessment of the technology is also important, especially once the use of that technology is considered the standard of care.

The determination of a technology's stage of adoption and diffusion may be the primary purpose of an assessment, which indicates that there is no single correct time to conduct an HTA in both medical and dental health care [37] . It is for this reason that we designed this study to determine the rate of adoption of general dental technologies among Canadian oral clinicians.

Section 2 – An investigation of the adoption of dental technologies amongst Canadian dentists

2.1 Manuscript: Oral health technology adoption among Canadian dentists (submitted)

Shahrokh Esfandiari, Reza Majdzadeh, Jocelyne Feine, Renaldo N. Battista

Abstract

Objective: We designed this study to determine the variables that influence the adoption rate of oral health technologies amongst Canadian dentists.

Design & Setting: In this cross-sectional study, we sent an anonymous survey questionnaire to all licensed Canadian dentists, both general practitioners and specialists, who were member of the Canadian Dental Association (CDA). A three part questionnaire accompanied by a postage prepaid envelope was sent with the April 2006 volume of the Journal of the Canadian Dental Association in late march, 2006. No second mailing was performed.

Participants: As of April 2006, 19,293 dentists were registered in Canada, extraneous to their CDA membership. By October 2007, we received 1781 responses.

Main outcome measures: We planned to measure the effect of age, gender, language, type of specialties, ownership, association with other dentists, and the location of practice on the adoption of any diagnostic or therapeutic technologies during the last 12 months. We successfully measured the effect of these variables on the adoption of new oral health technologies.

Results: Our multivariate regression analysis showed significant association between explanatory variables; age, ownership, and the specialty of Canadian dentists with the newly adopted technologies. The younger dentists, who were in practice for less than eleven years, were significantly more likely to adopt new technologies than their older counterparts (30+ years in practice) [(OR 1.53, 95%CI (1.17 to 2.03)]. The odds of those that owned their practices were 1.37 times higher to adopt the new technologies than those who did not own their practices [95%CI (1.06 to 1.76)]. Periodontists were the only specialists who adopted new technologies at significantly higher rate than general practitioners [OR 4.12, 95% CI (1.57 to 10.79)]. Clinicians who used meeting, discussion with other colleagues, continuing educational courses, and internet were more likely to adopt new technologies than those who did not.

Conclusions: This study provides evidence that the rate of adoption of new oral health technologies among Canadian dentists depends mainly on dentists' years in

practice, practice ownership, information sources on the technology, and their specialties.

Introduction

Why should we study health care technology adoption? Health researchers produce increasing amounts of important new technologies in health care. However, there is a large gap between what it is claimed the new technology can do and what patients actually receive [38-40]. An important reason for this gap is the unclear adoption process of the new evidence.

New health care technologies are produced at an alarming rate. It is believed that the adoption of innovative medical technologies may increase health care expenditures [41-43]. Although these new technologies have been proven in efficacy studies to alter and, in most cases to improve patient outcomes, in many cases the assessment on the effectiveness of these technologies is only available after technologies have been adopted and widely used [44].

There is still a great lack of understanding as to how physicians adopt and implement guidelines in their practices [38]. Although the adoption and use of new innovative technologies is guided by the expectation of improved clinical

outcomes, these decisions are mostly based on less than sufficient data. However, despite the rapid increase in medical information, there is no identified magic bullet for the adoption and implementation process, and few published studies on the topic [18, 45]. At best, we can identify a specific guideline strategy for a specific technology that may not apply to all other related technologies [40].

Therefore, to facilitate the rate of adoption and dissemination of new effective health care technologies, studies are needed to understand the incentives and the barriers in this process [46].

Factors to consider when assessing oral health technology adoption

Dental technologies are good examples of medium and low intensity health technologies whose adoption do not require mobilization of many financial and human resources. As opposed to, high intensity health technologies (i.e. CT scan , MRI,...) which require intense mobilization of resources for their adoption and diffusion into the health system [28]. For medium and low intensity technologies the classical theory of diffusion may explain the phenomenon of health technology adoption by physicians (in this case, dentists). This theory stems from recognizing factors that are associated with the innovation, the characteristics of those who adopt it, the dynamics of the system in which it operates, and the

setting in which practitioners perform [47]. Battista in his early work on innovation and diffusion of health technologies [28], has identified three determinants in health professional adoptive behavior. 1) Cognitive determinants that refers to physicians' knowledge of the new technology, 2) Sociodemographic determinants which may determine the professional's attitude towards adoption of the new technology, and 3) Organizational determinants that consider the effect of the health system in which physicians practice on their adoptive behavior.

Other researchers have stated that using the behavioral approach can help us understand the health technology adoption process [9]. The behavioral approach considers using organized activities or policies that interfere with the process or flow of human behavior. However, as important as this approach is in understanding the health technology implementation process, it cannot completely explain the adoptive attitude of the users of technology who are mainly health care workers and physicians. The available literature on human behavior does not single out any one approach as optimally effective in the adoption and the use of technology [30]. In fact, behavioral science concludes the extremely complex nature of human adoptive processes. After their systematic reviews of health, information, and behavior/organization literature Kukafka et al. [30] concluded that;

"... there is much to be learned about successful implementation of information systems in healthcare organizations. While behavioral theory supports the notion that usage behavior should be viewed from a multi-determinant perspective, none of the studies in our sample included a sufficiently broad set of the empirically investigated influencing factors. This finding may provide additional understanding of why implementation is extremely difficult to achieve, and why it is necessary to continue developing additional insights into the reason for high failure rates associated with underutilized systems."

So far, researchers have identified some key factors associated with implementation and user acceptance of Information Technologies [11]. These factors emerge from academic disciplines, such as psychology, sociology, social psychology, social anthropology, organizational behavior and development, management, and cognitive sciences. An assessment of six health technologies across ten industrialized countries demonstrated a vast disparity in adoption and diffusion of these technologies [48]. This clearly contradicts the neat evidence-based ideology in these countries. Therefore, the need is great to invent tools for policy makers that will enhance the adoption of health technologies.

Wouldn't it be much simpler for policy makers and decision makers in health systems to know what type of providers (physicians) will be more inclined to prescribe a particular type of technology? This kind of information could be

useful to develop educational approaches to shape physicians' adoptive behaviors towards safe, efficacious, socially accepted and cost-effective health technologies.

Education

If any single determining factor could have been named as the factor in health technology adoption by physicians, it would have been the effect of education on the adoption. It has been shown that educating physicians increases the rate of adoption of new technologies by this group [6-9]. Today, many Investigators believe that since physicians' practice beliefs influence their attitude towards technology adoption, educating physicians based on their specialty is far more effective than using generic messages in encouraging compliance with the most recent evidence-based guidelines [8].

Age and gender

In a study of variation in recommendations for cancer screening among primary care physicians in New Mexico by Herman et al. [49], it was shown that the introduction of evidence-based screening only slightly influenced screening rates, with younger physicians and those with university affiliations more likely to follow recommendations. They also noticed that female physicians were more

likely to endorse screenings than their male counterparts [8]. The effect of age and gender in physician's adoptive behavior in using a specific health technology like hormone replacement therapy (HRT) is underscored by the fact that among physicians similar in age and training, male physicians discussed HRT significantly more often than did female physicians [50].

Compensation methods, practice ownership, and expertise

It has been shown that health technologies are favorably adopted if they are simple, flexible, effective, do not impede autonomy, and are not used punitively [11]. It was also shown that physicians' compensation methods alter the way that they use or offer technologies to their patients. Further, it is believed that those physicians who own their practices show different adoptive behavior patterns than those who work on salary [51]. The level of physician's experience is also believed to have an effect on technology adoption [52]. While some researchers found that physician's gender may affect their adoptive behavior, others believe that the level of expertise required, the cost of the new technology, the location where it is delivered, and the time it will require to form an acceptable level of expertise determine the adoption of new technologies [50]. To this effect, Andrews et. al. [53] in their cross-sectional survey among primary care practitioners in the state of Kentucky, USA, found that practitioners in rural areas

have different adoption rate for online health technologies than their counterparts who are affiliated with centers in metropolitan regions.

To assess the adoption of the oral health technologies among Canadian dentists, we designed a survey instrument that largely takes account of the aforementioned factors that may or may not influence the adoptive behavior of dentists. Our questionnaire lists a detailed set of predictors that could affect the adoption rate of oral health technologies among these clinicians. Since our literature review showed no reference to similar surveys in oral health, we believe that this national anonymous survey is the first of its kind to assess the predictors of oral health technology adoption.

Methods and Materials

Feasibility study

We adopted and modified the only North American found questionnaire on the rate of adoption of medical technologies. This questionnaire was used amongst medical physicians by the American Medical Association's Socioeconomic Monitoring System [54]. English and French language versions of the questionnaire were developed using a forward backward technique [55, 56]. The

questionnaire had three parts: 1) general information on sociodemographic variables and practice status, 2) general technology, and 3) implant technology. A feasibility study was performed among a representative sample of 50 dentists in the Greater Montreal Region prior to the nationwide survey. In this study, we determined the 1) general applicability, 2) reliability, 3) acceptability, 4) validity, and 5) the amount of time needed to complete the questionnaire (Table. 1 a and b). This was done by two undergraduate dental students. The questionnaires were sent to clinicians by email or fax, or handed in person to all clinicians. All questionnaires were collected in person and quickly reviewed for completeness. The completed questionnaire was then pre-tested for comprehensibility and content validity with general dentists and dental students.

National survey

Based on the feasibility study, we have designed and modified a cross-sectional anonymous survey questionnaire that was sent to all licensed Canadian dentists, general practitioners as well as specialists, who were registered with the Canadian Dental Association (CDA). This questionnaire also had three parts: 1) general information on sociodemographic variables and practice status, 2) general technology, and 3) implant technology. The certification of ethical acceptability for research involving human subjects was obtained from McGill University

Institutional review Board (Appendix I). This three part questionnaire accompanied with postage prepaid envelope was inserted in a polybag with the April 2006 volume of the Journal of the Canadian Dental Association (JCDA) and mailed to registered Canadian Dentists who may or may not have been a member of CDA. No second mailing was performed. The CDA has a record of preferred language of communication for each dentist, and this was used to determine which language version (French or English) was sent to each address. The English and French language versions of the questionnaire were pre-tested for their linguistic equivalence (Appendices II & III).

All questions in our survey had categorical response options. The dependent variable of interest in this report was "During the past twelve months, did you perform for the first time any new diagnostic or therapeutic procedures that reflected advances in dental knowledge or technology?"

All statistical analyses were performed by a biostatician (RM) using statistical softwares; STATA ver.9 and SPSS ver.13. The descriptive statistics and the univariate analysis of the explanatory variables were performed and further followed by the forward and backward stepwise multivariable logistic regression analysis to explore any significant association between the explanatory variables and the above dependent variable.

Results

As of April 2006, 19,293 dentists (15,646 English and 3,647 French) were registered in Canada. The survey was sent to all registered Canadian dental clinicians in the April 2006 issue of Journal of Canadian Dental Association (CDA). By October 2007, we had received 1,781 responses. Descriptive statistics for our respondents, broken down by practice location, gender, age, language, type of practice, practice status, and ownerships are shown on table 2. The percentages of our respondents from Canadian provinces greatly resemble those provided by CDA throughout the country. These similarities are also observed when comparing the gender and the type of practice of our respondents and those of Canadian dentists.

A univariate statistical analysis for the association of the explanatory (independent) variables and the newly adopted general technology by Canadian dentists within the past twelve months was performed (Table 3). The information from the portion of the study dealing with implant technology is used in a separate study. This data indicates that the numbers of years that the dentists have been practicing, which country they were graduated from, their field of specialization, and whether they owned their practice or not, as well as, the sources of information about the technology were significantly associated with the adoption

of the new technologies. Based on these results we have created a model whereby variables that showed significant association with the adoption of new technologies were included for the multivariable logistic regression analysis (Table 4).

In terms of the number of years in practice, the odds of younger dentists, who have been practicing for less than eleven years, to adopt new dental technologies is 1.53 ($P<0.01$) times higher than those of their colleagues who are in practice for more than 30 years. Whereas the odds of adopting the dental technologies among those who are in practice from 12-21 and 22-29 years decreases to 1.5 and 1.29 ($P<0.01$) respectively, compared to older dentists of 50+ years old.

Among specialists, Periodontists were the only specialists compared to general practitioners who had shown significant willingness to adopt new dental technologies (OR 4.12, $P<0.01$). The rest of the specialists had shown no significant difference between the rates of adoption of the new dental technologies with those of the general practitioners. The odds of those who owned their dental practices to adopt new dental technologies were 1.37 ($p<0.02$) times higher than those who worked on a salary or those who received a percentage of the billings in the practice in which they were associated. Finally among those dentists who had adopted a new oral technology within the past twelve months,

the source of information on the adopted technology played a significant role in their adoption. Professional meetings and conferences, continuing dental education courses, discussion with other dentists, internet, and other (i.e dental company sale representative, study clubs) were the sources with significant effect on the technology adoption ($p<0.05$) whereas, dental journals and technology assessment reports produced by government agencies had no significant effect.

Discussion

An anonymous survey of Canadian dentists was carried out to assess the rate of adoption of new dental technologies. In devising the survey, we have carefully reviewed the medical and dental literature to find similar surveys that may have been used to determine the rate of the adoption among health professionals. The only survey that remotely resembled our field of interest was the one by Friedman in 1988, which used the results of a national survey instrument with US physicians on a long-term basis for the American Medical Association's Socioeconomic Monitoring System [54]. This monitoring system provided a unique opportunity for assessing the medical technology adoption process among medical physicians. Freidman found that the specialties, type of practice, years of practice, the age of the physician up to the 50 years old, and the specialist board

certification were determining factors in the rate of adoption of medical technologies among physicians. Those experienced physicians who were 50 years or older and were not board certified were less likely to adopt new medical technology. In addition, Radiologists showed higher adoptive attitude towards new technologies compared to other specialties. Based on these and other similar findings, we developed, validated and pilot tested our survey instrument prior to its nationwide use.

In most developed countries, dentistry is a private market. Dentists, whether influenced by patients, sales representatives or even TV commercials, choose the technologies that they see fit for their practices. Realizing what inspires dentists to choose or abandon certain technologies over others may require psychosocial analysis that is heavily rooted in behavioral science. The aim of this report is not to dissect the individual factors that may have influenced dentists in adopting dental technologies, but rather to explore a set of common characteristics of dental practitioners that could affect the rate of adoption of technologies in their routine practices.

Allison and Bedos [57] who studied Canadian dentists' views of the utility and accessibility of dental research found a strong pattern of revising care associated with the age of the dentists. They had noticed that the likelihood of altering habits

by which dentists care for their patients increased with age except for their oldest group, aged 61 years and older, in whom they had noticed slight decrease. Based on that finding, the authors inferred that the older clinicians become, the more likely it is that they will change their practice habits. However, we found that the younger dentists who had graduated more recently from dental school (0 to 11 years) have a significantly higher willingness to adopt new dental technologies than those with more work experience (30 years and more). In fact, there was a decreasing gradient in the likelihood of adoption amongst our dentist population up to the age of 50. This finding is similar to Friedman's national physician survey [18]. Allison and Bedos [57] used different age categories (<31, 31-45, 46-60, >60 years) than those in our study, which may explain in part the difference in findings between these studies since the age cut off of 50 years was not observed. It can also be argued that the altering habits and adopting new general technologies are perceived differently by dentists. Factors that affect the adoption of new technologies may differ from those affecting changes in physician's clinical habits.

The significantly higher willingness of periodontists to adopt new dental technologies than other specialists could be due to many factors including their training methods, and the type of new technologies available (ie, more relevant to this specialty).

Despite Friedman's finding that the type of practice, that is whether physicians practice alone or in association with other physicians, influences the physicians' adoptive behavior towards new medical technologies (i.e. those who were associated with other physicians in group practices were more likely to adopt new technologies), we found no such association among dentists in this study. However, our results confirm the notion that the power of decision making to adopt or abandon health technologies is still in the hands of the landlord clinician or the owner of the practice.

Those associate clinicians, who receive salary or a percentage of the practice's billing, irrespective of the mode of reimbursement, demonstrated no significant difference in adopting or abandoning dental technologies. It may be that clinicians who choose to own their practices are the type of people who are more willing to take risks than those who choose to work for others. Commonly, the associated dentist who is not an acting partner in the practice has little power towards purchasing a new technology.

It is naïve to still believe that the relationship between the health professionals (in this case the dentists) and patients is dominated by the physicians' absolute autonomy as an informed agent who makes important health related decisions on behalf of his/her patient [58]. Today, information is easily available at the fingertips of all consumers. Thus, the previously one-sided patient-physician

interaction is now tipped towards the patient. Patients who constantly hear success stories of this and that new technology become "technology-prone" [59]. Although consumers may perceive effectiveness to be greater than the actual health gain of advanced technologies, they are also more likely to be well informed about their particular health issues. For this reason, patients/consumers often demand that their physicians provide recent innovative technologies. Because characteristics like age, ownership and clinical expertise can determine the rate of adoption of dental technologies among these health professionals, dentists should consider the possibility that patients may eventually choose certain clinicians over others.

In an optimal medical care system, new technologies and innovations would be adopted rapidly once safety and efficacy are established and favorable cost-effectiveness ratios are predicted. The technologies would be purchased and started in the most efficient and appropriate settings and they would be available equally to everyone in need. Payment would reflect the actual costs of appropriate and efficient medical care at all times, regardless of which technologies are used and whether they are cost saving or cost increasing [20]. However, there is now evidence that the adoption of many health technologies is not scientifically or socially optimal [60]. Understanding the factors that influence the adoption of medical innovation and examining the impact of past

health policies on adopted and diffused technologies are prerequisites for developing a sound public policy.

The low response rate in our survey is a limitation that could suggest a bias towards adopters of technology. However, our participants' distribution for gender, location and type of practice is significantly comparable with those of all Canadian dentists documented by the Canadian Dental Association at the time of the survey [61]. Therefore, we believe that our sample may represent the Canadian dentists' population.

In conclusion, the findings of this study provide useful information for all three levels of decision makers. At the micro level, patients and clinicians could use these findings to improve their relationships. This will make it easier for patients to better understand the adoptive behavior of their clinicians, while clinicians strive for improving their weaknesses on adopting new health technologies. At the meso level, the university and the hospital administrators in a publicly funded oral health care system may use our findings to construct suitable regulations in provision of oral health in their institutions. Finally at the macro level, government authorities can use these findings to allocate resources in ways that will ease the present adoptive technological gaps among dentists.

2.1.6.Tables

2.1.6.1 Table 1. a) Sample description; feasibility study

Variable		Sample N=50	% of sample
Gender	Men	41	82
	Women	9	18
Age	20 to 30 years	4	8
	30 to 39 years	12	32
	40 to 49 years	12	24
	50 years and above	22	44
Type of practice			
	General practitioner	41	82
	Specialist	9	18
Practicing	Solo	23	46
	Group	21	42
	Solo and hospital	1	2
	Hospital & Group	5	10
Graduated from	Canadian dental school	45	90
	Foreign dental school	1	2
	Canadian and foreign schools	4	8
Ownerships	Owned	35	70
	Not owned	15	30

Table 1.b) Applicability, validity and reliability; feasibility study

applicability	Inter-observational applicability	r= 0.8
Internal consistency	Cronbach's alpha	α>0.7
reliability	Test-retest intra-class correlation coefficient	r=0.75

2.1.6.2 Table 2. Sample description; National survey

Variables	Rank	Sample N	% of sample	National AVG
Practice location				
Ontario	1	618	35	42.2
Quebec	2	421	23.9	21.9
British Columbia	3	332	18.8	15.3
Alberta	4	146	8.3	9.9
Nova Scotia	5	73	4.1	2.8
Manitoba	6	61	3.5	3
New Brunswick	7	43	2.4	1.5
Saskatchewan	8	38	2.2	1.9
Newfoundland	9	18	1	0.9
Prince Edward Island	10	11	0.6	0.3
Yukon	11	2	0.1	0.1
Northwest Territories	12	1	0.1	0.2
Nunavut	13	0	0	0
Total		1764	100	100
Gender				
Male		1240	71.6	76.7
Female		492	28.4	23.3
Total		1732	100	100
Age				
20 to 29 yrs		128	7.2	
30 to 39 yrs		341	19.2	
40 to 49 yrs		502	28.3	
50 yrs or more		804	45.3	
Total		1775	100	
Language				
English		1406	78.9	
French		375	21.1	
Total		1781	100	
Type of practice				
General practitioner		1602	90	89.8
Specialist:		178	10	10.2
	Public health	9	5.6	2.3
	Pedodontics	19	10.1	10.2
	Endodontics	15	8.4	9.7
	Oral surgery	22	12.8	18
	Orthodontics	57	31.8	33
	Oral medicine	3	1.7	1.7
	Periodontics	26	14.5	15.6
	Prosthodontics	26	14.5	8.9
	Geriodentology	1	0.6	NA
	Oral radiology	0	0	0.6
Total		1780	100	100
Practice status				
Alone		834	47	
Associates		941	53	
Total		1775	100	
Ownership				
Own their practice		1375	77.7	
Do not own a practice		396	22.3	
Total		1771	100	

2.1.6.3 Table 3. Crude analysis; National survey

During the past twelve months, did you perform for the first time any new diagnostic or therapeutic procedures that reflected advances in dental knowledge or technology?	Using new technology during past year		OR	95% CI		P-value
	Yes (%)	No (%)		Lower	Upper	
Female gender (vs male)	224 (28.9)	261 (27.8)	1.05	0.85	1.31	0.63
Age:						
50 years and above	314 (40.2)	473 (49.1)	1.00	-	-	-
40 to 49 years	243 (30.6)	256 (26.6)	1.43	1.13	1.80	<0.01
30 to 39 years	171 (21.5)	167 (17.3)	1.54	1.18	2.01	<0.001
20 to 29 years	61 (7.7)	67 (7.0)	1.37	0.93	2.93	0.10
Graduate from:						
Canada	707 (89.2)	843 (87.4)	1.00	-	-	-
US	44 (5.5)	45 (4.7)	1.17	0.74	1.83	0.48
Others	42 (5.3)	76 (7.9)	0.66	0.43	0.99	0.04
Time since graduation:						
Upper quartile (30 years and above)	193 (24.5)	306 (31.8)	1.00	-	-	-
Upper-mid quartile (22-29 years)	194 (24.7)	238 (24.8)	1.29	0.99	1.69	0.05
Lower-mid quartile (12- 21 years)	203 (25.8)	214 (22.3)	1.50	1.15	1.97	0.002
Lowest quartile (0-11 years)	197 (25.0)	203 (21.1)	1.53	1.17	2.03	0.001
English speaking (vs french)	624 (78.1)	767 (79.6)	1.09	0.87	1.37	0.45
Provine of practice:						
Ontario	263 (33.1)	350 (36.5)	1.00	-	-	-
Quebec	187 (23.5)	227 (23.7)	1.09	0.84	1.42	0.47
BC, YK and NWT	161 (20.3)	172 (17.9)	1.25	0.94	1.64	0.11
Prairies	121 (15.2	126 (13.1)	1.28	0.94	1.74	0.10
Atlantic region	63 (7.9)	84 (8.8)	1.00	0.69	1.45	0.99
Speciality:						
General practitioner	711 (89.0)	875 (90.8)	1.00	-	-	-
Orthodontic	32 (4.0)	225 (2.6)	1.57	0.89	2.80	0.09
Periodontic	18 (2.3)	8 (0.8)	2.77	1.14	7.40	0.01
Prosthodontic	15 (1.9)	11 (1.1)	1.68	0.71	4.07	0.19
Oral surgery	9 (1.1)	13 (1.3)	0.85	0.32	2.17	0.73
Pedodontic	5 (0.6)	14 (1.5)	0.44	0.12	1.30	0.11
Endodontic	5 (0.6)	10 (1.0)	0.61	0.16	1.99	0.37
Other	4 (0.4)	8 (0.8)	0.61	0.13	2.31	0.43
Owner of the principle clinic (Yes/No)	638 (80.2)	724 (75.6)	1.30	1.03	1.65	0.02
Status of practice:						
Alone	372 (46.4)	458 (47.8)	1.00	-	-	-
In association with others	393 (49.2)	456 (47.5)	1.06	0.87	1.29	0.54
In a hospital clinic	34 (4.3)	45 (4.7)	0.93	0.56	1.52	0.76
Information sources (used/not used):						
Dental journals	758 (94.9)	903 (93.7)	1.25	0.82	1.93	0.28
Professional meetings or conferences	731 (91.5)	807 (83.7)	2.09	1.53	2.87	<0.0001
Continuing education courses	767 (96.0)	871 (90.4)	2.36	1.54	3.69	<0.00001
Discussions with other dentists	583 (73.0)	568 (58.9)	1.88	1.53	2.32	<0.00001
Internet	425 (53.2)	368 (38.2)	1.22	1.00	1.50	0.05
HTA produces by government agencies	53 (6.6)	52 (5.4)	1.22	0.81	1.85	0.32
Other	81 (10.1)	49 (5.1)	2.11	1.44	3.11	0.00

2.1.6.4 Table 4. Multivariable regression results; National survey

During the past twelve months, did you perform for the first time any new diagnostic or therapeutic procedures that reflected advances in dental knowledge or technology?		OR	95% CI		P-value
			Lower	Upper	
Speciality:					
	General practitioner	1.00	-	-	-
	Orthodontic	1.57	0.89	2.76	0.119
	Periodontic	4.12	1.57	10.79	0.004
	Prosthodontic	1.92	0.81	4.53	0.138
	Oral surgery	0.75	0.31	1.86	0.540
	Pedodontic	0.61	0.21	1.82	0.380
	Endodontic	0.46	0.14	1.58	0.220
	Other	0.70	0.17	2.88	0.617
Owner of the principle clinic					
	No	1.00	-	-	-
	Yes	1.37	1.06	1.76	0.016
Information sources (used/not used):					
	Professional meetings or conferences	1.68	1.21	2.33	<0.01
	Continuing education courses	2.22	1.42	3.47	<0.001
	Discussions with other dentists	1.49	1.19	1.85	<0.001
	Internet	1.58	1.29	1.94	<0.001
	*Other**	2.04	1.37	3.03	<0.001
Time since graduation (year)					
	Upper quartile (30 yrs and above)	1.00	-	-	-
	Upper-mid quartile (22-29 yrs)	1.29	0.99	1.69	0.05
	Lower-mid quartile (12-21 yrs)	1.50	1.15	1.97	0.002
	Lowest quartile (0-11 yrs)	1.53	1.17	2.03	0.001

Section 3 – Technology Adoption among Canadian Dentists: summary, conclusions and implications for future research

3.1 Summary of thesis research

There is no evidence on the existence of HTA in Canadian oral health. Up to now, HTA in dentistry interpreted as a mere cost analysis of dental therapies/technologies. In Canada, there are systematic controls that limit the adoption of most high cost technologies (i.e. MRI) such as prospective hospital budgeting, whereas there are often no controls for privately provided technologies like the ones used in oral health care.

Much like medical technologies, dental technologies have to be adopted at the early stages of their diffusion by the providing clinicians in order to be accessible to the patients. That is what prompted the preparation of a cross sectional survey among all Canadian dentists. The objective of this thesis, therefore, was to study the attributes that may affect the adoptive attitudes of these clinicians towards dental technologies.

The findings of this research revealed that generally the adoption of dental technologies in Canada is significantly associated with the specialty of the dental

clinicians, the time elapsed from graduation, whether they own their clinics, as well as the sources of the information on or about the new technology.

The finding that dental practitioners who do not own their clinics are less likely to adopt new dental technologies for their patients than those who own their clinics may be due to the nature of dental practices in Canada, where the decisions on purchasing the technology are taken by the owner of the clinic and thereafter, the associates will use it. As to why only certain specialists significantly adopt more technologies, this may be due to many factors among which one can point to the specific training leading to the specialty and/or the nature of the discipline and its technology dependency. However, these hypotheses should be further investigated. On the other hand, the finding on the effect of the sources of the information on and about the new technology is crucially important on how to effectively disseminate this information to dental practitioners.

This research suggests that they are determinants that shape the adoptive behavior of dentist towards newly introduced dental technologies. Knowing what kind of clinicians will be more likely to adopt the assessed technology, would 1) help the producers of the OHTA into forming recommendations that may ease the diffusion of new dental technologies into practices, and 2) inform patients, dental

clinicians and government policy makers, who wish to influence the adoption of a clinically effective dental technology.

3.2 Methodological limits of the research

With respect to the use of the literature used in this research, it should be noted that most available literature on the diffusion and the adoption of health technologies is heavily focused on the diffusion of the embodied technologies which are mainly the high cost technologies like CT scanners and MRI within the hospital sector. Very little evidence exists on the diffusion of the disembodied technologies such as new technologies used in a private practice (other than drugs that are used at the office by physicians) which is the bulk of most dental technologies.

The core of this thesis was a cross sectional survey which was designed to describe the diffusion and the adoption of dental technologies in Canada. The small response rate in this survey, may have underpowered the study. However, it was shown that the distribution of our respondents was comparable to the Canadian dentists' population, and that the response rate of our study was also comparable to previous similar surveys in Canada [62].

In cross-sectional studies it may be difficult to ascertain the temporal order of exposure and disease, or in this study the adoptive behavior of dentists towards new technologies. Therefore, no causal inferences can be drawn from the study of the findings of this survey. The effect of the age, ownership and the type of specialty should be individually investigated to establish a conclusive causal relationship between these factors and dentists' adoptive behavior.

3.3 Conclusions

Accepting the methodological limitations of this project and the fact that some of the reported findings need to be confirmed in studies with larger sample sizes, the findings of the research reported in this thesis suggest that:

1. Canadian dentists with less than 11 years of practice significantly adopt new dental technologies more than their older counterparts with more experience (OR: 1.53; 95%CI: 1.17-2.03);

2. Among Canadian dental specialists, Periodontists are more willing to adopt new technologies than other specialists (OR: 4.12, 95%CI: 1.57-10.79);

3. Dentists who own their practices are more likely to adopt dental technologies than those who do not own their practices (OR: 1.37; 95%CI: 1.06-1.76);

4. Dentists who have attended professional meetings, conferences or continuing education courses and those who have participated in discussions with other dentists, and used internet were more likely to adopt new dental technologies.

3.4 Original contributions of the work within this thesis

The original theoretical and practical contributions of the research reported in this thesis to the scientific knowledge within the field of oral health are:

1. Section one raises awareness on the significance of oral health, its effect on health care systems, and the deficiency of work concerning health technology assessment in oral health in comparison to other health fields

2. Section two reports the analysis on the determinants on the adoption of general dental technology in Canada .This report is an original contribution which has findings with potential use in oral health technology assessment (OHTA) aimed at the effective provision of this technology.

3.5 Implications for future research

The findings reported in this thesis should inspire further investigation into considerations for establishing OHTA. There is no precedent for any studies that investigated the contributing factors on the rate of adoption of health technologies in dentistry. There is a need to understand whether dentists' adoptive behavior for health technologies is similar to other health care professionals who practice in private health care system. Future studies should explore these similarities, if any. Understanding the mechanism of this adoption will provide vital information on how to approach these professionals to optimize the adoption process in ways that improves the delivery of dental care to patients.

Although this study explored the adoption of general dental technologies among Canadian dentists, however, whether these findings are applicable towards specific innovative technologies needs to be further explored. In addition, the applicability of these findings in other countries needs to be studied as well.

References

[1] Romanow RJ. Building on Values: The Future of Health Care in Canada-Final Report. Ottawa: Health Canada 2002.

[2] Drummond M. Evaluation of health technology: economic issues for health policy and policy issues for economic appraisal. Social Science & Medicine. 1994 Jun;38(12):1593-600.

[3] Granados A. Health technology assessment and clinical decision making: which is the best evidence? International journal of technology assessment in health care. 1999 Summer;15(3):585-92.

[4] Jacob R, McGregor M. Assessing the impact of health technology assessment. International journal of technology assessment in health care. 1997 Winter;13(1):68-80.

[5] Bero L JA. How consumers and policy-makers can use systematic reviews for decision-making. Ann Intern Med. 1997;127:37-42.

[6] Cuyler RN. The challenge of partial hospitalization in the 1990s. The Psychiatric hospital. 1991 Spring;22(2):47-50.

[7] Reinhardt UE, Hussey PS, Anderson GF. U.S. health care spending in an international context. Health affairs (Project Hope). 2004 May-Jun;23(3):10-25.

[8] Triandis HC. Values, attitudes, and interpersonal behavior. Nebraska Symposium on Motivation. 1980;27:195-259.

[9] Ajzen I. The theory of planned behaviour. Organizational Behavior and Human Decision Process. 1991;50:179-211.

[10] Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly. 1989;13:319-40.

[11] Lorenzi NM, Riley RT, Blyth AJ, Southon G, Dixon BJ. Antecedents of the people and organizational aspects of medical informatics: review of the literature. J Am Med Inform Assoc. 1997 Mar-Apr;4(2):79-93.

[12] Curtis B KH, Iscoe N,. A field study of the software design process for large systems. Commun ACM. 1988;31:1268-86.

[13] Kuo SH. Implementation of asthma guideline in Taiwan--the management in medical centers. J Asthma. 2002 Dec;39(8):767-70.

[14] Rahman S. Environmental impacts of modern agricultural technology diffusion in Bangladesh: an analysis of farmers' perceptions and their determinants. Journal of environmental management. 2003 Jun;68(2):183-91.

[15] Enns HG HS. Implementation of information technology in developing countries: experience of Mongolian internet service provider. 32nd Hawaii international conference on system sciences; 1999; Hawaii: IEEE Comput Soc; 1999.

[16] Cutler DM MM, Newhouse JP,. What Has Increased Medical-Care Spending Bought? . American Economic Review 1998;88(4):132-36.

[17] Cutler DM MM. What is technological change? In: DA W, ed. Inquiries in the Economics of Aging. Chicago: University of Chicago Press 1998:51-81.

[18] Friedman B. The rate of adoption of new procedures among physicians. Medical Care. 1985;23(8):939-45.

[19] Phelps CE. Diffusion of information in medical care. J Econ Perspect. 1992 Summer;6(3):23-42.

[20] Hillman AL, Schwartz JS. The adoption and diffusion of CT and MRI in the United States. A comparative analysis. Medical care. 1985 Nov;23(11):1283-94.

[21] Friedman B, Devers KJ, Steiner CA, Fox S. The use of expensive health technologies in the era of managed care: the remarkable case of neonatal intensive care. Journal of health politics, policy and law. 2002 Jun;27(3):441-64.

[22] Petersen PE. The World Oral Health Report 2003: continuous improvement of oral health in the 21st century--the approach of the WHO Global Oral Health Programme. Community dentistry and oral epidemiology. 2003 Dec;31 Suppl 1:3-23.

[23] Widstrom E, Eaton KA. Oral healthcare systems in the extended European union. Oral health & preventive dentistry. 2004;2(3):155-94.

[24] Ceters for Medicare and Medicaid Services. Medicare Enrollment-All Beneficiaries. 2006 [cited; Available from: http://www.cms.hhs.gov/CapMarketUpdates/Downloads/2006walletcard.pdf

[25] Baldota KK LJ. A macroeconomic review of dentistry in Canada in the 1990s. Canadian Dental Association. 2004;70(9):604-9.

[26] Canadian Institute for Health Information. National Health Expenditure Trends, 1975–2007,. Ottawa; 2005.

[27] Deber R, Wiktorowicz M, Leatt P, Champagne F. Technology acquisition in Canadian hospitals: how are we doing? Healthcare management forum / Canadian College of Health Service Executives = Forum gestion des soins de sante / College canadien des directeurs de services de sante. 1995 Summer;8(2):23-8.

[28] Battista NR. Innovation and diffusion of health-related technologies;a conceptual framework. Intl J of Technology Assessment in Health Care. 1989;5:227-48.

[29] Duffy SQ, Farley DE. The protracted demise of medical technology. The case of intermittent positive pressure breathing. Medical care. 1992 Aug;30(8):718-36.

[30] Kukafka R, Johnson SB, Linfante A, Allegrante JP. Grounding a new information technology implementation framework in behavioral science: a

systematic analysis of the literature on IT use. J Biomed Inform. 2003 Jun;36(3):218-27.

[31] Rogers EM. Diffusion of innovations. 4th ed. New York: Free Press 1995.

[32] Robert Y SA. The burden of retroactive dental treatment for children in third world countries. Int Dent J. 2002;52(1):1-9.

[33] Peterson PE BD, Ogawa H, Estupinan-Day S, Ndiaye C,. The global burden of oral diseases and risks to oral health. Bulletin of World Health Organization. 2005;83(9):661-9.

[34] Axelsson S DH, Svensson A, et al.,. Need to assess dental care. Stockholm: The Swedish Council on Technology Assessment in Health Care; 2000.

[35] Leake JL BS, Lewis DW,. Technology assessment in dentistry. J Can Dent Assoc. 1994(60):1066-70.

[36] Bateman GJ SS. A brief guide to clinical guidelines. Br Dent J 2007;24(203(10)):581-3.

[37] Goodman C. HTA 101, introduction to health technology assessment. Falls Church: The Lewin Group 2004.

[38] Grimshaw JM EM, Tetroe J,. Implementing Clinical Guidelines: Current Evidence and Future Implications. The Journal of Continuing Education in the Health Professions. 2004;24:S31-S7.

[39] Solberg LI. Guideline implementation: what the literature doesn't tell us. Jt Comm J Qual Improv. 2000 Sept;26(9):525-37.

[40] Bero LA, Grilli R, Grimshaw JM, Harvey E, Oxman AD, Thomson MA. Closing the gap between research and practice: an overview of systematic reviews of interventions to promote the implementation of research findings. The Cochrane Effective Practice and Organization of Care Review Group. BMJ (Clinical research ed. 1998 Aug 15;317(7156):465-8.

[41] Foundation KF. How changes in medical technology affect health care costs. health care costs 2007.

[42] Brown E. New medical technology diffusion key element in health cost increases. Physician Executive. 1996 Jan 1996.

[43] Wells PNT. can Technology Truly Reduce Healthcare Costs? IEEEEngineering in Medicine and Biology Magazine. 2003 Jan/feb 2003:20-5.

[44] Redberg RF. The appropriateness imperative. American heart journal. 2007 Aug;154(2):201-2.

[45] Koutsavlis AT. Dissémination des guides de pratiques chez les médecins: Institut national de santé publique du Québec; 2001.

[46] Thomas L CN, McColl E, Rousseau N, Soutter J, Steen N,. Guidelines in professions allied to medicine. Cochrane Database of Systematic Reviews 1999, Issue 1. Art. No.: CD000349. DOI: 10.1002/14651858.CD000349.

[47] Rogers EM. Diffusion of innovations. 3rd edition ed. New York: The Free Press 1983.

[48] Packer C, Simpson S, Stevens A. International diffusion of new health technologies: a ten-country analysis of six health technologies. International journal of technology assessment in health care. 2006 Fall;22(4):419-28.

[49] Herman CJ, Hoffman RM, Altobelli KK. Variation in recommendations for cancer screening among primary care physicians in New Mexico. Journal of community health. 1999 Aug;24(4):253-67.

[50] Newton KM LA, Buist DS, Anderson LA, Delaney K,. What factors account for hormone replacement therapy prescribing frequency? Maturitas. 2001;39(1):1-10.

[51] Reschovsky JD, Hadley J, Landon BE. Effects of compensation methods and physician group structure on physicians' perceived incentives to alter services to patients. Health services research. 2006 Aug;41(4 Pt 1):1200-20.

[52] Power ML CM, Schulkin J,. Obesity prevention and treatment practices of U.S. obstetrician-gynecologists. Obstetrics & Gynecology. 2006;108(4):961-68.

[53] Andrews JE, Pearce KA, Ireson C, Love MM. Information-seeking behaviors of practitioners in a primary care practice-based research network (PBRN). J Med Libr Assoc. 2005 Apr;93(2):206-12.

[54] American Medical Association's Socioeconomic Monitoring System. Chicago; 1983-1985.

[55] McKenna SP DL. The translation and cultural adaptation of patient-reported outcome measures. Value Health. 2005;8(2):89-91.

[56] Markaki A AN, Hicks CM, Linois C,. Translating and validating a training needs assessment tool into Greek. BMC health services research. 2007;7(65).

[57] Bedos C, Allison PJ. Canadian dentists' willingness to be involved in dental research. Int Dent J. 2004 Apr;54(2):61-8.

[58] Greer AL. Medical technology and professional dominance theory. Social science & medicine (1982). 1984;18(10):809-17.

[59] d'Adler MA. The transfer of medical information. A journalist's view. International journal of technology assessment in health care. 1988;4(1):59-63.

[60] Deber RB, Thompson GG, Leatt P. Technology acquisition in Canada. Control in a regulated market. International journal of technology assessment in health care. 1988;4(2):185-206.

[61] Canadian Dental Association. Licensed dentists by specialty. Ottawa; 2006 December 31, 2006.

Appendix I

McGill

Faculty of Medicine
3655 Promenade Sir William Osler
Montreal, QC H3G 1Y6

Faculté de médecine
3655, Promenade Sir William Osler
Montréal, QC, H3G 1Y6

Fax/Télécopieur: (514) 398-3595

29 November 2005

Dr. Jocelyne Feine
Faculty of Dentistry
Strathcona Anatomy and Dentistry Building
3640 rue University
Montreal Quebec H3A 2B2

RE: IRB Study Number: A11-E26-05B

Dear Dr. Feine,

The study entitled "The Adoption of Implant Technology by Canadian and British Dentists" was presented for corroborative approval on behalf of PhD candidate – Shahrokh Esfandiari - at the full Board meeting of the Committee on November 28, 2005.

We are pleased to inform you that approval was provided by the Board and enclosed you will find the certificate of approval.

A review of all research involving human subjects is required on an annual basis in accord with the date of initial review and approval. The annual review should be submitted at least one month before **November 2006**. If any modifications to the study are required during the next twelve months, please inform IRB promptly.

Yours sincerely,

[redacted]

Serge Gauthier, MD
Chair
Institutional Review Board

cc: A11-E26-05B

Appendix II

McGill
Faculty of Dentistry

A Questionnaire on Canadian Dental Technology Adoption

We know very little about how dentists decide to adopt new diagnostic and therapeutic procedures. Dental technologies are rapidly evolving and clinicians are faced with the difficult task of choosing which new technology is best in their practice. Therefore, we are conducting this survey so that we can better understand the incentives and barriers to technology adoption.

We kindly ask you to take 5 minutes of your time to complete this questionnaire. It is anonymous and you may be assured that your response remains confidential.

Once you have completed the questionnaire, please return it in the prepaid envelope provided. If you have any questions about the questionnaire or any related issues, please contact the survey coordinator, Dr. Shahrokh Esfandiari at McGill University: (514) 398-7203 ext. 0243.

Thank you for your time,

Jocelyne Feine (Professor, McGill University)

Section 1: General Information

1. Location of practice: City.....Province.....

Postal Code ☐☐☐-☐☐☐

2. Gender: ☐ Male ☐ Female

3. Age:

☐ 20 to 29 years ☐ 30 to 39 years
☐ 40 to 49 years ☐ 50 years and above

4. Graduated from:

☐ Canadian Dental School
☐ American Dental School
☐ Foreign Dental School

5. Year of graduation from dental school: ☐☐☐☐

6. Years of Practice in Canada: ☐☐

7. Are you a:
☐ General Dentist
☐ Specialist, If specialist, what is your specialty.....

8. Are you practicing? (One or more possible answers)
☐ Alone
☐ In a hospital dental clinic
☐ In association with other Dental physicians

If in association, how many other dentists work with you? ☐☐

9. Are you the owner of the principal dental clinic in which you work?
☐ Yes
☐ No. If no, do you: ☐ receive a salary
☐ receive a percentage of the billing

Section 2: General Technology

1. During the past twelve months, did you use any of the following sources of information to learn about new diagnostic and therapeutic procedures?

☐ Dental journals
☐ Professional meetings or conferences
☐ Continuing education courses
☐ Discussions with other oral physicians
☐ Internet
☐ Technological assessments produced by government agencies
☐ Other sources, please specify .....

2. How would you rank the sources you mentioned in terms of their importance in learning about new diagnostic and therapeutic procedures?

	Not Important	Important	Very Important
-Dental journals	☐	☐	☐
-Professional meetings, conferences	☐	☐	☐
-Continuing education courses	☐	☐	☐
-Discussions with other oral physicians	☐	☐	☐
-Technological assessments produced by government agencies	☐	☐	☐
-Internet	☐	☐	☐
-Other sources, please specify	☐	☐	☐

3. During the past twelve months, did you perform for the first time any new diagnostic or therapeutic procedures that reflected advances in dental knowledge or technology?

☐ No. If No, go to Q. 4

☐ Yes. If Yes;

How many different diagnostic or therapeutic procedures did you perform for the first time?

☐☐☐ Please specify which and why?.....

4. During the past twelve months, did you drop any procedures from your normal office routine as a result of changes in dental knowledge or technology?

☐ No. If No, go to Q.5

☐ Yes. If Yes;

How many procedures did you drop because of changes in dental knowledge and technology?

☐☐☐ Please specify which and why?.....

How many of the procedures that you dropped were replaced by new procedures?

☐☐☐ Please specify which and why?.....

5. During the past twelve months, did you learn about any new diagnostic or therapeutic procedures that were relevant to your practice, but which you chose not to adopt in your practice activities?

☐ No. If No, go to section 3.

☐ Yes. If Yes, please indicate, whether your decision not to adopt new procedures was based on any of these reasons:

☐ The high cost of the procedure
☐ Inadequate surgical/technical expertise
☐ Insufficient information about the safety and effectiveness of the procedure
☐ Fear of liability
☐ Not enough patient demand
☐ Lack of proper clinical set-up
☐ Lack of trained staff
☐ The procedure is currently performed at a hospital or other facility in the area.
☐ Referred to specialist
☐ Other, please specify.....

Section 3; Implant Technology

I. During the past twelve months, did you <u>surgically</u> place any dental implants? (One or more possible answers)

☐ Yes. If yes, where?
- ☐ Maxilla
- ☐ Mandible

☐ No. If No, why not?
- ☐ The high cost of the procedure
- ☐ Lack of surgical training
- ☐ Insufficient information about the safety and effectiveness of the procedure
- ☐ Fear of liability
- ☐ Not enough patient demand
- ☐ Lack of proper clinical set-up
- ☐ Lack of trained staff
- ☐ The procedure is currently performed at a hospital or other facility in the area
- ☐ Referred to specialist
- ☐ Other, please specify.....

II. During the past twelve months, did you provide any dental implant <u>restorations or prostheses</u>? (One or more possible answers)

☐ Yes. If yes, which of the following implant restoration prosthesis have you placed
- ☐ Crown(s)
- ☐ Bridge(s)
- ☐ Implant retained dentures
  - ☐ Complete implant-retained denture
  - ☐ Partial implant-retained denture

☐ No. If No, why not?
- ☐ The high cost of the procedure
- ☐ Lack of technical expertise
- ☐ Insufficient information about the safety and effectiveness of the procedure
- ☐ Fear of liability
- ☐ Not enough patient demand
- ☐ Lack of proper clinical set-up
- ☐ Lack of trained staff
- ☐ The procedure is currently performed at a hospital or other facility in the area
- ☐ Referred to specialist
- ☐ Other, please specify.....

Appendix III

McGill
Faculty of Dentistry

A Questionnaire on Canadian Dental Technology Adoption

We know very little about how dentists decide to adopt new diagnostic and therapeutic procedures. Dental technologies are rapidly evolving and clinicians are faced with the difficult task of choosing which new technology is best in their practice. Therefore, we are conducting this survey so that we can better understand the incentives and barriers to technology adoption.

We kindly ask you to take 5 minutes of your time to complete this questionnaire. It is anonymous and you may be assured that your response remains confidential.

Once you have completed the questionnaire, please return it in the prepaid envelope provided. If you have any questions about the questionnaire or any related issues, please contact the survey coordinator, Dr. Shahrokh Esfandiari at McGill University: (514) 398-7203 ext. 0243.

Thank you for your time,

Jocelyne Feine (Professor, McGill University)

Section 1: General Information

1. Location of practice: City.....Province.....

Postal Code ☐☐☐-☐☐☐

2. Gender: ☐ Male ☐ Female

3. Age:

☐ 20 to 29 years ☐ 30 to 39 years
☐ 40 to 49 years ☐ 50 years and above

4. Graduated from:

☐ Canadian Dental School
☐ American Dental School
☐ Foreign Dental School

5. Year of graduation from dental school: ☐☐☐☐

6. Years of Practice in Canada: ☐☐

7. Are you a:
☐ General Dentist
☐ Specialist, If specialist, what is your specialty.....

8. Are you practicing? (One or more possible answers)
☐ Alone
☐ In a hospital dental clinic
☐ In association with other Dental physicians

If in association, how many other dentists work with you? ☐☐

9. Are you the owner of the principal dental clinic in which you work?
☐ Yes
☐ No. If no, do you: ☐ receive a salary
☐ receive a percentage of the billing

Section 2: General Technology

1. During the past twelve months, did you use any of the following sources of information to learn about new diagnostic and therapeutic procedures?

☐ Dental journals
☐ Professional meetings or conferences
☐ Continuing education courses
☐ Discussions with other oral physicians
☐ Internet
☐ Technological assessments produced by government agencies
☐ Other sources, please specify .....

2. How would you rank the sources you mentioned in terms of their importance in learning about new diagnostic and therapeutic procedures?

	Not Important	Important	Very Important
-Dental journals	☐	☐	☐
-Professional meetings, conferences	☐	☐	☐
-Continuing education courses	☐	☐	☐
-Discussions with other oral physicians	☐	☐	☐
-Technological assessments produced by government agencies	☐	☐	☐
-Internet	☐	☐	☐
-Other sources, please specify	☐	☐	☐

3. During the past twelve months, did you perform for the first time any new diagnostic or therapeutic procedures that reflected advances in dental knowledge or technology?

☐ No. If No, go to Q. 4

☐ Yes. If Yes;

How many different diagnostic or therapeutic procedures did you perform for the first time?

☐☐☐ Please specify which and why?.....

4. During the past twelve months, did you drop any procedures from your normal office routine as a result of changes in dental knowledge or technology?

☐ No. If No, go to Q.5

☐ Yes. If Yes;

How many procedures did you drop because of changes in dental knowledge and technology?

☐☐☐ Please specify which and why?.....

How many of the procedures that you dropped were replaced by new procedures?

☐☐☐ Please specify which and why?.....

5. During the past twelve months, did you learn about any new diagnostic or therapeutic procedures that were relevant to your practice, but which you chose not to adopt in your practice activities?

☐ No. If No, go to section 3.

☐ Yes. If Yes, please indicate, whether your decision not to adopt new procedures was based on any of these reasons:

☐ The high cost of the procedure
☐ Inadequate surgical/technical expertise
☐ Insufficient information about the safety and effectiveness of the procedure
☐ Fear of liability
☐ Not enough patient demand
☐ Lack of proper clinical set-up
☐ Lack of trained staff
☐ The procedure is currently performed at a hospital or other facility in the area.
☐ Referred to specialist
☐ Other, please specify.....

Section 3; Implant Technology

I. During the past twelve months, did you <u>surgically</u> place any dental implants? (One or more possible answers)

☐ Yes. If yes, where?
- ☐ Maxilla
- ☐ Mandible

☐ No. If No, why not?
- ☐ The high cost of the procedure
- ☐ Lack of surgical training
- ☐ Insufficient information about the safety and effectiveness of the procedure
- ☐ Fear of liability
- ☐ Not enough patient demand
- ☐ Lack of proper clinical set-up
- ☐ Lack of trained staff
- ☐ The procedure is currently performed at a hospital or other facility in the area
- ☐ Referred to specialist
- ☐ Other, please specify.....

II. During the past twelve months, did you provide any dental implant <u>restorations or prostheses</u>? (One or more possible answers)

☐ Yes. If yes, which of the following implant restoration prosthesis have you placed
- ☐ Crown(s)
- ☐ Bridge(s)
- ☐ Implant retained dentures
  - ☐ Complete implant-retained denture
  - ☐ Partial implant-retained denture

☐ No. If No, why not?
- ☐ The high cost of the procedure
- ☐ Lack of technical expertise
- ☐ Insufficient information about the safety and effectiveness of the procedure
- ☐ Fear of liability
- ☐ Not enough patient demand
- ☐ Lack of proper clinical set-up
- ☐ Lack of trained staff
- ☐ The procedure is currently performed at a hospital or other facility in the area
- ☐ Referred to specialist
- ☐ Other, please specify.....

Appendix IV

Appendix V