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Minimally invasive dentistry approach in dental public health

Deise Cruz Oliveira
University of Iowa

MINIMALLY INVASIVE DENTISTRY APPROACH IN DENTAL PUBLIC HEALTH

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Deise Cruz Oliveira

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Thesis Supervisor: Professor John J. Warren

Graduate College
The University of Iowa
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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

Deise Cruz Oliveira

has been approved by the Examining Committee
for the thesis requirement for the Master of Science
degree in Dental Public Health at the May 2011 graduation.

Thesis Committee: John J. Warren, Thesis Supervisor

Steven M. Levy

Justine Kolker

Fang Qian

To my husband, Cristiano Oliveira,
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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Dental caries is a multifactorial disease that has many contributing factors, including biological, genetic, socioeconomic, cultural, and environmental issues. Dental caries is an infectious disease that results in the loss of mineral (demineralization) from tooth structure as a result of acid production by caries-causative organisms. In order to develop this disease, it is necessary for the host, substrate and microflora to interact over a period of time.

Results from the Third U.S. National Health and Nutrition Examination Survey[1] have shown that dental caries a very prevalent disease. It is the most common childhood disease and is five times more prevalent than asthma and seven times as common as hay fever. Ninety-four percent of adults examined had decay experience and caries is a substantial health issue in the elderly population. More than half of older adults are affected by coronal and/or root caries; caries is a primary cause of tooth loss in this population.

Dental caries is the main reason for placement and replacement of restorations. The demineralization process occurs because of high consumption of sugary and/or starchy foods and sugared beverages, combined with insufficient fluoride exposure, inappropriate oral hygiene, and/or poor salivary flow.

More than 60 percent of dentists' restorative time is spent replacing existing restorations. The replacement of restorations can result in cavity preparations larger than the predecessors, which leads to weakening of the remaining tooth structure[12]. The longevity of a restoration is attributed to the restorative material properties, the technical quality of the restorative procedure and the patient's compliance with appropriate maintenance of their oral hygiene.

The traditional surgical dental caries management philosophy was based on "extension for prevention" and restorative material needs rather than on preserving the healthy tooth structure. This surgical approach, originally developed by G.V. Black and others, has been the standard in dental practice for over 100 years [3]. This technique emphasized large amalgam cavity preparations, which required removal of additional tooth structure in order to provide mechanical retention for the restorative material[3].

To better address this highly prevalent disease and conserve tooth structure, dental practitioners started to use new techniques and adhesive restorative materials in order to meet the caries preventive and restorative needs of children and adults[3]. In the 1970s, the surgical dental paradigm began shifting to this new approach for caries management. It was based on the medical model which emphasizes caries risk assessment, early caries detection, remineralization of tooth structure and especially preservation of tooth structure through minimal intervention in the placement and replacement of restorations. The minimal intervention paradigm emphasizes use of adhesive restorative materials in order to minimize the size of cavity preparation[4]. This new medical model, known as Minimally Invasive Dentistry (MID), is a conservative philosophy that reduces restorative procedure time, pain and stress, and results in decreased patient anxiety[4]. For instance, MID emphasizes that initial caries lesions in the enamel can be repaired by increasing the amounts of calcium, phosphate and fluoride in the saliva. Also, when a lesion needs to be restored, MID emphasizes adhesive restorative techniques, which allow removal of the decay in a way that involves minimal loss of healthy tooth structure.

While the paradigm has begun to shift from the G.V. Black surgical approach toward the Minimally Invasive Dentistry philosophy, several articles in the literature continue to suggest that many dental practitioners have not changed their operative strategies to the modern restorative approach which emphasizes preservation of tooth structure.

Dental Public Health (PH), one of nine recognized dental specialties, is focused on diagnosis, prevention and control of dental diseases and promotion of oral health through organized community efforts. PH serves the community through research, health promotion, education, and dental care programs. According to this concept, PH is the logical dental specialty to be in a leading position in the dissemination of the modern approach to caries management.

Despite the emergence of this modern approach to caries treatment (MID) and the leading role PH dentists play in advocating prevention, there are no published studies that evaluate United States public health dentists' knowledge, attitudes, or behaviors concerning MID.

Therefore, the purpose of this study was to determine if Minimally Invasive Dentistry (MID) is considered to meet the standard of care among public health dentists in the United States and to identify factors associated with beliefs that MID meets the standard of care. The research instrument was an online survey.

Four broad research questions were addressed:

1) In PH dentists' opinions, does MID meet the dental professional standard of care for treatment of primary teeth in the United States?
2) In PH dentists' opinions, does MID meet the dental professional standard of care for treatment of permanent teeth in the United States?
3) What factors influenced PH dentists' answers to the previous research questions?
4) What factors influenced PH dentists' use of sharp explorers to detect caries?

These issues are important because use of MID has the potential to allow more comfortable, cost-effective oral health care to the United States population and can substantially reduce treatment costs among public health programs. Given the scope of

such programs, and the high-risk status of many of their patients, this study could help to inform public policy regarding such dental care in the United States.

CHAPTER II

REVIEW OF LITERATURE

Minimally Invasive Dentistry (MID) is a conservative dental restorative philosophy that emphasizes caries risk assessment, early caries detection, remineralization of tooth structure and, most especially preservation of tooth structure through minimal intervention in the placement and replacement of restorations. According to this definition of MID, this chapter is divided into five sections: dental caries; philosophies of restorative care; dental practice in the United States; dental public health professionals; and dentists' opinion concerning MID.

Dental Caries

Dental caries was relatively rare until the 1600s. The disease was first diagnosed in Europe and spread to North America because of the increase in sugar consumption. The diagnosis process at that time was visual and the treatment was tooth extraction because it was thought to be gangrene.

The first truly scientific theory regarding dental caries was defined by Dr. W.D. Miller in 1890. It was the "chemico-parasitic" theory which indicated that dental caries is the decomposition of the tooth structure caused by bacterial acids present in the dental plaque[5]. However, because of technology limitations at that time, Miller was not able to determine the specific pathogens for dental caries. Thus, the "surgical model" continued to drive dentistry: the clinical symptoms were addressed by tooth extraction or restoration. The preventive approach, avoiding bacterial contamination, the cause of the disease, was never addressed[5].

Later, based on Miller's theory, dental caries was recognized as an infectious disease requiring a susceptible host, cariogenic bacteria, and a diet with refined carbohydrates[6]. As a result of a combination of all these factors, demineralization of the tooth structure may occur.

Although dental caries is classified as an endemic, preventable and curable disease by the National Institutes of Health (NIH Consensus Statement, 2001), dental caries continues to have high prevalence rates in the United States. According to the National Health and Nutrition Examination Survey[1], dental caries is the most prevalent, costly, and chronic childhood disease. It is related to tooth loss among the elderly population and might be implicated in severe health consequences in these individuals. In addition, 94% of adults in the U.S. had dental caries experience. NHANES is an ongoing surveillance system that provides data for a representative sample of the U.S. population over the age of 2 years.

Data from the 1999-2002 NHANES indicated that, among children aged 2-11 years, 41% had dental caries in their primary dentition[1] . Among these children, the predictors were low-income families, special-need child and ethnic minorities.

Continuing the NHANES 1999-2002 report, 42% of children and adolescents aged between 6-19 years and around 90% of adults presented with dental caries experience[1] Comparing data from the NHANES 1988-1994 and NHANES 1999-2002, the most recent survey findings suggest that there was a decline of dental caries experiences in permanent dentition and in edentulism rates. However, dental caries prevalence was not reduced in the primary dentition.

Bacterial Factors

Dental caries and periodontal diseases are a result of specific bacterial species that form the dental plaque. The dental plaque is a multi-species biofilm which adheres to the teeth surfaces. Normally, a healthy mouth presents with numerous bacteria species in the plaque. However, plaque *per se* is not odontopathic[7].

Dental caries is a multifactorial infectious disease. The dental caries process starts with acid formation by specific bacterial species in the dental plaque. The bacterial acid, in contact with the tooth structure, will cause demineralization of the hard tissue.

Dental caries occurring in the enamel begins with demineralization and possibly leads to dentin and pulp involvement. Dental caries occurring in the cementum is classified as root caries[8].

Studies have shown that dental caries is basically caused by mutans streptococcus (*Streptococcus mutans* and *Streptococcus sobrinus*) and *Lactobacilli* species (Anderson, 1991). Mutans streptococci (MS) are believed to be more involved in the dental caries initiation process, while lactobabacilli species are responsible for the disease progression[9]. In the remainder of this chapter, MS will be used to denote the specific organism and this group of closely related organisms. Regarding patients' caries risk development, individuals who present with more than 1 million colony-form units (CFU) per ml saliva of mutans streptococci[10] or 10^3 CFU/ml or more of lactobacilli[11] are considered to be at high risk for caries. Mutans streptococci were first identified in dental caries in humans in 1924 by Clarke[12]. However, in the 1970's many studies reported the presence of no mutans streptococci (MS) in newborns' mouth[13].

Köhler & Bratthall[14] analyzed the amount of MS in 36 children (aged 4-5 years old) and respective parents (34 mothers and 31 fathers). This study showed a positive quantitative correlation among mothers and their children regarding amount of MS; however, no correlation was found with fathers. Children classified as free of dental caries presented with less than 10^3 CFU/ml of MS. In addition, this study identified more than 50% of the children was infected with MS by 4 years of age and children's mothers were identified as the main transmitter of MS.

A 1993 study conducted by Caufield and colleagues[15] monitored the oral bacterial levels of 46 mother-child pairs from infancy until the child turned 5years of age. Thirty-eight children at a median age of 26 months were identified with MS colonization; however, in 8 children (17%) MS was not detected during the study period. The Caufield and colleagues' study[15] was the first to report the "window of infectivity" period in

infants, in other words, the period of initial MS infection after the child's birth, which the authors defined as being between 19 and 31 months for most of the children.

Alves and colleagues[16] prospective cohort study also investigated the non-familial sources of transmission of MS in 119 children from 28 day-care centers in Brazil during 18months. The purpose of this study was to track the transmission of MS from child to child, caregiver to child and mother to child. MS levels were determined in all participants at baseline in children between 5 to 13 months of age, when only 5.6% (N=9) of children were detected to have MS. After 6months, 15.6% (N=22), at one year 32.1% (N=42); and at 18 months 40.3% (N=48) had MS. The results of Alves and colleagues (2009) study showed that 40.3% of children were MS colonized and among these children (47.9%- N=23) were identified with dental caries. In addition, 50% (N=8) of the children-mother pairs matched genotypes. The highest level of MS was found among caregivers; however, none of their genotypes matched with the children for whom they were responsible. In 7 day-care centers, at least 2 children had similar genotypes of MS. Four pairs of children, among the 19 day-care centers had MS with identical DNA profiles. The study findings confirm that there is MS transmission among non-familial sources which are characterized as horizontal transmission.

Dental caries is a multifactorial infectious disease and MS transmission is one of the factors. Other factors include dietary sugars, eating frequency, fluoride, plaque, and saliva composition and flow. These are discussed below.

Dietary and Other Factors in Dental Caries Etiology

Warren and colleagues[17] investigated factors associated with caries cross-sectionally in children aged 6 to 24 months as part of a longitudinal cohort study. The study population was 212 mothers with children recruited from Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinic sites in southeastern Iowa. The survey instrument was applied to the mothers asking detailed information

about children's diet habits, oral hygiene, and family socioeconomic status. The dental caries examinations criteria used was d1 d2-3 criteria; d1non-cavitated and d2 cavitated enamel lesions, and d3 for dentin lesions. Samples of mother and children's saliva were collected in order to perform salivary Mutans Streptococcus (MS) levels. The findings showed that 187 children had teeth and 23 of those presented with d (1) or d (2-3) lesions. In conclusion, the Warren and colleagues[17] study suggest that plaque accumulation, MS levels, children's age, and family SES are factors associated to dental caries lesions in young children.

In a follow-up study, Warren and colleagues[17] performed longitudinal analyses with the same population of children. In this study, participants were examinated at baseline, and after 9 and 18 months. Based on the 128 children (60%) who remained in the study after 18 months, the study findings showed that the prevalence of d(1) level caries increased from 9% to 77% while d(2-3) level caries prevalence increased from 2% to 20%. The study results suggest that high consumption of sugary foods and early MS colonization in young children are factors that are predictive of dental caries experience in young children.

Marshall and others[18] studied the relationship between dental caries lesions and children's diet habits. The study population was 5 year-old children who participated in the Iowa Fluoride Study (n = 634). The participants' dietary habits were assessed through a 3-day food diary answered by their parents every year during the 5 year study period. The children were examined for dental caries at a mean age of 4.8 years (range 4.5-6.8 years). The study results suggested that higher consumption of sugary foods or 100% juice at snacks and soda pop at meals was associated with increased dental caries experience among young children. However, high consumption of sugary food or carbohydrates at meals was associated with decreased experience of dental caries among young children.

Margolis & Moreno[19] investigated dental plaque composition of 5 populations recruited from the Boston area. Specifically plaque composition was measured before a 10% sucrose rinse and at 7, 15, 30, and 60 min after the rinse. Participants were placed in two groups: caries-free (CF) where the DMFS was equal to zero and caries-positive (CP) where the DMFS was greater than 10. Results showed that high pH values and supersaturated plaque were found in CF groups and low pH and high lactic acid concentration were found in CP group. In conclusion, Margolis and Moreno[19] suggested that dental caries experience might be related to low saliva pH and high lactic acid concentration.

Psoter et al.[20] investigated the relationship between Early Childhood Caries (ECC) and social and demographic factors such as ethnicity/race, household income and parents' education level. The study population was composed of 5,171 Arizona pre-school children at the age of 5 who were examined in February, 1994 and September, 1995 by 5 calibrated examiners. The total number of clinical examinations was 3,850. Survey information was collected before the execution of exams. The Psoter and colleagues study demonstrated that ECC is associated with low income and low parents' education level; however, it did not find any association between caries and minority ethnicity/race group (African American, Mexican American, and Hispanic) in this study.

Other caries predictors were also identified by Dye et al.[21]. The authors analyzed the association between dental caries occurrence and dietary habits in children aged 2 to 5 years-old in the United States. This study used data collected during the third National Health and Nutrition Examination Survey (NHANES III) from 1988 to 1994. Eating habits information was collected from the parents in a 24-hour recall database. The study population included 4,236 children. Dye and colleagues' results[21] showed that non-poor children who skipped breakfast or who did not eat five servings of fruits and vegetables daily presented with more caries experience than the others. In conclusion, Dye and

colleagues[21] suggested that young children with poor eating habits are more likely to experience caries than other children without such habits.

Finally, Dini and others[22] investigated the association between dental caries experience, socio-demographic factors, breast-feeding and oral hygiene in children aged 3-4 years at daycares in Sao Paulo, Brazil. The study population was 303 children from 26 kindergartens. Socio-demographic information was collected from the parents before dental examination. The study findings showed that of the 80% of the children who received milk in their bottles with added sugar, 46% were diagnosed with dental caries lesions. Of the 46% children with dental caries, 17% presented with a more advanced stage of the disease. Note that the children who presented with extensive dental caries pattern were those fed by either bottle formula or breast-feeding after 2 years-old. In conclusion, Dini and colleagues[22] suggested that dental caries experience is associated with breast feeding over a prolonged period in young children.

Summary of Dental Caries

Dental caries is an infectious bacterial disease that results in tooth destruction by acid formed in the dental plaque by certain resident bacteria in the presence of sugar. In the early 2000's, 85% of 17 year-old adolescents had dental caries experience in the U.S.[1]

Dental caries risk factors include high sugary food consumption, prolonged eating frequency, non-fluoride exposure, moderate to high plaque accumulation and inappropriate salivary properties. Dental caries lesions are usually treated by tooth restorations. Restorative philosophies and restorations have evolved over the years; thus, the next section will describe the various restorative treatment philosophies.

Philosophies of Restorative Care

This section will review traditional dental restorative approaches taught for many years and the Minimally Invasive Dentistry (MID) philosophy.

The operative approach taught in dental schools during the 20th century and used by many dentists in clinical practice was based primarily on a textbook written by Dr. Greene Vardiman Black in 1908 titled, "A Work on Operative Dentistry"[9]. Dr. Black was the pioneer of scientific articles and texts on dental materials, cavity preparation and restorative techniques between 1869 and 1915. Black's classification of dental carious lesions is still taught today in dental schools.

Dr. G.V. Black was the first dentist to propose treatment of dental caries using engineering principles to improve cavity preparations for materials available at that time. Because there was no known means of caries prevention at the time, he advocated restoration extension as a means of preventing future caries lesions. Today, with recent technological progress, Black's doctrines are considered an aggressive approach by modern dental standards.

The Minimally Invasive Dentistry (MID) approach emphasizes caries management based on early diagnosis. A modified classification of caries is based on first assessing the site and size of each lesion then determining whether remineralization of the lesion is possible. A reduction of cariogenic bacteria and minimally invasive cavity preparation design through appropriate techniques and restorative material selections are the tenants of MID philosophy[23]. This new philosophy has allowed control of dental caries through prevention and conservation of tooth structure through conservative cavity preparations, adhesive materials and evidence-based decision-making, in contrast to traditional methods.

Conventional Dental Caries Management Approach

Black wrote: "Certainly that portion near the proximate contact… is most liable to be attacked; and the liability diminishes as we recede from that point… it is to cut the enamel margins from lines that are not self-cleansing to lines that are self- cleansing… When a cavity has occurred in the occluding surface of a molar; the dentist prepares for

filling with the idea that the fissures in this part of enamel have favored the occurrence of the cavity. For this reason, the fissures and grooves adjoining the cavity, even though not decayed, are cut away to such a point as seems to give opportunity for a smooth, even finish of the margins of the filling. This is done as a prevention of future recurrence of decay…"[24] Therefore, the conventional surgical caries treatment approach taught in dental schools for over 100 years was based on "extension for prevention" in other words, placement of restorative material in non-diseased but susceptible areas rather than preservation of healthy tooth structure. Black's doctrines were followed literally until the introduction of high copper silver amalgams in the 1970s[24]. However, many of techniques are still widely taught.

For instance, Tubert-Jeannin and colleagues[25] assessed the caries management strategies taught in French dental schools through a questionnaire. It presented a hypothetical situation where a patient aged twenty years had low caries activity, visited a dentist annually, had good oral hygiene and had one area of interproximal decay. The study sample was 180 teachers from the Operative Dentistry Department in French schools and the response rate was 49.1% (86 teachers). The authors found that 2.4% preferred Black's traditional class II preparations, and 8.3% preferred amalgam as restorative material. The results also demonstrated that French dental teachers intervene surgically early in the treatment of the carious process. The authors justify this behavior by explaining that the treatment population is classified as high caries activity most of the time, and as a result, dentists continue to use the surgical approach to place restorations before lesions progress. Thus, it is important to emphasize that Black's philosophy continues to be taught and influences dentists' treatment decisions in the 21st century.

Considerable research in the last three decades has reported that a carious lesion can be reversed prior to cavitation; the tooth surface can be remineralized and returned to health[9]. Thus, the surgical approach which does not prioritize conservation of tooth structure, may be un-necessary and often leads to the point where the majority of

dentist's time is occupied in replacement dentistry, i.e., the replacement of existing restorations that have become inadequate. The surgical approach particularly large cavity design was highly destructive and weakening of the tooth crown often led to further restorative procedures. During replacement of restorations for instance, the cavity becomes larger until very little of the original tooth crown is left to support further restoration and more extensive treatment such as crowns is required[26].

The surgical approach designed by G.V. Black was based on the gangrene theory. In other words, providers persisted in trying to eliminate the dental caries disease by gross surgical removal of tooth structure on the assumption that this will provide a cure. Cavity designs were classified and standardized and sound natural tooth structure was sacrificed in the name of geometric perfection to accommodate the restorative material[27].

Management of caries at the tooth level is termed traditional or surgical treatment whereas management at the total patient level is called the medical model of treatment[28]. G.V. Black classified carious lesions and tooth preparations by their location in permanent teeth [9]. This classification defined a series of designs based on the requirements for specific restorative materials[29].

These designs supported a surgical approach: carious lesions were completely removed and the tooth preparation extended into caries-resistant areas[23]. Dr. Black's classification did not consider the size and complexity of the lesion and therefore, may no longer be valid in managing modern caries challenges[30]. The greatest problem faced by dentists in G.V. Black's time was their lack of understanding of how rapidly or slowly the lesion progressed through enamel and dentin which ultimately led to the surgical removal of healthy tooth structures, along with the carious lesion. Mount and Ngo[29] suggested that the use of surgical correction as the primary approach to eliminate a bacterial disease needed to be re-evaluated.

The traditional surgical approach is "maximal intervention" which prioritizes restorative material retention instead of preservation of sound tooth structure. The

surgical approach was a necessary approach at the time of its development since no valid alternative existed[27]. The caries process was then thought to be irreversible: once enamel demineralization began, surgical excision was required to remove diseased tissue[23]. Patients with carious lesions were assumed to be at high-risk for disease progression and new lesion formation, with restorations sometimes planned at the first appointment. Also, restorations that were in poor condition were totally replaced rather than repaired[23]. The decision to place a restoration has traditionally occurred upon radiographic evidence of demineralization in enamel or to the DEJ[9].

Minimally Invasive Dentistry (MID)

The minimally intervention philosophy was introduced in dentistry in the early 1970s with the application of silver fluoride diammine[31]. This was followed by conservative restoration, preventive resin restoration (PRR) in the 1980s and the Atraumatic Restorative Treatment (ART) in the 1990s[4].

The primary focus in the medical model of caries management is identifying and eliminating the causative factors for caries, along with repairing damage caused by caries[28]. This is a departure from the traditional surgical model because the disease is viewed as an infection rather than as a lesion and its treatment objective is to reduce or eliminate pathogens[32]. The medical model synthesizes knowledge of the disease process into a simple conceptual model using new technologies[32]. The medical model of care addresses the early carious lesion and the causes of the disease process. Minimally Invasive Dentistry (MID) emphasizes conservative caries management strategies, resulting in less destruction of tooth structure.

In general terms, MID includes the following topics: early caries diagnosis and assessment of caries activity; the classification of caries depth and progression using radiographs; the assessment of individual caries risk (high, moderate, low); the reduction of cariogenic bacteria to decrease the risk of further demineralization; the arresting of

active lesions; the remineralization and monitoring of non-cavitated lesions; the placement of restorations in teeth with cavitated lesions using minimal cavity designs; the repair rather than the replacement of defective restorations; and assessing disease management outcomes at pre-established intervals[4].

Early diagnosis means detection of the carious lesion at early stages in order to apply remineralization therapy. To diagnose caries, the clinician, ideally, should have good lighting, a dry clean field and magnification for valid and reliable detection. Use of sharp explorers to detect initial caries is neither valid nor reliable and should be avoided[4]. Some of the diagnostic aids available that can increase validity and reliability of diagnoses are: visual inspection with or without translumination; radiography; electrical resistance (ECM: Electrical Caries Monitor); Quantitative Laser and Light Fluorescence (QLF: Quantitative Light-induced Fluorescence); Infra Red Laser Fluorescence (IRLF); Light transmission (FOTI: Fiber Optic Trans Illumination); and caries test kits (Saliva Test Kits, Lactic Acid Assessment Kits).

Caries activity is the process that begins with the presence of attached dental plaque and leads to demineralization of the underlying tooth structure. Caries activity needs to be monitored over time and often is difficult to assess. Factors involved in the disease that might be evaluated include: saliva (resting pH, stimulated salivary flow, buffering capacity); bacteria (composition, activity); diet (frequency of sugar intake, frequency of acid intake); fluoride exposures (past experience, current exposures); and history (dental, medical, compliance, and lifestyle)[4].

Remineralization of early lesions and reduction of cariogenic bacteria can help to arrest and even reverse the mineral loss associated with caries at an early stage before cavitation takes place. The demineralization process in enamel and dentin is not an irreversible process. During demineralization and remineralization cycles, the tooth surface loses and gains calcium and phosphate ions. This process relies on micro-environmental conditions, including decreasing the frequency of intake of refined

carbohydrates, ensuring optimum plaque control, ensuring optimum salivary flow and conducting patient oral health education. Agents such as chlorhexidine and topical fluorides can be applied to encourage remineralization. Chlorhexidine is an antibacterial agent and topical fluorides increase the availability of fluoride ion for remineralization and the formation of fluoroapatite with its increased resistance to demineralization[4].

Traditional cavity preparations such as those advocated by G.V. Black were developed at a time when carious lesions were usually diagnosed at a more advanced stage than lesions are today. At that time, dentists were trained to detect lesions and restore them. The most used restorative material was amalgam and cavity design preparations were more invasive than the adhesive material cavity preparation that we have today; also, high speed handpieces did not exist. Thus, with technological improvements such as adhesive restorative materials, high speed handpieces, combined with a better understanding of the remineralization and demineralization process and early caries detection, a more conservative restorative philosophy than in the past can be used. For instance, very conservative techniques such as air abrasion and lasers have been used for cavity preparation of resin-based composite restorations[4].

Repair, rather than the replacement of defective restorations, is another MID concept that can be part of the minimum surgical intervention category. It should be based on the patient's risk of developing caries, the professional's judgment of benefits vs. risks and conservative principles of cavity preparation. The replacement of existing restorations represents more than 50 percent of general dentists' activities, so that repairing restorations may save considerable time in dental practice and allow for more patients to be seen[4].

Minimal cavity designs that emphasize preservation of natural tooth structure should guide the smallest as well as the largest cavity preparation. Therefore, the next section will describe specific elements of minimal restoration design.

Minimal Cavity Preparation Designs

Developments in dental materials as well as in equipment justify a new approach to the classification of caries lesions. Prevention and hard tissue preservation are the primary goals. A proposal for a new classification system of cavities has been developed by Mount et al.[29]. It guides the profession away from the surgical approach toward the biological approach. The idea behind the new classification is that the professional should only gain access to the lesions and remove only infected areas or areas that are broken down to the point where remineralization in no longer possible. Black's concept of "extension for prevention" is no longer valid and the current paradigm is rather "prevention for extension".

Minimally invasive occlusal cavity preparation may involve only barely penetrating a fissure and may be more "free form" rather than have a prescribed shape. The preparations are usually small and minimally involve the dentin[4].

Some shallow lesions may only require minimal preparation and placement of sealants. The procedure consists of opening the fissure with a ¼ round bur to optimize visual inspection, followed by the cleaning of the fissures using a pointed brush and water and application of sealant. Application of a bonding agent to the etched surface prior to placement of the sealant has improved the retention rate and decreased marginal leakage. Light curing is advocated as it positively impacts the long-term effectiveness of the sealant[4].

There are proximal cavity designs that take advantage of high-speed handpieces and small burs for the cavity preparation. Slot preparations, a kind of proximal preparation, are the preferred preparation design for proximal lesions. It is a small box or slot design, limited in size to the extent of the lesion. The proximal lesion can be reached from the occlusal (vertical slot) or facial/lingual (horizontal slot). It involves the removal of the marginal ridge. It does not include occlusal pits or fissures, if caries removal in these areas is not necessary. It may be restored with amalgam or resin-based composite.

On the other hand, tunnel preparations are another kind of proximal cavity design that is performed by accessing the carious dentin from the occlusal surface, while preserving the marginal ridge. For this reason they are considered a conservative approach. The tunnel preparations are considered difficult to execute due to access and visibility. There are two types of tunnel preparations. The "closed" tunnel preparation leaves the demineralized proximal enamel intact and the "open" tunnel preparation is accessed from the occlusal surface [4]. It is difficult to perform tunnel cavity design preparations in children or teenagers with large pulps[4].

Several different MID techniques will be described in detail in the following sections.

Minimally Invasive Dentistry Techniques

The MID philosophy is composed of different kinds of techniques which include hand instrumentation, chemomechanical systems, air abrasion, and laser cavity preparation[4].

Atraumatic Restorative Technique (ART) is a hand instrumentation technique. ART is a minimal intervention approach to arrest a caries lesion. ART is considered to have a combined technique-material effect. ART is based on removing the infected layer and maintaining the affected layer (demineralized dentin) to arrest the caries progression (Massler's theory) while using the healing potential of glass ionomer cement (GIC) to remineralized affected dentin. ART is pursued with low speed caries removal burs and hand instruments. ART was first used to manage carious lesions in Africa in the mid-1980s. After that, "it came into use in Thailand and China in the 1990s at the initiative of the WHO, supported by the Dutch Government and also by manufacturers of glass ionomer materials"[33]. ART utilizes glass ionomers' (GI) fluoride release to remineralize affected dentin. ART's main advantage is allowing restorative treatment to be conducted in locations with no electricity and without the aid of sophisticated dental equipment or in

modern settings when traditional restorative approaches are not feasible or not appropriate. As such, ART can be a cost-effective means of providing basic oral health care when the financial resources or the dental infrastructure are limited[34]. However, ART is not widely used in the United States.

ART is also useful for in-office emergency care, temporization of treatment in rampant caries cases, pediatrics, and geriatrics (nursing-home environment). In these applications the ART procedure consists of limited excavation to remove infected dentin, cleaning walls at the periphery (DEJ) and placement of GIC material creating an effective anti-bacterial seal through ion exchange. This will stop the demineralization process. The GIC material is left in place for at least 3 weeks then removed and followed by the complete excavation of the cavity and placement of a permanent restoration[35].

Another MID technique is the chemomechanical method for dentinal caries removal which is based on the action of sodium hypochlorite (NaOCl), a proteolytic agent and the interaction of 3 amino acids with carious dentin. Sodium hypochlorite causes the removal of organic components so that the smear layer is removed during excavation and the dentin tubules are left after cavity preparation. This dentinal caries removal method, when associated with glass-ionomer material restoration, has been proposed as a good alternative in difficult locations such as sub-gingival root caries or recurrent carries at crown margins[36].

Preparation with air abrasion removes carious tooth structure using kinetic energy through abrasion without heat, vibration or noise. Air abrasion can be used to both diagnose and treat early-occlusal lesions with minimal preparation of the tooth. Cavity preparations made with this technique may have greater longevity due to more rounded internal contours as opposed to the ones made using hand instrumentation. The round contours decrease stresses and the incidence of fracture. Such preparations are normally restored with resin-based composite restorative material[4].

Challenges of using air abrasion are controlling the abrasive by using of a rubber dam and high-volume evacuation. There is a risk of air embolism in the oral soft tissue which is increased in patients with severe dust allergy, chronic obstructive lung disease, and asthma. In addition, some conditions such as open wounds, recent placement of orthodontic appliances, advanced periodontal disease, and recent extractions also pose a risk[37].

Laser cavity preparation (hydrokinetic systems) is also considered a MID technique because it removes only the caries lesion and not healthy tooth structure[37]. Lasers are used to cut dental hard tissues and can also be used to remove soft caries. Laser irrigation facilitates sealing of fissures by melting and re-crystallizing enamel. For improved retention after laser irradiation, the use of acid etching and light-cured fissure sealant demonstrate good results[37].

The replacement of restorations leads to larger restorations and sequential reduction in restoration life. Repair is a more conservative approach and is based on the fact that caries under restorations that are well sealed generally do not progress. Because repair conserves tooth structure, this should be the preferred approach instead of replacement. GIC used for restoration repair is preferable in cervical areas due to its characteristics of fluoride release and adhesion[38]. There is always a risk when choosing between replacement and repair of restorations. The professional should evaluate the risk of caries development compared to its conservative benefits in order to make a decision[39].

Adhesive dental materials are associated with conservative cavity preparations because these materials do not require mechanical retention; instead, they rely on the adhesive process to bond to the tooth structure. There are several materials that can be used such as glass ionomer cements (GICs), resin-based composite/dentin bonding agents and layered combinations of resin-based composites and GICs[40].

In 1972, Glass Ionomer Cement (GIC) was introduced as a restorative material option for anterior teeth (particularly Class III and V cavities). It is chemically composed

of silicate glass powder and polyalkenoic acid. The most important properties of this class of materials are its adhesion to tooth structure and subsequent release of fluoride and other ions such as calcium and aluminum into the teeth and saliva. It is also a material that self- recharges from the fluoride released by dentifrices and topical treatments. GICs have good performance in smooth-surface, buccal/lingual surfaces, and small anterior proximal cavities[41]. Resin-modified materials can be used for fissure sealing, cervical restorations, proximal anterior lesions in permanent teeth and proximal anterior and posterior lesions in deciduous teeth. The addition of resin to GICs can also benefit the handling properties and brittleness of the material[41].

GICs disadvantages include technique sensitivity: they are very sticky materials which require agility and manual skills from the operator. For instance, placing glass ionomer restorations with open margins are a very common mistake among inexperience students[41].

Effective bonding of resin composites, particularly to enamel, is a key factor in minimal intervention dentistry because there is no need for mechanical retention. Etching dentin and enamel creates micromechanical retentions and formation of a hybrid layer which improves the quality of the bond to the tooth structure[40]. The first composites were paste/liquid form and were developed by Robert Chang in 1969 and Henry Lee in 1970. The first resin-based composite was Adaptic (Johnson and Johnson, New Brunswick, N.J.), a paste/paste material which utilized room-temperature (approximately 8 minutes) in order to be polymerized. In the late 1970s, a photo-polymerized resin-based composite system (DENTSPLY/Caulk) was developed. This system utilized a hand-held light source that emitted ultraviolet (UV) energy[9].

Dental composite resins were heavily criticized during the 1970s and 1980s because they did not present the same physical-mechanical properties as amalgam (Summit & others, 2001). As a result, a new and better generation of hybrid composite resins were developed which have shown success in posterior tooth restorations.

Currently, the failure rates of composite restorations are more related to proper use than the materials' physical and biological properties[9].

MID also includes the lamination "sandwich" technique which takes advantage of the combination of strong adhesion of GICs to tooth structure and the superior physical properties of the resin-based composites. The combination of the two materials, where resin composite is laminated over glass-ionomer, may offer a useful alternative in situations where the occlusal load is heavy and there is a lack of enamel to provide adhesion to resin composite[4].

The concept of preventive dentistry was developed along with the early understanding of the demineralization and remineralization processes. As an extension of this concept, the philosophy of minimal intervention dentistry has arisen. MID is based on a new understanding of cariology, adhesion in restorative dentistry and bio-interaction between the restorative materials and the tooth structure. In other words, MID combines knowledge of prevention, remineralization, ion exchange, healing and adhesion with the object of reducing carious damage using the simplest and least invasive treatment possible[23]. The overall MID philosophy is to preserve as much tooth tissue as possible and to offer more patient-friendly care to patients who are fearful of dental treatments. Hence, MID can be effective in private practice and public programs[23].

A key component of MID involves remineralization of early carious lesions. Considerable research in the last three decades has reported that a carious lesion can be reversed prior to cavitation; the tooth surface can be remineralized and returned to health. The presence of fluoride will promote remineralization of the tooth surface by bonding to calcium and phosphate, returning to a remineralized stage. The next section will focus on the tooth remineralization process.

Fluoride and Remineralization

Fluoride inhibits demineralization, increases enamel resistance to acid attack and promotes remineralization by fluoride-enriched apatite. High concentrations of fluoride may lead to bacterial metabolism inhibition[42].

One of the best defenses against dental caries is fluoride but the benefits need to be balanced with the risks of dental fluorosis[43]. Community water fluoride (CWF) was considered one of the ten greatest public health achievements of the 20th century by the U.S. Centers for Disease Control and Prevention (CDC, 1999). For many years, since 1945 CWF was estimated to reduce dental caries experience by 50%; however, today is unreasonable to believe that CWF reduces caries in 50% because it is no longer the only fluoride source. Current studies of the CWF effectiveness in the U.S. reported that there is a reduction of 18-35% in caries experience among children who live in fluoridated communities compared to children living in non-fluoridated communities[43].

While those in non-fluoridated communities do not receive benefit directly, they are likely to consume fluoride in foods processed with fluoridated water and thus receive some benefit[44]. CWF has also reduced the prevalence and incidence of dental caries experience in children, adults and among elderly in the United States[45].

Another fluoride vehicle that is very effective is fluoride varnish (FV). Quiñonez and colleagues[46] conducted a randomized, controlled trial of a preschool-aged-children fluoride varnish program and assessed the cost-effectiveness. According to the results, the cost-effectiveness analysis demonstrated that FV application was more effective in reducing caries than no FV application. The FV provided an additional 1.52 months caries-free per child by 42 months of age. They reported an overall preventive effect of 35% reduction during the first 3 months after placement. The results are generally consistent with a study by Ismail & Bader[47] that reported 30-63% reduction in caries based on FV application.

Skold et al.[48] conducted a cost-analysis study in order to compare fluoride rinse and fluoride varnish cost-benefits in school-based programs. The results showed that fluoride rinse, which requires patient compliance, was less cost-effective than fluoride varnish. Based on caries incidence, this study showed that there was no difference between fluoride varnish and fluoride rinse for new dentin lesions; however, for new enamel lesions and caries progression rate, the fluoride varnish provided more effective prevention than school-based fluoride rinse programs[48].

Improved concentrations of ions such as calcium, phosphate and fluoride inhibit demineralization and help the remineralization process. Thus, public health programs that elevate the concentration of these ions are likely to provide effective caries-prevention strategies. For this purpose, fluoride has been used in a wide variety of products and its caries preventive mechanism can be explained by increased fluoridated apatite precipitation[9].

Calcium compounds and calcium carbonate have been used as dentifrice components because they increase hydroxyapatite precipitation. Nakashima, et al.[49] tested the efficacy of a dentifrice composed with calcium carbonate in enamel lesion. The calcium carbonate toothpaste was applied twice a day to the surface of the lesions followed by a brief distilled water rinse for 20 days. The results showed that there were remineralized areas in the artificial enamel lesions by use of calcium carbonate toothpaste. The calcium carbonate dentifrice presented a 48.8% mineral gain compared to no improvements with the use of the non-calcium carbonate toothpaste. In conclusion, Nakashima and colleagues[49] suggested that the calcium carbonate dentifrice may remineralize incipient enamel lesions.

With the development of new technologies, the milk product casein phosphopeptide/amorphous calcium phosphate complex (CPP/ACP) has arisen. The main purpose of this product is to increase the concentration of calcium and phosphate in the dental plaque and enhance saliva flow[50]. CPP/ACP may contribute to anticariogenic

activity and enhance remineralization of existing lesions[44]. The CPP/ACP has been recognized as a safe carrier for calcium, phosphate and hydroxide (fluoride) ions to promote enamel remineralization[51].

CPP/ACP has been used in sugar-free gums in the Reynolds and colleagues[52] study. The authors investigated the ability of CPP/ACP to be retained in supra-gingival plaque and remineralize enamel lesions in situ when delivered in a mouthrinse or sugar-free gum in a randomized assignment. The double-blind clinical trial found that mouthrinses composed of 2% and 6% CPP/ACP significantly increased calcium and phosphate concentration levels in the plaque compared to no increase from regular mouthrinse with no calcium phosphate. Regarding the chewing gums, CPP/ACP gums presented a significant increase of calcium and phosphate levels compared to the non-CPP/ACP chewing gums. This mouthrinse study demonstrated that CPP/ACP was incorporated into supragingival dental plaque and significantly increased levels of calcium and inorganic phosphate in plaque to a superior level compared to other forms of calcium. However, no studies have yet demonstrated CPP/ACP's effect on reducing caries.

Anderson et al.[53] described the use of xylitol and chlorhexidine for caries management. Xylitol is a five-carbon sugar alcohol with a similar sweetening ability to sucrose and has been shown, in several studies, to control caries and otitis media in infants. Xylitol creates an unfavorable metabolic environment for *Streptococcus mutans*, limiting the ability of the organism to utilize xylitol as an energy source. For the most part, xylitol use is considered safe, although large doses can cause diarrhea. Another product used for dental caries management is the antibacterial agent chlorhexidine which attaches to intraoral surfaces and is slowly displaced by calcium ions in human saliva. This sustained release mechanism gives the drug substantively. Its bactericidal effects are available up to six hours after rinsing with a 0.12% solution. Comparing xylitol and

chlorhexidine, Anderson et al.[53] indicated that current literature favored xylitol for caries control due to its ease of use, availability and low cost.

The knowledge and understanding of the demineralization-remineralization process that occurs in tooth structure has increased considerably in the last 30 years; however, have shown that oral health providers do not yet feel comfortable with promoting re-mineralization as a means of caries treatment. Thus, the early restorative intervention continues to be a barrier to the modern restorative approach.

There are contradictory points of view about cost-benefit of the MID approach in the literature that do not support the modern restorative approach. For instance, McComb[54] concluded, in a systematic review, that operative conservatism such as MID does not guarantee increased restoration longevity. McComb concluded that MID treatment costs are more expensive than the surgical approach. However, as part of the same study conclusion, the author reported that conservative treatments such as preventive resin and proximal slot restorations, can provide equivalent longevity when compared to the conventional techniques in the permanent dentition, and that MID improves the longevity in large-sized restorations due to the initial reduction in tooth structure removal. Due to varying results of modern restorative dentistry, more research about this topic is needed.

The next section will talk about the relationship between the MID approach and Evidence-Based Dentistry (EBD).

Evidence-based Dentistry (EBD)

The MID approach also includes Evidence-Based Dentistry (EBD), which Burt and Eklund[45] have described as doing the right thing, for the right patient, at the right time. EBD is based on three essential components: the scientific basis for treatment; the practitioner's clinical abilities; and the patient's values. These will combine for the final treatment decision-making[45]. EBD searches for valid and reliable scientific evidence

applied to the clinical patient situations combined with critical thinking in order to determine whether the information is credible[55].

Unfortunately, many accepted dental treatments have very little scientific evidence to support their use over alternative approaches. For example, Kolker and colleagues[56] suggested that little evidence is known in the literature about "why a crown should be done instead of a large amalgam." This study compared the performance of posterior large amalgam restoration (amalgam restorations composed of four surfaces or more) and crowns. The amalgam restorations or crowns had to place between five to10-years from 1987 or 1988 at the University of Iowa, College of Dentistry.

Kolker et al.[56] assessed the Treatment Outcome Trees (TOT) which tracks all treatment that the teeth received after placement of amalgam restorations or crowns. By calculating the TOT subsequent following restorative treatment could be predicted. The authors found that a higher percent of teeth with large amalgam restorations, that were placed 5 years ago, received subsequent large treatment such as root canals, extractions, and crowns. This trend continued until the restorative treatments became 10 years-old. With time, the percentage of subsequent treatments increased for large amalgam restorations from 48% to 64% and for teeth with crowns from 12% to 22%. Gender was a significant variable: the results found that females were less likely to have subsequent treatments than males, independent of the initial restorative treatment[57].

Another study performed by Kolker and colleagues[58] suggested that teeth with crowns received less subsequent treatment than teeth with large amalgam restorations. As a follow-up study using the same data source, Kolker and colleagues[59] found that, independent of large amalgams or crowns, women and teeth in the maxillary arch had higher cost-effectiveness ratios than those in men and teeth in lower arch.

In conclusion, the results of these studies showed that there was no overall difference between large amalgams, and crowns in cost-effectiveness. However, it is important to note the higher incremental cost-effectiveness for crowns compared to

amalgams during restorative treatment decision-making. Although crowns had advantages over large amalgam, Kolker and colleagues[59] were not able to conclude that crowns represented a superior restorative technique over large amalgams.

Allison and Bedos[60] investigated the lack of evidence to support restorative treatment decisions. The authors mailed questionnaires to 17,648 dentists in Canada to investigate how much access they had to dental research, how dental research was useful in their clinical situations, and if having access to dental research was a financial priority in their practices. The response rate was 15.8% (2,797 participants). Regarding the participant pool, 92.8% (2,595) were clinical dentists, 2.8% (78) teachers, 0.8% (23) researcher, and 3.6% (101) had other as their main job prescription. The majority of the respondents (95.8%) reported that research would change their clinical practice approach. Generalists reported to alter the use of a dental material ($p<0.001$), medical treatment ($p=0.035$), or educational message ($p=0.006$) based on the research. On the other hand, specialists ($p=0.002$) and teachers ($p<0.001$) reported changing at the management strategy treatment level. Changes in treatment technique was also associated with male gender ($p<0.001$).

The relationship between clinical practice and clinical research forms the basic concept of evidence treatment decision-making[61]. Both involve patients, therapeutic interventions and assessment of outcomes. Clinical practice is based on a subjective evaluation of outcomes, with clinical success judged qualitatively. Clinical research attempts to make objective assessments without knowledge of treatments received by patients to control bias. Therapeutic efficacy is quantified and findings are analyzed statistically[61].

Iqbal and Glenny[62] assessed current knowledge, attitudes, use and barriers to the use of Evidence-Based Practice by 300 general dental practitioners in the northwest of England in January 2001, using a self-completed questionnaire. The study response rate was 69.6%. Results found that when the participants were asked about what they would

do in an uncertain clinical situation, 60% responded that they would turn to friends, 12% would consult a textbook and 2% would search on the internet. In addition, 87% of respondents revealed that they would change their clinical approach based on dental research articles with highly significant results. When asked about barriers to the EBD approach in their practices, respondents mentioned lack of time, financial cuts, availability of resources and attitudes of patients to change to be the most common barriers.

An important example about EBD is the use of a sharp explores to diagnose caries lesions. Traditional methods for identifying caries have been with a mirror, explorer and radiography to detect lesions at a more advanced stage[63]. Mount and Ngo[27] recommended examinations using a rounded explorer with light pressure on the side of the tip of the explorer because a sharp explorer could create trauma to an intact enamel surface and lead to future lesions.

Warren and colleagues[64] investigated the effects of the use of an explorer in artificial root lesions in extracted teeth. The authors suggest that the trauma caused by a sharp explorer cannot be reversed by optimal remineralization. In conclusion, this *in-vitro* study suggested that the use of a sharp explorer with firm pressure against intact root surfaces should be avoided.

In summary, "MID allows dentists to become "true physicians of the mouth" rather than "tooth technicians"[65]. MID treats the entire dental caries disease process; however, the ultimate goal of MID is prevention. MID philosophy aims to reduce disease risk factors and increase protective factors. Through the MID approach, dentistry has become more scientific and research-based; however, more research is needed to assess the acceptance of MID by dental professionals.

Summary of Philosophies of Restorative Care

There is evidence in the scientific literature that supports the MID philosophy; however, MID has not been adopted quickly by dentists perhaps because of the way dental care is delivered in the U.S. Thus, the structure of dental practice in the U.S. is discussed below.

Dental Practice in the United States

The American Dental Association (ADA) is the largest dental organization in the United States. The association is highly organized and promotes the public image of dentistry[45]. According to the ADA[66] dentistry is a unique profession that offers many career options combining science and technology with helping people enhance and maintain their oral health, quality of life, appearance and self-esteem. Demand for dental care continues to grow due to the increasing number of older adults keeping their teeth longer, and increased awareness of oral health care. Dentists treat a diverse group of patients; the healthy; the ill; the young; the elderly; the disadvantaged and those with special needs.

Dentistry is a professional career that offers the flexibility to balance professional and personal lives because it offers the opportunity to be your own boss. A dentist's average income is considered in the highest 5% of U.S. income according to the U.S. Census Bureau. The practice of dentistry in the United States occurs through private and public dental practices, academic institutions, industry, and the Armed Forces[23]. By far, private dental practice is the largest component of the dental health care system, with public delivery systems making up only a small proportion of the system.

American Dental Schools

In 1840, Horace Hayden and Chapin Harris established the world's first dental school, the Baltimore College of Dental Surgery and originated the Doctor of Dental Surgery (DDS) degree. This marked the first formal education in dentistry in the United

States[67]. In the period of the 1800s, dental schools were "largely proprietary;" in other words, they were not affiliated with major universities and were private for-profit institutions. In the early 1930s the last proprietary school was abolished and all dental schools became affiliated with major universities in the U.S.[67]

As of 2010, there were 58 fully accredited dental schools in the U.S.[66, 68] The most current information from the ADA reports that in 2011, there are 61dental schools in 36 States and Puerto Rico[68]. The 61 dental schools include 3 new dental schools in the process of initial accreditation.

Dental educational programs in the U.S. lead to a Doctor of Dental Surgery (DDS) or a Doctor of Dental Medicine (DMD) degree after four years of education. The DDS and DMD are equivalent degrees. In 2004, 37 dental schools awarded the D.D.S. degree, which was first used by the Baltimore College of Dental Surgery and 19 awarded the D.M.D. which was first used by Harvard Dental School[67].

Post-doctoral Education

After graduation, dentists who seek additional training might continue their education in a specialty or other advanced program. The ADA recognizes nine specialties: Dental Public Health; Endodontics; Oral and Maxillofacial Pathology; Oral and Maxillofacial Radiology; Oral and Maxillofacial Surgery; Orthodontics; Pediatric Dentistry; Prosthodontics; and Periodontics[66]. Advanced education programs include: Postgraduate General Dentistry (PGD); General Practice Residency (GPR); and Advanced Education in General Dentistry (AEGD). Generally, GPRs are hospital-based and AEGDs are dental school-based. GPR-trained dentists are more likely to be on a hospital staff and to treat medically compromised patients[69].

Academic dental institutions are the foundation of the U.S oral health care system. Dental schools provide dental education programs (pre-doctoral), specialty training (post-

doctoral) and advanced dental education programs. The mission of academic dentistry includes education, research, and patient care[70].

Dental Workforce in the United States

Dental care delivery in the United States involves private and government entities such as private and public dental practices, academic institutions and the Armed Forces. As stated previously, most dental care is provided in private dental practices[45].

The practice of dentistry has improved for dentists: working hours have decreased and remuneration has increased. However, the pattern of practice for dental professionals is different than the needs of the nation. For this reason, Mertz and O'Neill (2002)[71] addressed this issue in their paper called "The growing challenge of providing oral health care services to all Americans". It is a systematic review of the literature that addressed and updated information about oral health care in the U.S. This study compared the dental professional and physician workforce. Results showed that the number of dentists is much smaller than physicians and that the dentist workforce has increased at a slower rate compared to the population increase in the U.S. In addition, most of the dentists were middle-aged (ages 40–55), male and less ethnically diverse. In summary, dentistry has become a more lucrative, less time-consuming and has more solo professionals than in medicine[71].

According to the 2006 ADA Distribution of Dentists in the U.S. by Region and State[72], there were 179,594 professionally active dentists (clinical practitioners, dental school faculty or staff, armed force dentists, government-employed dentists at the federal, state, or local levels, interns and residents, and other health or dental organization staff members) and 164,864 active private practitioners in the U.S. Thus, private practitioners represent approximately 91.5% of the population of active dental practitioners[72].

Among 179,594 professionally active dentists in 2006, 80.8% were male and 19.7% (35,444) were female. The mean age of all professionally active dentists in the U.S

was 49.4 years old. Also in 2006, solo dentists comprised 63.1% of all private practitioners, 20.0% worked with one other dentist and 16.9% with two or more dentists[72]. Some advantages of private practice are choice of practice location, good income, autonomy and high status in the community. Disadvantages include overhead costs, equipment maintenance and adherence to government regulations[45].

Comparing 2006 ADA Distribution of Dentists in the U.S. by Region and State[72] to the 2008 ADA dentist distribution[68], the report indicated there was an increase of 2,180 dentists. In 2008, there were 181,774 were active dentists and, of those, 167,769 (92.3%) were private practitioners. Regarding gender, 38,867 (21.4%) of all active dentists were female.

In 2008, 79.1% (143,783) of dentists reported to be general dentists and 20.9% (37,991) reported to be a specialist. Among those 37,991 specialists, 26.6% were orthodontists, 18.5% oral surgeons, 15.3% pediatric dentists, 13.5% periodontists, 12.5% endodontists, 8.7% prosthodontists, 3.7% public health dentists, 1.0% oral pathologists and 0.3% oral radiologists[68].

The ADA Future of Dentistry report predicted that the number of professionally-active dentists will be 182,255 in 2010 and 189,295 in 2020. Projections through 2020 indicate that male active private practitioners will decline in 2020, whereas the number of female active private practitioners will increase from 19.2% in 2006 to 30% in 2020.

Dental Public Health Professionals

Dental Public Health is one of the nine board-certified specialties of dentistry in the United States and has been recognized as a specialty by ADA since 1950. Dental Public Health is defined as “the science and art of preventing and controlling dental diseases and promoting dental health through organized community efforts. It is that form of dental practice which serves the community as the patient rather than the individual. It is concerned with dental health education of the public, applied dental research, and the

administration of group dental care programs as well as the prevention and control of dental diseases on a community basis."[66] The American Association of Public Health Dentistry (AAPHD) is the organization responsible for the American Board of Dental Public Health. Founded in 1937, AAPHD's mission is to improve oral health of all American citizens through early diseases detection and prevention[73].

Dental Public Health Organizations

The stated vision of AAPHD is "optimal oral health for all" (www.aaphd.org). The membership of AAPHD is composed primarily of public health dentists and dental hygienists involved in program administration, education, research and clinical practice. In May 2007, AAPHD had 876 members[74]. In January 2011, from information received from Pamela Tolson, AAPHD executive director, indicated that the AAPHD currently has under than 1000 members, not counting students (email exchanged with Pamela Tolson, AAPHD Executive Director, January 23rd, 2011)

The other major national organization for Dental Public Health in the United States is the Association of State and Territorial Dental Directors (ASTDD). This national non-profit organization represents the directors and staff of state public health agency programs for oral health. Full membership is limited to one per state, and the member is the state or territorial dental director, except where there is no director of a state oral health program. The ASTDD allows associate membership for persons other than state or territorial dental directors; in May 2008, ASTDD had 75 associate members[75].

The National Network for Oral Health Access (NNOHA) is a nationwide network of dental providers such as dentists, hygienists and dental directors. The main focus of NNOHA is improving the overall health of the underserved individuals through increasing access to oral health services in the U.S. for patients see in community health centers. The NNOHA was founded in 1990 by some members from Federally Qualified

Community Health Centers (FQHCs). The NNOHA is a non-profit organization and the mission of the NNOHA is "to improve the oral health status of the underserved through advocacy and support for Health Centers."[76]

The American Association for Community Dental Programs (AACDP) is a voluntary membership organization for local community dental programs. Members of AACDP are staff of city, county and community-based health programs with an interest in oral health issues and access to care[75].

Dental Public Health Workforce

The dental care system in the U.S. is delivered mainly by dentists in the private sector [45]. Unfortunately, there is a considerable portion of the population that cannot afford dental treatment and consequently does not have access to dental care. PH professional's primary goal is to fill the health care gaps for those whom the private sector cannot or will not treat. This is the reason why PH professionals are very much needed in the U.S. (Burt & Eklund, 2005).

Regarding the history of Dental Public Health workforce, the Association of State and Territorial Health Officials (ASTHO) reported, through the National Public Health Program Reporting System (NPHPRS), that there were two peaks in history about number of PH providers in government agencies. According to a review done by Gebbie and Merrill (2002)[77], the first big peak was in 1959 and found 1,406 dental professionals involved in PH and the second in 1980 when 2,850 were identified. These studies included any dental professional working in PH, regardless of whether they were PH diplomates or not.

In 1998, the U.S. Health Resources and Services Administration (HRSA) reported that only 2,032 public health dental workers were employed in federal, state and local agencies[78]. These oral health providers were responsible for planning, developing,

implementing and evaluating programs to promote and maintain the oral health of all American citizens.

Thus, in order to manage this health care need there are Dental Public Health programs in the U.S. to encourage the training of more dentists in PH. Currently there are 11 PH recognized programs by the ADA. The average number of professionals admitted is 1-4 students per academic program and that approximately 33 to 44 PH professionals graduate every year in PH in the U.S.[66]

The number of Dental Public Health specialists appears inadequate to meet the nation dental care challenges. Based on the ADA 2008 Distribution of Dentistry in the U.S. by Region and State, 1,405 dentists are specialists in PH which represents 3.7% of the 20% (37,991) of the specialists in 2008. Note that most of the PH dentists in the U.S. do not have a specialized training in PH; most of them are general dentists who work in public settings.

Regarding PH diplomates, the numbers is even smaller. In March 1997, there were only 127 diplomats of the American Board of Dental Public Health (ABPH). On average, nine dentists per year took the examination for the five years of 1992-1997 (ABPH, 1997). In 2009, the list of ABPH Active Diplomats showed 163 diplomats of which 5 became diplomats in 2009[74] . Based on the latest information, the ABPH has 230 active and life-time diplomates (email exchanged with Pamela Tolson, AAPHD Executive Director, on January 23rd, 2011).

The ABPH specialty certification requires two years of accredited advanced graduate education in the specialty, fulfillment of a 2-year work experience requirement and completion of the specialty board examinations including an objective examination, oral examination, PH problem solution and case history presentation.

The small number of DHP specialists can be explained by the rigorous two or more years of training and two or more years of experience in Dental Public Health practice necessary for successful eligibility the American PH board's certification plus

the low compensation compared to other specialties and private practice. In addition, there is a perception that Dental Public Health is a non-patient care specialty; consequently, this specially is not as widely recognized as other specialties in the academic and private sectors[79].

There are several PH career opportunities: PH professional can be employed in the administration of public health programs (community promotion, prevention and dental care to specified groups); they become faculty members in community-oriented programs; or become researchers in epidemiology and prevention. Researchers in the behavioral sciences related to dental health also can be considered Dental Public Health personnel[80].

Recently, more and more hygienists, nurses and administrators have become state dental directors in the U.S. This is because most of PH graduate students are international dentists and those professionals are usually not employed as state dental directors.

Kaste et al.[81] investigated the perception of diplomats of the American Board of Dental Public Health (ABPH) of their training in Dental Public Health at the pre-doctoral level. The study instrument was a mailed survey composed of 13-questions. The study population was 48 diplomats of the ABPH associated with academic institutions in March 1997. The results reported that 20 of the 55 U.S. dental schools had at least one ABPH diplomat faculty member, with a mean of 1.8 diplomats per school. Most of PH faculty held a master's degree in public health (MPH). The participants reported that lack of time, financial support, incentives, along with the rigid requirements for ABPH board certification was the principal reasons that additional faculty were not board certified. In conclusion, insufficient numbers of PH faculty at dental schools plus insufficient motivation to encourage candidates to pursue specialty status were the main reasons that faculty did not pursue the ABPH certification[81].

According to the American Dental Education Association (ADEA) annual survey of senior dental students, PH is the least popular specialty reported by the students[82].

Since 1995, less than 1 percent of senior dental students applied for PH advanced programs in the U.S. and, as reported in the 2000-2003 survey, the number dropped even further[83].

Summary of PH Professionals in the United States

In order to achieve optimal oral health, the Dental Public Health workforce should be appropriately incentivized and trained; representing the diversity of the populations it serves and is sustainable for the future. It is important to emphasize the need for PH dentists to maximize efficiency and maximize prevention by using the most modern approaches available[84].

In summary, the main purpose of the PH specialty is to ensure that well-prepared professionals will provide the leadership for Dental Public Health in the areas of pre-doctoral dental education, research, and federal, state and local dental health programs. Epidemiologic studies are an important foundation to assess the community oral health status and, with this information, oral health problems can be targeted and interventions designed. Also, clinical trials and surveys can benefit dental practice, influence oral health policies and improve the oral health and general health of the public. All these aspects are facilitated by a trained PH specialist[85]. PH practitioners have established effective prevention and dental disease control methods such as community water fluoridation programs, and have improved dental care access through programs to all Americans[45].

PH trained dentists are trained in prevention and so there is an expectation that they will be at the forefront in implementing the MID philosophy. Currently, there are no studies in the literature investigating the relationship between PH dentists and MID approach. Moreover, there are limited studies of general practitioners and MID in the literature or that have evaluated how dentists have adopted the MID philosophy in their

practices. Therefore, the next section will discuss dentists' knowledge, attitude and behavior concerning MID philosophy.

Dentists' Opinion concerning MID

Minimally Invasive Dentistry (MID) is an approach to caries management based on early diagnosis, classification of caries based on site and size of each lesion, reduction of cariogenic bacteria, and minimally invasive cavity preparation design through appropriate techniques and restorative material selections. It is unclear how dentists see the MID approach as we do not know their level of knowledge concerning MID. Therefore, this section will describe the scientific literature regarding several elements of MID including dentists' knowledge, attitudes and behavior concerning MID, dentists' restorative treatment decisions and their opinions regarding replacement and repair of restorations.

Dentists' Knowledge, Attitudes and Behavior Concerning MID

Fiset & Grembowski[32] evaluated the adaptability of MID philosophy for caries management among general dentists in Washington state. The purpose of this study was to identify whether dentists had used the medical model of caries management. The survey focused on adult caries management and use of salivary functional tests, fluoride varnishes, chlorhexidine, pit-and-fissure sealants and use of resin-based composite (RBC). The study sample was obtained by selecting every 60th name from the 1995 list of licensed dentists in Washington. In this way, a total of 532 dentists were selected to participate. Exclusion criteria included retired dentists and specialists resulting in excluding a total of 70 individuals. Three mailings were performed over a period of 13 months. The overall response rate was 70% (321 surveys) from the 462 dentists who were sent questionnaires. The participant pool was divided in two groups and participants were classified as either earlier (16%) or later adopters of MID concepts (78%). This

categorization was based on practitioner and dental practice characteristics theoretically or empirically associated with the MID philosophy, such as communication of information and practice environment[32].

Regarding demographic characteristics, 89.3% were male, 88.7% white, 59.8% graduated from the University of Washington, and 77% were in solo practice[32]. The results showed that 100% of respondents used RBC material, 40% used chlorhexidine rinse, 2% used saliva tests, approximately 35% fluoride varnishes, and 40% pit-and-fissure sealants. Further analyses were done based on early (who were among the first 22% of respondents to begin using a technique) vs. late adopters (78%). Results showed that for the use of chlorhexidine rinse, 40.7% vs. 21.3% of early and late adopters, respectively enjoyed experimenting with new treatments ($p=0.024$) and 94.1% vs. 64.6% respectively had dentist friends who also used chlorhexidine rinse ($p=0.016$). For the use pit-and-fissure sealants for adult patients, 100% vs. 73.2%, respectively, reported to know other dentists using sealants ($p=0.009$), and 95.7% vs. 56.6%, respectively, had other dentist friends using sealants ($p<0.001$). For the use of fluoride varnish, 100% vs. 52.2%, respectively, reported to have dentist friends using fluoride varnishes ($p=0.002$), and 37.5% vs. 61.8%, respectively, of dentists graduated from the University of Washington ($p=0.026$)[32].

Regarding the most important sources of information for use of chlorhexidine, sealants and fluoride varnish, the values ranged from 41-56% among the three sources for CE courses; 31-35% for conferences/seminars; 27-43% for professional newsletters; 25-49% for professional journals; and at least 25% for local dentists, study clubs, state and national meetings[32]. Local dentists were identified as a source for information for 17 to 22% for the respondents regarding the three MID techniques.

In order to analyze dentists' knowledge concerning fluoride varnish, 29 true statements were presented and the participants had the option to agree or disagree with

the statements. As a result, 20.8% of the early adopters agreed with the statements compared to 11.8% of the late adopters[32].

Regarding the reasons cited for not using fluoride varnish or sealants for adult patients, 275 dentists answered this question and 79% indicated that they did not use fluoride varnish and 52% did not use sealants for adult patients. The reasons cited for not using fluoride varnish or sealants respectively for adult patients included: lack of awareness 92%(42) and 2% (0), unaware of cost/benefit of such treatments 41%(19) and 46%(23), patient does not desire treatment 36%(17) and 40%(20), lack of insurance coverage 70%(32) and 104 (52), lack of caries risk 37% (17) and 129% (64), and other reasons such as availability 19%(9) and 9%(4)[32].

In conclusion, earlier adopters of MID concepts had more correct information about MID than later adopters. Fiset & Grembowski[32] concluded that the knowledge regarding MID was not uniform among the survey respondents.

Fiset and colleagues[86] later evaluated the relationship between reimbursement and use of fluoride varnish (FV) among a random sample of 532 general dentists in Washington state. The study instrument was a mail survey which was sent to the dentists in 1995 (n= 532) before reimbursement of FV started and to the same dentists in 1997(n= 460) two years after reimbursement rates increased. The study hypothesis was that higher reimbursement rates would increase FV utilization among dentists. Two- hundred eleven dentists (81.8%) answered both surveys. The study findings showed that 42% of dentists reported using FV regularly in 1997 compared to 26% in 1995. Regarding the source of information for fluoride varnish users, 49% reported professional journals as the main source of information followed by 45% for professional newsletters, 43% for Continuing Education (CE) courses and 34% for conferences and seminars. When the participants were asked about the reasons for not using FV, from a list of reasons, 27% reported lack of insurance coverage, 26% reported to be unaware about FV, 25% reported to not be convinced about the FV cost: benefit ratio. More that 53% of dentists who did

not use FV reported that they had the intention of using FV regularly in adult patients in the future. In conclusion, there was an increase of FV utilization from 32% to 44% from 1995 to 1997 due to reimbursement and other factors. The study's results suggest that, considering the evidence of FV effectiveness, this product was underutilized by general practitioners in Washington State[86].

Domejean- Orliaguet and colleagues[87] investigated whether French general private dentists had implemented caries management concepts in their private practices. The purpose of this study was to investigate factors related to restorative treatment and patient characteristics. These authors mentioned that based on their review of the literature; there was not much information about implementation of caries management techniques and their impact on restorative approaches in practices. The study population included 100 private practitioners randomly selected from one of the metropolitan regions of France. A mailed questionnaire was sent to the providers and a financial compensation was offered to the respondents. The participants were asked to report the characteristics of 35 consecutive preventive/restorative treatments performed in vital permanent teeth in their practices. Exclusion criteria included patients less than 7 years old, cases with pulp exposure or inflammation, and indirect restorations. Inclusion criteria were primary lesions and non-invasive procedures. The questionnaire was composed of three parts: patient characteristics, treatment information, and provider characteristics. Analytic methods included descriptive analyses and bivariate chi-squared test to investigate the relationship between treatment and patient characteristics. Of the 100 French dentists that were invited to participate, 33 agreed to do so, but only 26 completed the study. Therefore, 921 forms were completed for a minimum of 35 consecutive preventive/restorative treatments. Regarding treatment categories, 608 were initial treatment and 313 secondary treatments. From the 608 initial treatments, 51 were prevention, 517 carious lesions, and 40 non- carious lesions. Regarding treatment choices, 516 restorations were placed, 80 cases were sealants, and 12 were other

treatments. Of the 516 restorations, 378 were on posterior teeth restorations and 136 anterior teeth. Note that the article did not account for whether 2 restorations were anterior or posterior[87].

Regarding practitioners' demographic characteristics, 13 (50%) dentists were males and 13 (50%) females[87]. Eleven of the providers reported graduating from dental school 11 to 20 years earlier (44%), 9 (36%) reported more than 20 years, and 5 (20%) less than 11 years. In terms of practice settings: 10 (38.4%) reported urban, 8 (30.8%) rural and 8 (30.8%) for small towns. Regarding schedule per day, 16 (61.5%) respondents reported working 3.5 to 4 hours per day, while 10 (38.5%) reported 4.5 to 5 hours. Regarding dental assistant, 20 (76.9%) practitioners answered that they did not any have dental assistants compared to 5 (19.3%) who employed only part time assistants and 1 (3.8%) who had a full time assistant[87].

Regarding patients characteristics, 224 (49.6%) were male and 228 (50.4%) female[87]. Insurance coverage was common, with 403 (91%) of the patients having full coverage. The ratio of sound teeth to teeth present was computed for each patient and it was reported that 160 (35.4%) presented a ratio less than 0.5, 154 (34.1%) a ratio between 0.5 and 0.75, and 138 (30.5%) above 0.75. Regarding oral hygiene, participants reported that 290 (64.4%) presented none or almost no plaque, 109 (24.2%) presented plaque on many teeth, and 51 (11.4%) high plaque accumulation throughout the mouth. The frequency of the type of dental appointment was 172 (38.8%) regular attendees, 165 (37.3%) irregular, and 106 (23.9%) new patients[87].

Regarding cavity designs for posterior teeth restorations, 230 of the cavity preparations were limited only to the lesion, 12 were tunnel or slot design cavity preparations and 119 extended to sound tooth structure. Restorative materials used were 49% amalgam, 40% composite and 12% GIC or compomers. About diagnostic tools, 39% of treatment decisions were based on visual inspection, 40% probing, and 21% radiographic analyses. The authors considered that use of radiographs was much below

accepted standards for minimal invasive treatments. In addition, only 15% of initial treatments were non-invasive[87].

Domejean- Orliaguet study[87] further analyzed restoration decisions and found that decisions were significantly associated with insurance status (p=0.001), oral hygiene (p=0.011), and frequency of dental appointment (p=0.038). Cavity design was associated with patient's age (p=0.01), oral hygiene (p=0.002) and insurance (p=0.023). Dental material choice was associated with insurance (p=0.043), frequency of dental appointment (0.01, and patient dental status (p=0.036).

In conclusion, Domejean- Orliaguet suggested that dentists provided different restorative treatment depending on patients' profile. In addition they concluded that appropriate caries management protocols had not been widely implemented in most of French private practices in the study area[87].

Riley and colleagues[88] attempted to identify factors related to dentists' choice for preventive agents and if a choice of one preventive agent would make the practitioner more likely to use other preventive agents. The study population was 970 private practice dentists who reported restorative dentistry procedures to The Dental Practice-Based Research Network (DPBRN). The response rate of this survey was 58% (564 dentists), and after application of exclusion criteria, such as being a dentist from outside the DPBRN five regions (AL/MS, FL/GA, MN, Kaiser Permanent group, and SK: Denmark, Norway, and Sweden), the final study population was 534 practitioners. Note that DPBRN requires that participants provide information about their dental practice characteristics and providers characteristics at the time of their enrollment in the network. Therefore, the most important demographic characteristics that were significantly associated with use of dental caries preventive agents were practitioner years of dental practice and proportion of patients with private insurance. Greater practitioner years of dental practice was related to less use of non-prescription fluoride (p=0.049), prescription

fluoride (p=0.036), and use of chlorhexidine rinse (p=0.002). Patients with private insurance was associated with more in-office fluoride applications (p=0.049)[88].

The mail questionnaire was sent to the participants asking about the percentage of patients older than 18 years old with dental sealants who would be recommended to use over-the-counter (OTC) fluoride rinse, highly concentrated fluoride toothpaste, chlorhexidine rinse, or xylitol chewing gum. Also, participants were asked if they would perform caries risk assessment for their patients and if they would do individualized preventive treatment. Regarding the findings, approximately 15% reported to use dental sealants, 38% in-office fluoride, 27% OTC fluoride, 25% highly concentration fluoride, 25% chlorhexidine rinse, and 33% xylitol chewing gum[88].

In addition, a hypothetical clinical case was described and related to different scenarios which the dentists could report their treatment decisions. The clinical case presented was: "… a 30-year-old female with no relevant medical history. She has no complaints and is in your office today for a routine visit. She has attended your practice on a regular basis for the past 6 years."[88] For the low-risk scenario, they added that "she has no other restorations than the one shown, no dental caries, and is not missing any teeth." [88] For the high-risk scenario that "she has 12 teeth with existing dental restorations, heavy plaque and calculus, multiple Class V white spot lesions, and is missing five teeth"[88]. Also, participants were able to see occlusal pictures of the specific teeth and radiographs for proximal lesions.

Based on the scenarios, the participants were asked about occlusal lesions, and the results showed that 187 (36%) of respondents would not restore the occlusal lesion in a low-risk patient immediately, they would monitor and restore the lesion later if necessary, 322 (60%) would restore the deeper lesions only and 13(3%) would immediately restore the early lesions in the low-risk patient[88]. For interproximal lesions, 236 (47%) of respondents reported that they would delay restorations for lesion in a low-risk patient,

269 (53%) would restore the deeper lesions, and 2 (less than 1%) would immediately restore the early lesions in low-risk patient.

For results according to preventive agents used, the participants were divided in three categories related to their preventive agent choice: "selective users" (N=339), "non-prescription fluoride preference" (N=75), and "in-office fluoride preference" (N=111)[88].

"Selective users" (N=339) represented the group of dentist who used preventive agents in a moderate way. This group reported that 19% of their adult patients would receive fluoride dentifrice prescription, 10% who would receive a dental sealant, and 64% would use caries risk assessment for their patients[88].

The "Non-prescription fluoride preference" (N=75) group reported that 18% of their adult patients would receive fluoride dentifrice prescription, 23% who would receive a dental sealant, and 83% would use caries risk assessment for their patients[88].

The "In-office fluoride preference" (N=111) group reported that 23% of their adult patients would receive fluoride dentifrice prescription, 33% would receive a dental sealant, and 70% would use caries risk assessment for their patients[88].

In conclusion, Riley and colleagues[88] results suggested that dental caries preventive agents are widely used by private practitioners; however, caries risk assessment is only used by some dentists. The use of preventive agents was associated with younger dentists and practices with high percentage of patients with private insurance.

Gaskin and colleagues[89] evaluated the federal service dentists' (Air Force, Army, Navy, and Public Health Service) and civilian dentists' familiarity with MID using a mailed survey. The study sample was 1500 members of the American Dental Association including 900 federal service and 600 civilian dentists. The purpose of the study was to describe the knowledge, attitudes and behavior of federal and civilian dentists in the U.S. concerning MID concepts. The survey was focused on dentist demographic and practice characteristics, MID knowledge, MID attitudes and MID behavior. The questions were

closed ended. After addressing study exclusion criteria, the effective response rate for this study was 31% (N=465)[89].

Regarding demographic findings, results showed that 81% of participants were male[89]. Federal dentists were younger and had graduated from dental school later than civilian dentists. Overall the mean age was 45.6 years (from 26 to 75 years); federal dentists were younger (37.6 years) than civilian ones (49.1 years). The mean number of years since graduation was 22.8 years for civilian and 10.6 years for federal. The mean number of years in practice was 20.6 years for civilian and 8.8 years for federal. Fifty-eight percent of respondents completed a postgraduate training; of those, 75% of federal dentists and 51% of civilian dentists completed some type of postgraduate training. Seventy-six percent of respondent reported to have more than 20 CE course credit hours per year, and approximately 65% reported 76-100% of their work time per week to be in direct patient care[89].

Regarding MID knowledge, Gaskin's study[89] presented two questions to address this topic which were: "How much do you know about MID?" and "How much do you know about ART?" The findings revealed that 37.2% of respondents knew "some" about MID and 36.6% knew "some" about ART. Those knowing "none", were 10.2% and 13%, respectively. More of respondents reported to know "much" about MID, as results showed that 41.5% of respondents knew "much" about MID while 21.4% knew "little."[89]

Regarding MID attitudes, the question was "What is your attitude toward fluoride as an effective remineralizing agent for adult patients?"[89] Results revealed that 96.7% agreed or strongly agreed that fluoride was an effective remineralizing agent and only 0.4% of respondents disagreed. In addition, there were three subquestions that addressed dentists' attitudes concerning MID philosophy. Regarding agreement with the subquestions, 60.4% of respondents agreed that G.V. Black cavity preparation were still relevant in some clinical circumstances, 91.8% agreed or strongly agreed that the use of

adhesive restorative materials such as RBC reduced the size of cavity preparations and 63.5% agreed that there is time to perform caries risk assessment for every patient[89].

Regarding behavior towards MID, Gaskin's study[89] posed four subquestions considering clinical decisions for white-spot lesions, stained composites, carious lesions on anterior teeth, and enamel proximal carious lesions. Results showed that 56.4% of the respondents would restore and not extract a central incisor in a high risk patient with financial limitations, 70% would monitor and not restore a white-spot lesion on a low-caries risk patient, 67.1% would monitor and not replace an anterior restoration in a high risk patient where esthetic was not a concern, and 14.2% would monitor and not restore a proximal carious lesion in a high risk patient with limited finances. Note that all these percentages were related to this behavior in these situations always or most of the time[89].

Regarding dental practice behavior related to MID, 41.9% of respondents reported that they always or most of the time used topical fluoride, 33.7% performed caries risk assessment for all patients, 20.1% prescribed 5,000 ppm fluoride toothpaste, 19.2% sealed composite restorations, 13.5% sealed amalgams, and 13.5% remineralized non-cavitated lesions[89].

Overall, the results showed that female dentists used the MID approach more than male dentists[89]. Also, remineralization of non-carious lesions was used more among federal dentists than civilian dentists. Less than 10% of respondents used microbial tests, chlorhexidine of saliva enhancer materials such as CPP/ACP paste (e.g.: MI paste). Only 30.9% of civilian dentists' patient pool was between 0 to 18 years of age, which limited this study's results to an adult population. In conclusion, Gaskin and colleagues'[89] study suggested that federal service dentists have more knowledge and are greater users of MID techniques compared to civilian dentists in the United States.

Dentists' Restorative Treatment Decisions

The caries management by risk assessment practitioner's guide by Young and Featherstone[90] stated that the terms Minimal Intervention, MID, and CAMBRA all convey the same meaning and that they all stand for prevention, conservative cavity preparation and evidence-based clinical decisions. The following section will review studies related to dentist's treatment decisions related to MID philosophy.

Brennan & Spencer[91] examined factors related to dentist treatment decisions, classified dentists in terms of clinical decision making and investigated the relationship between decision-making and services provided. The study population was 1,202 dentists randomly selected from the Australian Dental Association. A mailed survey composed of six pairs of alternative treatment choice scenarios was sent to the dentists. The questionnaire asked the dentists to list factors important in choosing between alternative treatments pairs which included: crown versus amalgam; root canal versus extraction; bridge versus denture; prophylaxis versus scaling; visual examination versus radiographs; and preventive intervention versus restoration. Services provided were recorded by using the Australian Dental Association's 1992 schedule of dental services. Three follow-ups were sent to non-respondents. The study response rate was 676 dentists (60.3%); however, only 552 were considered for analysis because 81 dentists were not currently working in Australia. The results revealed that 80% (N=276) of the dentists were males, 20% (N=69) were females and 29.3% were between 40 to 49 years. There were no significant differences in treatment decisions by provider age or gender. The respondents ranked the most important factors that would influence their treatment decision in the following order: treatment cost, caries risk, patient preference, periodontal status, oral hygiene status and patients' age. It was noted that dentists tended to consider patients' preference more than treatment options. Also, many dentists reported that factors such as patients' socioeconomic status influenced their treatment decisions. The authors concluded that treatment decision making is a complex process and that it is

composed of many different factors. Such decisions are influenced by provider clinical decision-making style: in other words, dentists that were taught a more invasive approach were more likely to choose more invasive treatments than dentists trained in conservative techniques[91].

Tubert-Jeannin and colleagues[25] addressed the caries management strategies taught in French dental schools by operative dentistry faculty members. The study population was 180 operative faculty members at sixteen dental schools in France. Five dentists were excluded because they did not practice in a university practice yielding a sample size of 175 teachers. The mailed survey instrument was divided in two sections and respondents could reply anonymously. The first section presented clinical scenarios focused on different stages of caries lesions, restorative techniques and material choice. The second section was composed of statements or questions pertaining to the knowledge of proximal lesions progression such as the average time for proximal lesion progression from the enamel to the dentin in the permanent dentition. All questions were related to a clinical hypothetical scenario of a twenty year-old patient with good oral hygiene, low caries risk level and who visited a dentist annually. The study response rate was 49.1% (n=86). The findings revealed that 51.2% of respondents were 35 to 50 years old and 60% of respondents had a private practice in addition to their teaching activity. Regarding beliefs, 88.3% believed that radiographs underestimate caries lesions size compared to clinical examination findings and 26.2% believed that it was very important to never fill a sound tooth compared to 19% that believed it was very important to fill all carious lesions regardless of size. Responses to the questions regarding the average time a lesion would progress from outer enamel to dentin showed there was a variety of answers: six months (10%); seven to twelve (32%); thirteen to twenty-three (33%); and more than two years (25%). Regarding lesions only in enamel, 21.9% of respondents would restore the lesion whereas 39% would do a minimal cavity preparation to the dentin-enamel junction (DEJ) for a carious lesion confined to enamel, and another 39.1% would wait until the

lesion reached dentin. In cases where a restoration was clearly needed, 61% would perform a tunnel preparation, 36.9% a saucer-shaped preparation and 2.4% a traditional class II preparation. Regarding material choice in such cases, 78.6% suggested composite or composite plus glass-ionomer restoration, 11.9% glass-ionomer only and 8.3% would recommend amalgam as the material of choice. In conclusion, the authors suggested that there was a wide disparity among French operative faculty members' opinions and beliefs regarding dental caries clinical management, particularly regarding proximal carious lesions. Also, the authors mentioned that, based on the wide variability of opinion among faculty, students' treatment may be influenced. This, in turn may lead to health and economic consequences for patients and society because the treatment may be overly invasive and increase treatment costs[25].

The inconsistency of treatment decision-making in dentistry is widely known[91] and differences in treatment thresholds may be the main reason for this wide variation. Therefore, in 1992, Kay and colleagues[92] examined the impact of dentists' restorative treatment thresholds in treatment decision-making in dentistry. Twenty dentists in the city of Glasgow, United Kingdom made a total of 360 treatment decisions about proximal lesions based on 15 pairs of bitewing radiographs. The scenario described a 16 year-old with moderate caries risk who visited a dentist annually. Radiographs were taken of mounted extracted teeth and all participants examined the same pairs of radiographs. Results showed that 3 dentists would restore all lesions that presented in enamel only, 8 would restore any lesion that had reached the DEJ and 9 would only restore if the lesion had reached dentin. The study found that dentists often do not agree regarding decisions to restore. In conclusion, the authors suggested that different restorative treatment thresholds should not be considered as the reason for inconsistent treatment decisions among dentists[92].

In a later study, Kay & Nuttall[93] investigated dentists' treatment decision-making. This study surveyed 20 dentists from Glasgow, United Kingdom. The participants were

selected from the "Yellow Pages" phone book and all selected participants agreed to participate in the study thus, the response rate for this study was 100%. In the first part of the study, all participants answered a survey about treatment thresholds, decisions and attitudes, and second they analyzed 15 bitewing radiographs and had to make the decision about the treatment. So, results were collected regarding the two parts and matched in order to investigate whether the dentists were consistent with their treatment decisions. The "gold standard" answer was that all carious lesions in the bitewings should be restored when they extended to dentin. Fourteen of the 20 dentists reported that they would restore lesions which extended to dentin, 3 participants reported to be more concerned about being too invasive and 3 dentists reported that they would rather restore all carious lesions, even though doing so would risk restoring sound teeth. Only 11 dentists who answered "definitely restored" in the survey would actually perform restorative treatment when these situations were presented in the radiographic scenarios. In conclusion, overall the treatment decisions were not predictive factors of their treatment thresholds[93].

Lewis and colleagues[94] evaluated the relationship between restorative thresholds, restorative decision-making and the depth of carious lesions in proximal areas among Canadian dentists. The study population consisted of 16 dentists who worked at the dental school clinics of the North York Dental College (Ontario, Canada) and in private practice. Fifteen pairs of bitewing radiographs, depicting carious lesions with different lesion depths, were shown independently to the participants and the participants indicated their treatment decisions. The participants were shown the same radiographs, randomly assigned, one-half hour later and asked to report their restorative treatment thresholds again. Findings showed that 3 dentists would restore enamel lesions, 9 would wait until the caries reached DEJ and 4 would wait until the caries reached dentin. Overall, the participants reported that they would restore 12.9% (627) of the lesions, 5.9% (289) would probably restore and 4.7 % (227) would possibly restore proximal lesions at the

enamel level. Regarding lesion depth, 63.9% (3,110) lesions were classified as sound, 12.4% (604) as present in outer enamel, 5.3% (258) as inner enamel, 3.4% (164) as at DEJ, 9.1% (442) as outer dentin and 5.9% (286) as inner dentin. Inconsistencies were found in dentists' restorative treatment thresholds and false positive inconsistencies (i.e.: "Definitely restore") were more prevalent than false negative ("Definitely not restore"). Participants tended to be more invasive in their treatment decisions during the second viewing of the radiographs. This study suggested that restorative thresholds should not be taken into consideration in explaining restorative decision-making by dentists because the same dentist analyzing the same radiograph at different times might have different treatment opinions. In summary, this study showed that dentists are not consistent with their restorative treatment thresholds when evaluating the same case at different times[94].

Traebert and colleagues[95] examined the treatment decision-making of southern Brazilian dentists. The study instrument was a phone interview in which 3 calibrated dentists described clinical cases including patient's characteristics including oral hygiene, patient compliance with oral care, treatment affordability, the depth of proximal carious lesions, and lesions' translucence in bitewing radiographs. A case about dark fissures and white spots was also included in the interview process. The study sample size was 929 dentists randomly selected from three southern states in Brazil: Paraná, Santa Catarina, and Rio Grande do Sul. The response rate was 840 dentists which represented 89.4% of the total population. Study findings revealed that 96.9% of respondents would restore the lesion when it reached dentin, 79% would restore when the lesion extended to the DEJ, 54.4% would restore the lesion when it was in inner enamel and 31.5% would restore the lesion in outer enamel. Also, 21.8% of respondents reported that they would restore dark fissures without signs of demineralization. Overall, the dentists with postgraduate training presented a more conservative treatment approach than the ones without advanced training. The study did not report significant differences based on other variables, such as age or gender. In conclusion, based on the findings there was a large proportion of

dentists that would restore lesions confined to enamel; therefore the authors suggested that southern Brazilian dentists might over-treat patients[95].

Traebert and colleagues[96] again investigated the restorative thresholds of southern Brazilian dentists. The in-office survey was conducted by a trained dentist and included 89 dentists located in the Midwest area of southern Brazil (Santa Catarina state). Four different bitewing radiographs with different carious lesion depth were shown to the participants. Response rate was 94.4% (n=84). Results showed that 91.7% of dentists would restore lesions which extended to dentin, 33.3% would restore lesions in enamel but not involving the DEJ and 16.7% would restore lesions in inner enamel. The authors concluded that there was a wide variation in restorative thresholds based upon the carious lesion depth by bitewings radiographs among Brazilian dentists, and that this trend may lead to overly invasive restorative treatments[96].

Another study related to restorative treatment thresholds was reported by Ghasemi and colleagues in 2008[97] . This study was conducted during two dental meetings in Tehran, Iran. The 1,033 participants received two clinical case descriptions with respective bitewing radiographs: one case presented a low-caries patient and the other one a high-caries patient. Sixty-three percent of respondents were men and 37% females. The survey findings demonstrated that 77% of participants would restore a lesion in enamel in the high-risk patient case and 32% would restore the enamel lesion in the low-risk patient scenario. Female dentists reported a more conservative restorative approach than did males. The authors concluded that Iranian dentists tended to be invasive in their restorative treatment approach[97].

Replacement of Restorations

One of the main MID tenets focuses is conservative cavity preparations and preservation of tooth structure. Since MID philosophy prioritizes conservative restorations, repair is more consistent with this philosophy because it more frequently

preserves tooth structure. Studies have shown that repair can become the definitive treatment in many cases; however, in other circumstances there are reasons for replacement of the existent restorations.

A study performed by Mjör and Medina in 1993[98] investigated the reasons for placement and replacement for gold restorations. Mailed surveys were sent to 20 dentists. The participants were asked to indicate the main reasons for placement and replacement of gold restorations. Participants were also asked to record the longevity of restorations until need for replacement and report the age of the gold restorations which had not needed replacement for more than 10 years. This study only included patients who attended the clinicians' private practice regularly for more than 10 years. The results showed that 480 cast gold and 265 compacted gold restorations were placed. The reasons for placement of the 480 cast gold restoration were 39% to replace an amalgam restoration, 29% to replace gold restoration, 23% due to primary carious lesions and 9% to replace composite restoration. Regarding the 265 compacted gold restorations reported, 40% were placed due to primary caries, 26% to replace other gold restoration, 18% to replace another kind of filling and 16% to repair defective gold casting margins. Regarding restorations' longevity, the study revealed that 111 of the 265 compacted gold restorations that failed had a mean age of 18.5 years. Gold castings' life-span was between 15 to 16 years and compacted gold restorations were between 17 and 18years. In summary, findings showed that the most cited reasons for cast gold replacement included fractured tooth (36%) and secondary carious lesions (22%). For compacted gold restorations replacement, the most cited reasons were large restorations (29%) and secondary caries (21%)[98].

Gordan and colleagues[99] investigated whether resin-based composite (RBC) repair is taught in the North-American dental schools and compared the results with a similar European survey. The mailed survey was sent to one faculty member in each of 64 dental schools located in U.S., Canada and Puerto Rico. The response rate was 81%,

(52 dental schools) and from those, 37 (71%) reported to teach RBC repair techniques to their students. Of the 71% that taught RBC repair, 27 (73%) of the 37 reported teaching RBC repair at the clinical level, 3 (8%) reported teaching such techniques during preclinical lectures and 7 (19%) did not specify clinical or didactic. When the authors asked about reasons for RBC repair, 31% reported margin defects (n=84) and 27% margin discoloration (n=73) as being the most cited indications. Regarding the reasons to teach RBC repair, 37% answered tooth structure preservation (n=100) and 27% answered less invasive procedures to the pulp (n=73) as the most commonly cited reasons. In conclusion, the authors suggested that North-American dental schools teach RBC repair techniques, considering this restorative approach as a definitive restoration[99].

Blum and colleagues[100] conducted a similar study to the 2003 Gordan's study[99]. The Blum survey was conducted among dental schools in the United Kingdom, Ireland, Germany, and Scandinavia. A total of 58 institutions were invited to participate in this survey. The response rate was 83% (48), which included 100% (15) of schools from UK and Ireland, 75% (24) of German, and 82% (9) of Scandinavian schools. Results revealed that all British, Irish, Scandinavian and 92% of German schools taught RBC repair in a clinical situation; however, only 86% of Scandinavian and 83% of German schools considered RBC repair a definitive and successful approach. When the authors asked about the reasons to not teach RBC repair, the German respondents indicated lack of evidence (21%) and no clinical experience with this type of procedure (17%) as the most cited reasons. The authors concluded that there was variation in teaching RBC repair techniques among dental schools in the United Kingdom, Ireland, Germany, and Scandinavia[100].

A Cochrane review by Sharif and colleagues[39] regarding the effectiveness of replacement versus repair of defective restorations in adults analyzed 279 scientific articles related to resin based composite (RBC) replacement and repair. By definition, RBC replacement was described as complete removal of restoration, secondary caries,

bases and liners of a restoration, followed by new restoration placement. On the other hand, repair included removal of the defective restoration part only.

The criteria used by Sharif and colleagues[39] Cochrane review were that a study had to involve adults more than 16 years-old as the study population and those subjects must have defective restorations in premolar and molars. Also, studies were required to be a randomized controlled clinical trial and not be considered a duplicate study and must meet specific Cochrane review inclusion and exclusion criteria. Therefore, after screening 279 studies, only 4 studies were selected for further analyses: Gordan[101], Moncada[102], Moncada[103], and Moncada[104]. However, Gordan[101]did not randomize all study groups. Moncada used the same study population in both the 2006 and 2009 studies and Moncada[104] did not randomly allocate groups (the study's groups were defined by type of restoration defect). Hence, none of the 279 studies met the Cochrane review criteria as there was not a randomized clinical trial that evaluated the effectiveness of RBC replacement versus repair procedures. Based on articles review, the authors suggested that clinicians should base their clinical decisions on their experience, individual circumstances and patients' preference.

Sharif and colleagues[105] also evaluated the effectiveness of amalgam replacement versus repair in adults. This review analyzed 145 potential studies about amalgam replacement and repair. Article selection was based on studies' titles and abstracts and was conducted by two investigators. Studies that appeared to be duplicated were eliminated. As a result, only 3 studies Moncada[102], Moncada[103], and Moncada[104] met these requirements. However, two of the Moncada studies, 2006 and 2008 presented the same population and patients were not randomly allocated to treatment groups on the Moncada[104] study. Therefore, similar to the RBC Cochrane review, none of the 145 studies were classified as randomized control clinical trial and eligible for inclusion.

In conclusion, based on these two Cochrane reviews by Sharif and colleagues[105] regarding RBC and amalgam replacement versus repair, the authors found that there were

no randomized controlled clinical trials regarding this subject in the literature. In general, the authors suggested based on the articles available in the literature that amalgam repair restoration could be effective and 2-year survival rates were good. Regarding clinical treatment decisions, this paper conformed to the findings of the previous literature on this subject, and suggests that clinical decision about amalgam replacement versus repair should rely on clinician experience, individual situations, and patients' preference.

Mjör and colleagues[106] evaluated the reasons for replacement of restorations on permanent teeth in general dental practice and analyzed whether it differed by patients' age and gender or dentists' gender and year of graduation. The authors evaluated 24,429 restorations done by 243 Norwegian dentists. Of these, 9,805 were replaced and the reasons for replacement were recorded. The most commonly cited reason for replacement of a restoration was found to be secondary caries (41%), fracture of restoration (14%) and discoloration of the restoration (8%). They found that secondary caries was the reason for replacement of each type of restorative material studied, and that discoloration was still a significant reason for replacing composite restorations. The study also found that female clinicians and the youngest dentists diagnosed secondary caries more frequently than did male clinicians or the most experienced groups. The authors stated that the difference in the diagnoses of secondary caries between the younger and most experienced clinicians could be attributed to better judgmental ability gained with experience. Mjör and colleagues[106] acknowledged the limitation that the clinicians were not calibrated and justified this by mentioning that decisions to replace a restoration are subjective in 'real life' dentistry as well. In conclusion, the authors suggested that there is a need to emphasize why and when not to replace a restoration during the didactic and clinical education of dentists[106].

As with any other restorative materials, RBC has finite life-span, and the main reasons of RBC restorations are discolorations and secondary caries[107]. Replacement of restorations requires removal of more tooth structure and in the case of tooth colored

filling such as composites, removal of sound tooth structure may occur because of the inability to distinguish between sound tooth structure and composite restoration, which might affect life of the tooth[108].

Summary of Dentists' Opinion concerning MID

Gaskin and colleagues[89] is the only study in the literature that specifically investigated dentists' knowledge, attitudes and behavior concerning the MID approach. Gaskin's study found that younger dentists were more likely to use MID philosophy than older dentists. In addition, many studies in the literature have shown that dentist's decision-making is affected by many factors, and repair of restorations is not widely used in the U. S. In conclusion, it appears that the MID philosophy has not been utilized thoroughly in dental practice in the U.S.

Overall Summary of Literature Review

Clinical trial and *in-vitro* studies have demonstrated that dental caries is a preventable infectious disease and that dental caries is the main reason for placement and replacement of restorations. As evidence-based dentistry has developed through the years, technology has improved and dental caries rates have declined among the population.

In the early 1970s, a new approach for caries management developed with concepts based on the medical model. This new philosophy prioritized caries risk assessment, early caries detection, remineralization of tooth structure (i.e., fluoride), adhesive restorative materials, conservative cavity preparations and chemotherapeutic agents to preserve tooth structure and to increase restored tooth longevity and minimize invasive interventions.

Decision-making in dentistry is a complex process. Several studies have shown that many factors are related to its decision, such as patients' treatment affordability, patients' preferences and providers' training.

Thus, with more evidence-based dentistry, new technologies, the decline of dental caries rates, more appropriate diagnostic processes, greater reimbursement and deeper understanding of the MID approach; it would be logical for dentists to begin changing their dental treatment philosophies. However, while evidence in the literature has shown that dentists are using MID, too few studies have been reported to allow assessment of whether MID use is increasing.

If dental philosophy is to shift from detecting and treating lesions to more general diagnosis and treatment of the whole patient, it will likely be a long process because first dentists and their team (hygienists, dental assistants, lab technicians), then the public will have to be educated. Dentistry will have to change from a profession that values technical procedures to one that values diagnosis and management.

There are no studies available that have examined PH dentists' knowledge, attitudes, and behaviors concerning MID in the U. S. The study detailed in this paper is the first to evaluate information regarding PH dentists' familiarity with the MID philosophy. This Master's thesis research assessed a sample of U.S. Public Health providers' knowledge, attitudes and behaviors regarding minimally invasive dentistry. Considering the high-risk status, the public insurance coverage of many PH practitioners' patients and the potential impact MID could have on public insurance programs; this study will help to inform public policy regarding such dental care in the United States.

CHAPTER III

MATERIALS AND METHODS

Introduction

The primary purposes of this study were to determine if Minimally Invasive Dentistry (MID) is considered to meet the standard of care among public health dentists in the United States, and to identify factors associated with beliefs that MID meets the standard of care. A secondary purpose was to explore factors associated with the use of a sharp explorer in dental caries detection. The research instrument was an on-line survey. Names and e-mail addresses of participants were obtained from the National Network for Oral Health Access (NNOHA) and American Association of Community Dental Programs (AACDP) membership lists.

Appendix A shows a copy of the introductory e-mail. Appendix B shows a copy of the survey instrument. All independent and dependent variables are summarized in Appendix C.

It should be noted that the primary intention of this research was to survey PH dentists; however, because there are few dentists with formal PH training, the focus of this research shifted to dentists working in public health settings. Thus, in the rest of this thesis, the term PH dentist is used to denote dentists working in public health settings, regardless of training. It should also be noted that there are no explicit standards of care for dentistry in the current literature, so the approach used in this study was to leave it to the participants to classify whether they believed that their understanding of MID met the standard of care in dentistry in the U.S.

Research Questions

The general research questions addressed by this study were:

1. In PH dentists' opinions, does MID meet the dental professional standard of care for treatment of primary teeth in the United States?

2. In PH dentists' opinions, does MID meet the dental professional standard of care for treatment of permanent teeth in the United States?
3. What factors influenced PH dentists' responses to the previous research questions?
4. What factors influenced PH dentists' use of sharp explorers to detect caries?

Hypotheses

General Hypotheses

1. General Hypothesis: The majority of public heath dentists believe that MID does meet the dental professional standard of care for primary teeth in the United States.
2. General Hypothesis: The majority of public heath dentists believe that MID does meet the dental professional standard of care for permanent teeth in the United States.
3. General Hypothesis: There are certain dentist and practice factors related to views that MID meets the U.S. standard of care.
4. General Hypothesis: There are certain dentist and practice factors related to the use of a sharp explorer for caries detection.

Specific Hypotheses

The specific hypotheses for this study are as follows:

1. A majority of dentists who believe that ART meets the standard of care for primary teeth in the U.S. also believe that MID meets it for permanent teeth.
2. A higher proportion of female dentists believe that the MID philosophy meets the standard of care for treatment of primary and permanent teeth than of male dentists.

3. A higher proportion of dentists who graduated in the past three decades, believe that the MID philosophy meets the standard of care for treatment of primary and permanent teeth than of dentists who graduated more than 30 years ago.
4. A higher proportion of dentists with PH or general public health post-graduate training believe that the MID philosophy meets the standard of care for treatment of primary and permanent teeth than of dentists without such training.
5. A higher proportion of dentists with Pediatric Dentistry training believe that the MID philosophy meets the standard of care for treatment of primary teeth than of dentists without such training.
6. A higher proportion of dentists with General Practice Residency training believe that the MID philosophy does not meet the standard of care for treatment of primary teeth than of dentists without such training.
7. A higher proportion of dentists who have heard more about MID believe that the MID philosophy meets the standard of care for treatment of primary and permanent teeth than of dentists who have heard little or nothing about MID.
8. A higher proportion of dentists who received MID training during dental school believe that the MID philosophy meets the standard of care for treatment of primary and permanent teeth than of dentists who did not receive MID training during dental school.
9. A higher proportion of dentists who received MID training in a didactic format believe that the MID philosophy meets the standard of care for treatment of primary and permanent teeth than of dentists who did not receive MID training during dental school.
10. A higher proportion of dentists who treat a large proportion of Medicaid patients do not believe that the MID philosophy meet the standard of care for treatment of primary and permanent teeth than of dentists who see small proportion of Medicaid patients.

11. A smaller proportion of dentists with PH or general public health post-graduate training use a sharp explorer during caries detection than of dentists without such training.
12. A smaller proportion of dentists who graduated in the past three decades, use a sharp explorer during caries detection than of dentists who graduated more than 30 years ago.
13. A higher proportion of dentists who worked in federal dental clinics believe that the MID philosophy meets the standard of care for treatment of primary and permanent teeth than of dentists who worked in other settings.
14. A higher proportion of dentists who worked in federal dental clinics use a sharp explorer during caries detection than of dentists than dentists who worked in other settings.

Research Design

This was a cross-sectional observational study. This study utilized a sample of public health dentists within the U.S., all of whom were NNOHA and AACDP members. The public health dentists' sample size was 363 providers (290 from the NNOHA and 73 from the AACDP).

Survey Instrument

The survey was divided into two sections and consisted of thirty questions. The first part asked about dentists' familiarity with the MID approach, while the second part gathered information about practitioner and practice characteristics. Appendix B presents the questionnaire.

Several questions (numbers 1, 7, 8, 9, 10, 11, 12, 13, and 14) used Likert-type scale response categories (1-5) to assess the respondents' levels of agreement regarding preventive and restorative techniques such as use of ART, tunnel preparations, performance of caries risk assessment for all patients, and use of MI paste.

Many questions included statements for which the participants were asked if they agreed or used specific techniques. The statements were created based on the literature. A list of MID features was created and specific questions related to each feature were developed. An attempt was made to include most of the procedures, concepts and techniques related to MID in order to have a relevant survey instrument to assess United States public health dentists' awareness and use of MID techniques.

The main purpose of the survey was to determine whether MID was considered to meet the standard of care for primary teeth (question 5) and permanent teeth (question 6) in the United States. However, after data collection and review, the use of a sharp explorer in caries detection (question 10a) was included as a new dependent variable. The decision to analyze the use of a sharp explorer as dependent variable was based on its common usage during the caries detection process. Studies have shown that the use of sharp explorers for caries detection should be avoided because they may produce traumatic defects on hard tissue leading to future caries development[109]. In addition, there is no evidence in the literature that using a sharp explorer improves the accuracy of caries diagnosis beyond visualization alone[110,111]. In contrast, there is evidence that the use of a sharp explorer can lead to the transfer of microorganisms from one fissure to another[112].

Also, the use of a ball ended (not sharp) explorer or the side of the explorer tip (not the tip), with gentle pressure (not firm) for caries detection, is related philosophically to MID. The third reason to include this analysis was because there was an even distribution across the range of responses for the use of sharp explorer.

The use of sharp explorer question used Likert scale response categories (1-5), with options of: always (100%), most of the time (75-99%), often (50-74%), sometimes (10-49%), and never or rarely (0-9%). For the purpose of analysis, the responses were dichotomized. Therefore, when the respondents answered always, most of the time, and often, these answers counted as a yes answer; on the other hand, sometimes, never or rarely counted as a no answer.

The research instrument was pre-tested with 5 faculty members from the Department of Preventive and Community Dentistry and 6 from the Department of Operative Dentistry at the College of Dentistry, University of Iowa in September 2009. As a result, some wording changes were made in order to clarify questions, but no major question changes occurred.

Study Population

The study population consisted of all public health dentists identified through the NNOHA and AACDP membership lists for the 2009 reference year.

Regarding the selection of the population, the AAPHD membership was considered, but not selected because, as a group, they were believed to be less likely to be active clinicians. ADA members identified as working in PH would have been preferable; however, the membership list was not available at the time of this study. Therefore, we included only NNOHA and AACDP members because they were believed to be a representative group of PH clinicians in the United States.

The target population was from all states, territories and regions of the United States. It included dentists who were dental directors, those who received Dental Public Health training or another kind of dental specialty training, and general practitioners who considered themselves as public health dentists by virtue of working in public health settings.

Inclusion and Exclusion Criteria

The study population consisted of 290 members of the NNOHA and 73 members of the AACDP. The only inclusion criteria consisted of being a NNOHA member and/or an AACDP member, and being a non-retired dentist.

Institutional Review Board (IRB)

The University of Iowa IRB (IRB-01) approved this research project on January 22nd, 2010 via expedited review. A waiver of documentation of consent was approved so that formal written consent was not required. A submitted electronically completed questionnaire was considered as the subject's consent to participate.

Survey Procedures

The study survey link was emailed to each public health dentist's e-mail address according to the NNOHA and AACDP membership lists. An introductory e-mail signed by the principal investigator with the survey link and additional information was sent to each member of the study population. This e-mail included information about the purpose of the research, the relevance of the study, why he/she was invited to participate in this research, the estimated amount of time to complete the survey, how responses would be anonymous, how no individual identification would be possible, how participation was voluntary, and the contact information of the principal investigator, thesis supervisor, and University of Iowa IRB (Appendix A). The introductory e-mail and the study survey link were initially sent on January 25th, 2010.

The survey was anonymous in order to increase the participation rate. That is, no subject identifiers were linked to survey, and respondents or non-respondents could not be tracked or identified. Also, to preserve the anonymity of the respondents, very few questions regarding personal characteristics were included.

Approximately six weeks after (March 9th, 2010) the first e-mail was sent, a reminder e-mail and the survey link were again sent to all public health dentists on the NNOHA and AACPD membership lists. The surveys were collected during a period of 3 months, from January 25th to April 25th, 2010.

Variables

Dependent Variables

There were three dependent variables in this study, which were: 1)MID meets the standard of care for primary teeth, 2)MID meets the standard of care for permanent teeth and 3)use of a sharp explorer for caries detection. The first two were dichotomous (i.e., "yes" vs. "no"), and the third one, use of sharp explorer, was reported on an ordinal scale. The use of sharp explorer question used Likert scale response categories, but for the purpose of analyses, this variable was dichotomized by recording "always" , " most of the time" , and " often" as "yes", versus "sometimes", " never" and " rarely" as "no".

Appendix C lists the independent and dependent variables.

Independent Variables

The independent variables collected in this study were gender, age (in years), year of graduation, location (state) of dental school, weekly hours devoted to patient care, type of practice (federal, local, and private), PH or public health post-graduate training, other post-graduate training, type of PH or public health post-graduate training, type of other post-graduate training, and clinic characteristics (e.g.; state, location, number and type of staff, dental clinic demand per week, patients' ages, patients' insurance status).

Some variables were categorical, including MID training, MID training setting, MID training format, techniques used for treatment of caries in primary teeth, techniques used for treatment of caries in permanent teeth, and use of techniques for caries detection.

Gender, PH or public health post-graduate training, other post-graduate training and MID training were dichotomous independent variables, with answer options of male or female for gender, and yes or no for all others.

Age, year of graduation, weekly hours spent in patient care, and numbers of dental clinic staff were continuous variables. Clinic location (population size) and number of dental clinic visits per week were reported on an ordinal scale.

State of dental school, type of practice, type of PH or public health post-graduate training, type of other post-graduate training, dental clinic state, dental clinic location, MID training setting variables, and MID training format variables were nominal variables.

Note that the categories of type of practice variables were: federal, local, private, and other. The category "other" was not defined; it was an extra option for the respondents who did not classify themselves in the other categories.

Patients' age groups, patients' insurance status, techniques used for treatment of caries in primary teeth, techniques used for treatment of caries in permanent teeth, and use of techniques for caries detection were reported on an ordinal scale.

For those variables with the five categories of "strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree" the responses in the middle category of "neither agree nor disagree" were excluded from bivariate analyses. Similarly, for those variables with the five categories of "very effective, effective, ineffective, very ineffective, and I don't know this technique", the responses in the category "I don't know this technique" were excluded. Also, for those variables with five categories of "very likely, likely, unlikely, very unlikely, and not applicable", the responses for the "not applicable" category were excluded.

The exclusion of the "neither agree nor disagree", "I don't know this technique", and "not applicable" categories, as discussed above, resulted in excluding up to 40% of respondents for some variables. Variables, in which more than 20% of the responses were excluded, due to the above described responses, were not included in the multivariable logistic regression models. Only those variables with significant bivariate relationships ($p \leq 0.10$) were considered for inclusion in the multivariate logistic regression models. Stated another way, those with less than 80% included responses (meaning more than 20% excluded) were not considered further for inclusion in the multivariable logistic model regression.

Statistical Methods and Data Analysis

As an on-line survey, data were entered by respondents as they completed the survey. After the 3 months of survey collection, the data were converted into a SAS format data set. SAS for Windows (vs9.2, SAS Institute Inc, Cary, NC, USA) was used for the data analysis. A p-value of less than 0.05 was used as the criterion for statistical significance.

Composite Variable Analyses

Questions 7 and 8 asked about how effective the participants considered techniques of caries in primary teeth and permanent teeth, respectively. Question 7 (primary teeth) and 8 (permanent teeth) sub-questions and answer choices were the same.

Sub-questions asked about Atraumatic Restorative Treatment (ART), "sandwich techniques (glass ionomer plus composite), remineralization with fluoride varnish or other office topical fluoride products, remineralization with topical high concentration fluoride at home, and Amorphous Calcium Phosphate-ACP (i.e., MI paste); and the answer choices included very effective, effective, ineffective, very ineffective, and "I don't know this technique". The last option, "I don't know this technique", was not included in the composite variable analyses.

The composite variables were derived from the sub-questions for questions 7 and 8. Each of the options of question 7 and 8 were assigned to a point value based on the level of agreement with 4 points attributed to very effective, 3 for effective, 2 for ineffective and 1 for very ineffective. The estimates of internal consistency evaluated by Cronbach's alpha were 0.69 for question 7a through 7e and 0.62 for question 8a through 8e. Clearly, both are lower than the recommended minimum value of 0.70 [113]. Thus, the new two variables as dependent variables were not considered for the comprehensive analysis. However, limited bivariate exploratory analyses of the composite variable for

question 7, the sum of scores of question 7a through 7e ranging from 5 to 20, were conducted with descriptive demographic independent variables.

Univariate Analyses

Each response was analyzed using descriptive statistics. For all variables, frequency distributions were obtained and assessed for outliers. Descriptive statistics were computed, and frequency distribution tables were generated.

Bivariate Analyses

The bivariate analyses were conducted to explore associations between each dependent variable and each of the independent variables. The standard chi-square test and Fisher's exact test were used for nominal categorical variables, and Cochran-Mantel-Haenszel tests were used for ordinal variables. A two-sample t-test or Wilcoxon rank-sum test was used, as appropriate, to compare the groups with respect to quantitative measures.

Logistic Regression Analysis

Three separate multiple logistic regression models were developed, and odds ratios (ORs) were used to evaluate factors associated with; 1) use of MID meeting the standard of care for primary teeth, 2) use of MID meeting the standard care for permanent teeth and 3) use of sharp explorer techniques during caries detection. As stated previously, the exclusion of the "neither agree nor disagree", "I don't know this technique", and "not applicable" categories, resulted in excluding up to 40% of respondents for some variables. Only those variables with 80% or more of cases were included and those with significant bivariate relationships ($p \leq 0.10$) were considered for inclusion in the multivariate logistic regression models. Among included variables, those showing significant associations in bivariate analyses ($p \leq 0.10$) for each variable were considered for inclusion in the final model using forward stepwise logistic regression

analysis. All regressions were performed using "PROC LOGISTIC" with the goal of creating a parsimonious model. All possible two-way interactions for all main effect variables in the final model were examined.

When developing the final logistic regression model, multicollinearity diagnostics were conducted to examine the effects of the significant correlations between all significant explanatory (independent) variables on the results of regression. Variance inflation factors (VIF) and eigenvalue analysis were used.

Forward and backward stepwise logistic regression analyses were conducted in this study; however, the backward models were eliminated due to better overall fit the models. For the first dependent variable, MID meeting the standard of care for primary teeth, the backward stepwise model was eliminated due to a SAS warning message stating that the validity of the model fit was questionable. For the second dependent variable, MID meeting the standard of care for permanent teeth, both the forward and backward procedures yielded the same significant results and equal Hosmer and Lemeshow Goodness-of-Fit test measures ($p=0.9712$). For the third variable, use of a sharp explorer during caries detection, the significant variables were the same and the Goodness-of-Fit test measures were similar, $p=0.6491$ for the backward procedure and $p=0.6717$ for the forward procedure. Thus, forward stepwise logistic regression results were the focus of this thesis because it showed an equal or better-overall model fit for all three dependent variables.

CHAPTER IV

RESULTS

Introduction

The main purposes of this study were to determine if Minimally Invasive Dentistry (MID) is considered to meet the standard of care among public health dentists in the United States, and to identify factors associated with beliefs that MID meets the standard of care. The response rate and results of univariate, bivariate, and multivariate analyses are discussed in this chapter.

The initial intention of this research was to survey PH dentists; however, because there were few dentists with formal PH training, the focus of this research was shifted to dentists working in public health settings.

Response Rates

One hundred thirty-six of 363 Dental Public Health dentists from the National Network for Oral Health Access (NNOHA) and American Association Community Dental Programs (AACDP) membership lists responded to the survey after two emails were sent. Thus, the overall response rate for this study was 37.5% (n=136). Two-hundred ninety NNOHA dentist members and 73 AACDP dentist members received the survey. Because responses were anonymous, it was not possible to determine response rate by organization. Approximately 80 dentists responded after the first e-mail and 56 responded after the second e-mail.

Univariate Analyses

The descriptive statistics for demographic characteristics of PH dentists (n=136) presented in Table D1 show that 52.9% (72) of the respondents were male and 47.1% (64) were female; 33.1% (44) were 39 years old or younger, 35.3% (47) from the age of 40 to 54, and 31.6% (42) were 55 years old or older. Thirty-eight (28.4%) respondents

graduated in the 2000's, 26.9% (36) in the 1980's, 23.1% (31) in the 1990's, and 21.6% (29) in the 1970's or 1960's.

Respondents were asked in which state the dental school they attended was (Question # 18), with respondents having a pull down menu to select the state. For data analysis purposes, states were grouped by region as follows: Region 1 (Northeast) included: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut New York, Pennsylvania and New Jersey; region 2 (Midwest) included: Wisconsin, Michigan, Illinois, Indiana, Ohio, Missouri, North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa; region 3 (South) included: Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida, Kentucky, Tennessee, Mississippi, Alabama, Oklahoma, Texas, Arkansas, Louisiana; and region 4 (West) included: Idaho, Montana, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico, Alaska, Washington, Oregon, California, and Hawaii.

Using this grouping, 41.8% (56) indicated that they had attended a school in the Midwest (region 2), 21.6% (29) reported South (region 3), 19.4% (26) Northeast (region 1), 12.7% (17) West (region 4), and 4.5% (6) who graduated from a non-U.S. dental school.

When the participants were asked if they had completed post-graduate training in Dental Public Health (PH) or Public Health (PH), 83.5% (111) answered that they did not have any PH or PH training and only 16.5% (22) had training in these areas. Specifically, 12.5% (17) had MPH type of training, 2.9% (4) had completed a MS or PH residency and only 0.7% (1) had completed a PhD. For this question the participants could report all options that applied.

When participants were asked if they had specialty or advanced training other than PH, 69.7% (92) answered no, and 30.3% (39) answered yes, including 11% (15) who had received GPR training, 7.4% (10) AEGD, 6.6% (9) pediatric dentistry, 1.5% (2) oral surgery, 0.7% (1) endodontic, 0.7% (1) orthodontic, and 0.7% (1) periodontic

training. No participant answered that they had geriatric dentistry, restorative dentistry, oral pathology, oral radiology, prosthodontics, or special care dentistry training.

Table D2 presents the results for questions related to the PH dentists' ages and years since graduation. The average age was 46.8 years (range: 27-74 years), and the mean number of years since graduation was 20.1 years (range: 1-50 years).

Table D3 presents the descriptive statistics of dental practice characteristics. Question #19 assessed how many hours per week the dentist provided direct patient care, and 38.9% (49) reported 30 to 39 hours, 24.6% (31) answered 40 hours or more, 15.9% (20) between 20 to 29 hours, 11.9% (15) 19 or fewer hours, and 8.7% (11) reported no patient care. Question #20 asked respondents to describe the main dental practice type, with the data combined in 3 groups: 1) federal (for Federally Qualified Health Center (FQHC) 64.7%(88), Indian Health Service 2.2% (3), Military 0%, National Health Service Corps 2.2% (3), and other U.S. federal service 0% (2) local (for locally funded clinic 6.6% (9), state dental program 7.4% (10), and academic institution 7.4% (10)); and 3) private practice 5.2% (7). Answers resulted in 61.9% (83) for federal, 19.4% (26) for local, and 5.2% (7) for private practice. The region of the dental clinic was determined by asking in which state the clinic was located (Question #25), and 42.5% (54) reported the Midwest (region 2), 26.8% (34) the West (region 4), 19.7% (25) the South (region 3), and 11% (14) the Northeast (region 1). The main dental clinic/practice location was based on the number of inhabitants at that location (Question #26). Results showed that 29.1% (37) were located in cities (50,000-249,999), 18.9% (24) in metro areas (250,000-1 million), 17.3% (22) in large metro areas (>1 million), 14.2% (18) in small towns (2,500-19,999), and 11% in rural areas (<2,500). Question # 28 asked how many patients attend the dental clinic per week and 7.5% (9) answered 1-49 patients per week , 20% (24) answered 50-99 patients per week, 37.5% (45) answered 100-249 patients per week, 24.2% (29) answered 250-500 patients, and 10.8% (13) answered more than 500 patients per week.

Table D4 presents results about MID training, Question #1 asked "how much have you heard about MID?", and 37.5% (51) reported to have heard something about MID, 31.6% (43) reported to have heard much about MID, 16.9% (23) reported to have heard very much about MID, 11% (15) reported to have heard little and 2.9% (4) reported to have heard nothing about the MID philosophy. Question # 2 asked the participants if they had had training in MID, and 53.3% (72) answered no, they had never had training in MID, 46.7% (63) answered yes, that they had had training in MID. Thus, question #3 asked those who had had training in MID, in what setting did they receive most of this training. In this question, participants could check all options that applied. Thirty-nine percent (53) answered that they received their training during continuing education courses, 16.9% (23) answered during dental school and 5.9% (8) during a graduate program or residency. Question #4 asked "what was the format for the MID training received?", and 50% (56) reported to have received this training as a lecture only, 17.9% (20) received it as a lecture and hands-on course, 0.9% (1) received it as a hands-on (clinical) only format and 31.2% (23) of respondents did not answer this question.

Table D5 present the results for questions related to direct patient care (hours per week), and practice characteristics, including numbers of dentists, dental hygienists, dental assistants and administrative staff. The direct patient care ranged from 0-45 hours per week, with a mean of 28.0. The number of dentists in the dental practice ranged from 0 to 100 dentists per clinic, with a mean of 5.3. The number of dental hygienists in the dental practice ranged from 0 to 15 per clinic, with a mean of 2.3. The number of dental assistants in the dental practice ranged from 0 to 70 per clinic, with a mean of 7.8. The number of administrative staff in the dental practice ranged from 0 to 69 per clinic, with a mean of 5.0.

Table D6 describes the descriptive statistics for patients' characteristics. Question #29 asked "What is the approximate percentage distribution of patients' ages in your dental practice?" The percentage of young children (0-4 years) seen in the dental practice

ranged from 0-50%, with a mean of 13.3%. The percentage of children (5-12 years) seen in the dental practice ranged from 0 to 95%, with a mean of 25.7%. The percentage of teenager (13-19 years) ranged from 0 to 70%, with a mean of 17.8%. The percentage of adults (20-65 years) ranged from 0 to 100%, with a mean of 35.2%. The percentage of elderly (> 65 years) ranged from 0 to 40%, with a mean of 10.2%. Table D6 also reported on question #30, which asked "What is the approximate percentage distribution of patients' insurance coverage in your dental practice?" The percentage of patients who had Medicaid ranged from 0 to 100 percent, with a mean of 47.8%. The percentage of patients who had SCHIP (State Children's Health Insurance Program) ranged from 0 to 85 percent, with a mean of 11.9%. The percentage of patients who had private insurance ranged from 0 to 70 percent, with a mean of 12.6%. The percentage of patients who had no insurance/out of pocket ranged from 0 to 100 percent, with a mean of 33.1%. The percentage of patients who had other kinds of insurance (non-specified) ranged from 0 to 100 percent, with a mean of 14.6%.

Table D7 presents the descriptive statistics for the dependent variables, which are MID meets the standard of care for primary teeth, MID meets the standard of care for permanent teeth, and the use of a sharp explorer as a caries detection technique. Question #5 asked "In your opinion, does MID meet the dental professional standard of care for primary teeth in the U.S.?", and 85.8% (109) answered yes, that MID meets the standard of care; on the other hand, 14.2% answered no, that MID did not meet standard of care for primary teeth.

Regarding the second dependent variable (question #6), 77.2% (98) answered yes, that MID meets the standard of care for permanent teeth, while 22.8% (29) answered no, that MID did not meet the standard of care for permanent teeth in the U.S. It is important to mention that there are no explicit standards of care for dentistry in the current literature, so the approach used in this study was to leave to the participants' understanding of the standards of care for dentistry in the U.S.

Question #10 asked "For caries detection during one exam, for what proportion of your patients do you use each of the following techniques?" For sub-question 10a that referred to the use of a sharp explorer as a caries detection technique, 27.9% (38) answered that they always (100%) use this technique during caries detection, 23.5% (32) answered that most of the time (75-99%), 13.2% (18) answered that often (50-74%), 11.8% (16) answered sometimes (10-49%), and 23.5% (32) reported that never or rarely (0-9%) used a sharp explorer during caries detection procedures. The combination of the answers always, most of the time, and often was re-coded as a "yes" answer with regard to use of a sharp explorer during caries detection, representing 64.7% (88) of respondents. The responses for sometimes, and never or rarely, were considered to be "no" answers, representing 35.3% (48) of participants who did not use a sharp explorer as a caries detection technique.

Table D8 reports on questions which asked participants to give their evaluation of effectiveness of techniques on primary and permanent teeth. The techniques evaluated by the questions were ART (Atraumatic Restorative Treatment), sandwich technique (glass ionomer + composite), remineralization with fluoride varnish or other office topical fluoride products, remineralization with topical high concentration fluoride at home, and amorphous calcium phosphate – ACP (e.g., MI paste). The table presents answers for sub-questions #7a through 7e for primary teeth and for sub-questions #8a through 8e for permanent teeth.

Regarding the respondents' evaluation of effectiveness of techniques for caries treatment in primary teeth, the percentages that considered each of the techniques to be very effective were: ART 22.8% (31), sandwich technique 22.1% (30) and fluoride varnish 22.8% (31). The techniques most often considered ineffective were topical high concentration fluoride at home 27.2% (37), MI paste 14.7% (20) and fluoride varnish 11.8% (16). Very few techniques were assessed as being very ineffective. One of the categories that respondents could choose was "I don't know this technique" and, these

results showed that MI paste was unknown by 30.9% (42) of the respondents, followed by ART with 20.6% (28) and sandwich technique at 15.4% (21).

Table D8 also presents results for questions which asked participants to give their evaluation of caries treatment techniques effectiveness for permanent teeth. The following were most frequently considered very effective: sandwich technique 21.3% (29) and fluoride varnish 14.7% (20). The percentages who thought the specific treatments effective were: fluoride varnish 66.9% (91), both topical high concentration fluoride at home and sandwich technique with 59.6% (81), MI paste 47.0% (64), and ART with 43.4% (59). On the other hand, in contrast to primary tooth results, all techniques with the exception of sandwich technique at 2.9% (4) were considered ineffective by at least 12.5% (17) of the respondents. Very few respondents considered the techniques to be very ineffective. The results for "I don't know this technique" category again found that MI paste 29.4% (40) was the most unknown technique, followed by ART 20.6% (28), and sandwich technique 14.7% (20). Interestingly, fluoride varnish was known by all the respondents.

Table D9 describes the awareness of respondents regarding newer techniques for caries detection, such as ECM (Electrical Caries monitor), QLF (Quantitative Light-Induced Fluorescence), IRLF (Infrared Laser Fluorescence), and FOTI (Fiber Optic Transmission Illumination - Light Transmission). Question #9 asked "How much have you heard about each of the following techniques for caries detection?" The results show that respondents did not know "very much" about any of the techniques, but they knew the most about the FOTI technique. The percentage of respondents who reported knowing nothing about ECM, IRLF and QLF were higher than for the other techniques listed above: 44.1% (60), 44.1% (60), and 36.0% (49) for these techniques, respectively.

Table D10 presents results for sub-questions 10a through 10i which evaluated the frequency of use of techniques for caries detection (use of a sharp explorer, use of an explorer that is not sharp, use of magnification (e.g., loupes), radiographs, ECM, QLF,

IRLF, FOTI, and compressed air drying with illumination). Respondents were asked “For caries detection during an exam, for what proportion of your patients do you use each of the techniques? Please choose one answer for each technique”. A Likert scale was used to assess the frequency: always (100%), most of the time (75-99%), often (50-74%), sometimes (10-49%), and never/rarely (0-9%).

The frequencies for techniques reported to be used “always” were radiographs 47.8% (65), magnification (loupes) 37.8% (51), sharp explorer 27.9% (38), and compressed air drying with illumination 25.7% (35) (Table 10). We found that for the use of sharp explorer, 51.4% (70) of the respondents used this technique “always” or “most of time”, while on the other hand, 23.5% (32) never/rarely use this technique.

The use of explorer that is not sharp presented a distribution toward the lower end of frequency of use, where only 8.3% (11) declared that they always used this technique, however 38.3% (51) never or rarely use this technique.

Magnification loupes were mostly either used “always” (37.8%) or “never/rarely” (32.6%) used by the participants. Radiographs had a high frequency of use, as many participants “always” 47.8% (65) or “most of the time” 36.0% (49) used this technique during caries detection. The techniques found to be “never” used for most of the respondents were ECM 97.8% (133), QLF 97.8% (133), and IRLF 99.3% (135). FOTI (light transmission) presented a very low frequency of use with sometimes 16.2% (22) and never/rarely 68.4% (93). Compressed air drying with illumination is the technique that is most evenly distributed, with similar proportions using this technique “always” or “most of the time” (47%) and “sometimes” or “never/rarely” (40.4%).

Table D11 presents results on the level of agreement with preventive and restorative statements for questions #11 through #13 which related to the same general question: “Please indicate your level of agreement with each of the following statements”. Likert scales were used for respondents to choose between one of the options: strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree.

Question #11a posed the following statement: “There is a direct relationship between carious lesions and intake of refined carbohydrates”, and 93.3% (127) of respondents strongly agreed or agreed with this statement. For “Fluoride is an essential agent in the tooth remineralization process” (Question 11b), 92.6% (126) of respondents strongly agreed or agreed with this statement. For “Sealants are not very effective in prevention of pit and fissures caries” (Question 11c), 89.7% (122) answered that they disagreed or strongly disagreed with this statement. For “Sealants should be used as a routine procedure for high caries risk children” (Question 11d), 89.7% (122) of respondents strongly agreed or agreed with this statement.

Question 12a stated that “When possible a tunnel preparation design for proximal caries lesions should be used instead of a traditional proximal box in adults”. The highest proportion of respondents who answered neither agreed nor disagreed 39.7% (54), followed by agree 26.5% (36), and disagree 16.9% (23). For the question, “Preventive dentistry is more important for children than adults” (Question 12b), 60.3% (82) disagreed or strongly disagreed with this statement. For “Caries risk assessment should be conducted with all patients” (Question 12c), 84.6% (115) answered that they strongly agreed or agreed with this statement. For “Dietary habits should be assessed for all patients” (Question 12d), 82.3% (112) strongly agreed or agreed with this statement. These results were all presented in Table D11.

Questions #13a through 13e are also included in Table D11. For the statement “Small minimal cavity preparations compromise materials retention” (Question 13a), the highest proportion of the respondents who answered disagreed 47.1% (64), followed by 25% (34) that neither agreed nor disagreed. For “Dentists should recommend that high caries risk patients receive diet counseling” (Question 13b), the majority of respondents 83.8% (114) strongly agreed or agreed with this statement. For “ART does not meet the standard of care in the U.S.” (Question 13d), 41.2% (56) of the respondents disagreed, followed by 36.0% (49) that neither agreed nor disagreed. For “The use of a closed

sandwich technique is appropriate for children and adults", 75.0% (102) strongly agreed or agreed with this statement, followed by 22.8% (31) that neither agreed nor disagreed. For "ART could be often used with high caries risk children and rampant caries patients" (Question 13e), 35.3% (48) neither agreed nor disagreed, but when combining strongly agree 22.8% (31) and agree 30.9% (42), we noticed that most of the participants (53.7%) agreed with this statement.

Table D12 presents the reported likelihood of performing the following procedures for each new patient (sub-questions #14a through 14f). Question #14 stated "How likely are you to perform the following for each new patient?", with the options being very likely, likely, unlikely, very unlikely, and not applicable. The first procedure asked was "caries risk assessment for adult patients", the results showed that 67.6% (92) were very likely or likely to perform this procedure. For "Caries risk assessment for children", 86.1% (117) were very likely or likely to perform this procedure. For "Evaluate the patients' dietary habits", 78.6% (107) were very likely or likely to perform this procedure. For "Identify current exposures to fluoride", 83.8% (114) were very likely or likely to perform this procedure. For "Review medical history and lifestyle", 75.7% (103) were very likely to perform this procedure, and 22.1% (30) were likely to perform the procedure. For "Plan restorative materials and techniques based on the patient's caries risk assessment", 86.0% (117) were very likely or likely to perform this procedure.

Bivariate Analyses

MID as a Standard of Care for Primary Teeth in the U.S.

Table D13 shows the bivariate results for the dependent variable, MID meets the standard of care for primary teeth in the U.S. and factors related to MID training. Significant associations ($p<0.05$) were found between MID meets the standard of care for primary teeth and two factors that they had heard about MID and that MID met the standard of care for permanent teeth. Respondents who answered that they had heard

much or very much about MID were more likely to believe that MID met the standard of care for primary teeth than those who did not (93.8% vs. 6.2%, p=0.0103). Those who believed much or very much that MID met the standard of care for permanent teeth were more likely to believe MID met the standard of care for primary teeth, compared with their counterparts who did not (94.8% vs. 5.4%, p<0.0001).

Table D14 presents bivariate results assessing associations between MID meeting the standard of care for primary teeth in the U.S. and factors related to MID techniques. The significant factors were effectiveness of ART as caries treatment for primary teeth (p<0.0001), effectiveness of fluoride varnish as caries treatment for primary teeth (p=0.0047), effectiveness of ART as caries treatment for permanent teeth (p<0.0001), and effectiveness of sandwich technique as caries treatment for permanent teeth (p=0.0224). For all four treatments, a higher proportion of respondents who agreed that these techniques were effective also agreed that MID met the standard of care for primary teeth in the U.S. The sandwich technique for primary teeth approached significance (p=0.0661), but no other MID technique variables were found to have a statistically significant relationship with meeting the standard of care for primary teeth. Note that for these variables, the responses for participants who responded “I don’t know this technique” were excluded from the statistical analysis.

There were no significant relationships when the associations between MID as a standard of care for primary teeth in the U.S. and caries detection techniques were assessed, as presented in Table D15.

Table D16 shows the results for bivariate analyses between MID meeting the standard of care for primary teeth in the U.S. and opinions regarding restorative and preventive techniques. The significant factors included responses that small cavity preparations compromise materials’ retention (p=0.0030), ART does not meet the standard of care in the U.S. (p<0.0001), and ART could be used with high risk children and rampant caries patients (p=0.0015). Higher proportions of respondents who disagreed

that small cavity preparations compromise materials' retention (91.9% vs. 8.1% for those who agreed) and disagreed that ART does not meet the standard of care in the U.S. (94.5% vs. 5.5% for those who agreed) agreed that MID met the standard of care for primary teeth in the U.S. On the other hand, a higher proportion of respondents who agreed that ART could be used with high risk children and rampant caries patients agreed that MID met the standard of care for primary teeth in the U.S (94.4%). Note that for these variables, the responses for participants who responded "Neither agree nor disagree" and "Not applicable" were excluded from the statistical analysis.

Table D17 reports the results of bivariate associations between MID meeting the standard care for primary teeth and characteristics of PH dentists. PH post-graduate training was the only significant factor ($p=0.0408$) found to be associated with belief that MID met the standard of care in primary teeth. Regarding PH post-graduate training, 100% of participants who had such training answered that MID met the standard of care for primary teeth, while only 82.5% of those who did not have PH training held this belief.

Tables D18, D19, D20 and D21 present the bivariate results between MID meeting the standard of care for primary teeth in the U.S. and the continuous variables of this study. Table D18 is related to characteristics of PH dentists (dentist's age and year since graduation from dental school), Table D19 relates to dental clinic characteristics, Table D20 to patients' age distributions, and Table D21 to patients' insurance coverage types. None of the variables presented in Tables D18, D19, D20 and D21 presented significant results when associated with the dependent variable, MID meets the standard of care for primary teeth.

The questions that had sufficient responses (equal to or greater than 80%) and were significantly ($p\leq0.10$) related to agreeing that MID meets the standard of care for primary teeth were further investigated by multivariable analyses. The results from the multivariable analyses are presented later in this chapter.

MID as a Standard of Care for Permanent Teeth in the U.S.

From descriptive statistics Table D7, 77.2% (98) of the respondents answered yes, and 22.8% (29) answered no to Question #6: "In your opinion, does MID meet the dental professional standard of care for permanent teeth in the U.S.?"

Table D22 shows the bivariate results for associations between MID meets the standard of care for permanent teeth in the U.S. (dependent variable) and MID training. Significant associations were found between MID meets the standard of care for permanent teeth and the following factors: that they had heard about MID ($p=0.0102$), that they had completed a continuing education course ($p=0.0361$), and that they believed MID met the standard of care for primary teeth ($p<0.0001$). For the variable MID meets the standard of care for primary teeth ($p<0.0001$), 85.2% who answered yes also answered that MID meets the standard of care for permanent teeth, while 72.2% of those who answered no also answered that MID does not meet the standard of care for permanent teeth.

Table D23 presents the bivariate results for associations between MID meets the standard of care for permanent teeth in the U.S. and factors related to MID techniques. The significant factors were effectiveness of ART as caries treatment for primary teeth ($p=0.0002$), effectiveness of fluoride varnish as caries treatment for primary teeth ($p=0.0433$), effectiveness of fluoride varnish as caries treatment for permanent teeth ($p=0.0433$), effectiveness of ART as caries treatment for permanent teeth ($p=0.0263$), and effectiveness of topical high concentration fluoride at home as caries treatment for permanent teeth ($p=0.0032$). Note that the responses for participants who responded "I don't know this technique" for these variables were excluded from the statistical analysis.

There were no significant relationships between MID meets the standard of care for permanent teeth in the U.S. and caries detection techniques that were analyzed as presented in Table D24.

Table D25 shows the results for analyses between MID meeting the standard of care for permanent teeth in the U.S. and opinions regarding restorative and preventive techniques. The significant factors included tunnel cavity preparation should be used instead of proximal box in adults ($p=0.0315$) and ART does not meet the standard of care in the U.S. ($p<0.0001$). A higher proportion of respondents who agreed that tunnel cavity preparations should be used instead of proximal box in adults agreed that MID met the standard of care for permanent teeth in the U.S (88.6% vs. 11.4%). On the other hand, a higher proportion of respondents who disagreed that ART does not meet the standard of care in the U.S agreed that MID met the standard of care for permanent teeth in the U.S (86.3%). Note that for these variables, the responses for participants who responded "Neither agree nor disagree" and "Not applicable" were excluded from the statistical analysis.

There were no significant relationships between MID meets the standard of care for permanent teeth in the U.S. and characteristics of PH dentists that were analyzed as presented in Table D26.

Tables D27, D28, D29 and D30 present the bivariate results among MID meets the standard of care for permanent teeth in the U.S. and the continuous variables of this study. Table D27 is related to characteristics of PH dentists (dentist's age and year since graduation from dental school), Table D28 shows variables related to dental clinic characteristics, Table D29 presents patients' age distribution, and Table D30 reports patients' insurance coverage types. None of the variables in Tables D27, D28, D29 and D30 had significant results when associated with the dependent variable MID meets the standard of care for permanent teeth.

The questions that had sufficient responses (equal to or greater than 80%) and were significantly ($p\leq0.10$) related to agreeing that MID meets the standard of care for permanent teeth were further investigated by multivariable analyses. The results of the multivariable analyses are presented later in this chapter.

Use of Sharp Explorer for Detecting Caries

Regarding the use of a sharp explorer as a caries detection technique (Question #10a), the original Likert scale answer options were re-grouped into "yes" or "no" for analysis (Table D7) using the following criteria. For "yes", the first three options always (100%), most of the time (75-99%), and often (50-74%) were included, and for "no", the remaining two options of sometimes (10-49%), and never or rarely (0-9%) were included. From descriptive statistics Table D7, 64.7% (88) of the respondents answered yes, and 35.3% (48) answered no to Question #10a "For caries detection during an exam, for what proportion of your patients do you use each of the following techniques? Use of sharp explorer".

Table D31 reports the bivariate results assessing the associations between use of sharp explorer for detecting caries (dependent variable) and the independent variables regarding MID training. Table D32 presents the bivariate results for the dependent variable and factors related to MID techniques. There were no significant relationships between the dependent variables and the variables presented in Tables D31 and D32. Note that for these variables, the responses for participants who responded "I don't know this technique" were excluded from the statistical analysis.

Table D33 presents the bivariate results assessing the associations between use of sharp explorer for detecting caries and caries detection techniques. The significant factors included use of an explorer that is not sharp (a dull) for caries detection ($p=0.0088$) and use of radiographs for caries detection ($p=0.0038$). A higher proportion of respondents who used an explorer that is not sharp for caries detection sometimes or never used a sharp explorer for detecting caries (73.1% vs. 26.9%). In addition, a higher proportion of respondents who sometimes or never used radiographs during the caries detection process did not use a sharp explorer for detecting caries (80.0%).

Table D34 shows the results for analyses assessing the associations between the use of sharp explorer for detecting caries and opinions regarding restorative and

preventive techniques. The significant factors included the use of tunnel preparation instead of proximal box in adults (p= 0.0373), small cavity preparations compromise materials' retention (p= 0.0024), and the use of ART for high caries risk children and rampant caries patients (p=0.0474). More respondents who strongly agreed or agreed that small cavity preparations compromise materials' retention used a sharp explorer for detecting caries (90.9% vs. 9.1%). On the other hand, a nearly equal proportion of respondents who strongly disagreed or disagreed that tunnel cavity preparation should be used instead of proximal box in adults used or did not use a sharp explorer for detecting caries (56.2% vs. 43.7%). In addition, more respondents who strongly disagreed or disagreed that ART could be used for high caries risk children and rampant caries patients used a sharp explorer for detecting caries (80.0% vs. 20.0%). Note that for these variables, the responses for participants who responded "Neither agree nor disagree" and "Not applicable" were excluded from the statistical analysis.

Table D35 reports the results for analyses assessing the associations between the use of sharp explorer for detecting caries and characteristics of PH dentists. The significant factors included years since graduation from dental school as a categorical variable (p= 0.0194), type of practice (p=0.0027), and PH post-graduate training (p=0.0017). More dentists who graduated in the 1960's and 1970's (58.6%) did not use a sharp explorer during caries detection process than those who graduated in the 1980's (30.6%), in the 1990's (26.3%) and in the 2000's (25.8%). Regarding type of practice, more dentists who worked in federal (77.1%) and private (57.2%) settings used a sharp explorer for caries detection than for locally-based public health practices (50%). Concerning PH post-graduate training, more dentists with PH post-graduate training (63.6%) did not use a sharp explorer during caries detection than those who did not receive PH training (28.8%).

Tables D36, D37, D38 and D39 present the bivariate results assessing the associations between use of sharp explorer for detecting caries and the continuous

variables of this study. Table D36 is related to characteristics of PH dentists (dentist's age and year since graduation from dental school), and significant associations were found between sharp explorer use and PH dentists' age ($p=0.0355$) and years since graduation from dental school ($p=0.0101$).

For the continuous variable PH dentists' ages, there was a significant age difference ($p=0.0355$) between those who used (mean 45.2 years) or did not use (mean 49.7 years) a sharp explorer as a technique for caries detection. There was a similar relationship between sharp explorer use and years since graduation.

Table D37 shows variables related to dental clinic characteristics. Significant results included direct patient care hours per week ($p=0.0026$). Those who used a sharp explorer as a technique for caries detection had greater mean hours per week with direct patient care than those who did not use a sharp explorer (mean hours: 30.9 vs. 21.8 hours).

Table D38 presents results concerning associations between patients' age distribution and use of a sharp explorer for detecting caries, and Table D39 reports results concerning associations between patients' insurance coverage types and use of a sharp explorer for detecting caries. There were no significant relationships between the use of sharp explorer for detecting caries and patients' age distributions and patients' insurance coverage variables.

The questions/variables that had sufficient responses (equal to or greater than 80%) and were significantly ($p\leq0.10$) related to the use of a sharp explorer as caries detection technique were further investigated by multivariable analyses. The results of the multivariable analyses are presented later in this chapter.

Summary of Bivariate Analyses

Table D40 presents a summary of independent variables which were significantly associated with dependent variables ($p<0.05$). The following five independent variables

were significantly associated with beliefs that MID met the standard of care for both primary teeth and for permanent teeth, respectively: that respondents had heard about MID ($p=0.0103$ and $p=0.0102$) for primary and permanent, that ART is effective as caries treatment for primary teeth ($p<0.0001$ and $p=0.0002$), that fluoride varnish is effective as caries treatment for primary teeth ($p=0.0047$ and $p=0.0433$), that ART is effective as caries treatment for permanent teeth ($p<0.0001$ and $p<0.0001$), and that ART meets the standard of care in the U.S. ($p<0.0001$ and $p<0.0001$).

There were three independent variables that were significantly associated with both beliefs that MID met the standard of care for primary teeth and the use of sharp explorer for detecting caries. Those who believed that small cavity preparations compromise materials' retention ($p=0.0030$ and $p=0.0024$) were less likely to believe that MID meets the standard of care in the U.S. In contrast, those who believed that ART could be used with high caries risk children and rampant caries patients ($p=0.0015$ and $p=0.0474$), and PH post-graduate training ($p=0.0408$ and $p=0.0017$) were more likely to believe that MID meets the standard of care in the U.S.

Belief that tunnel preparations should be used instead of proximal box in adults was the only independent variable that was significantly associated with both beliefs that MID met the standard of care for permanent teeth and use of sharp explorer for detecting caries, with the respective p-values of $p=0.0315$ and $p=0.373$.

Hypotheses

Results of bivariate analysis suggested that all general hypotheses were supported by the study, as described below.

General Hypotheses

1. General Hypothesis: The majority of public health dentists believe that MID does meet the dental professional standard of care for primary teeth in the United States.

This study supports this hypothesis, based on answers from Question #5 which asked "In your opinion, does MID meet the dental professional standard of care for primary teeth in the U.S.?" Results were that 85.8% (109) answered yes, that MID meets the standard of care for primary teeth in the U.S, while 14.2% (18) answered no.

2. General Hypothesis: The majority of public health dentists believe that MID does meet the dental professional standard of care for permanent teeth in the United States.

Results support this general hypothesis based on answers to question #6, which showed that 77.2% (98) answered yes, that MID meets the standard of care for permanent teeth, while 22.8% (29) answered no.

3. General Hypothesis: There are certain dentist and practice factors related to views that MID meets the U.S. standard of care.

This study supports this hypothesis that there are factors related to the view that MID meets the standard of care for primary teeth. The significant factors found were that dentists had heard about MID, that they believe that MID meets the standard of care for permanent teeth, dentists' belief that fluoride varnish is effective as caries treatment for primary teeth, and attending PH post-graduate training. Thus, dentists who had heard more about MID, believed in MID techniques for adults, believed in fluoride varnish as an effective agent for caries treatment and had PH training were more likely to believe that MID meets the standard of care for primary teeth.

Regarding the factors related to this view of MID for permanent teeth, the significant factors revealed that dentists who had heard more about MID, who had attended MID continuing education courses, who believed that MID meets the standard of care for primary teeth, who believed that fluoride varnish is effective as caries treatment for permanent teeth, and who believed that topical fluoride at home is effective as caries treatment for permanent teeth were more likely to believe that MID meets the standard of care for permanent teeth.

4. General Hypothesis: There are certain dentist and practice factors related to the use of a sharp explorer for caries detection.

This study supports this general hypothesis that there are factors related to use of a sharp explorer for caries detection. The significant factors were: use of a non-sharp explorer, use of radiographs for caries detection, having had PH post-graduate training, dental practice type (Federal, Local or Private), year of graduation from dental school, and number of direct patient care hours per week.

Those who more frequently used non-sharp explorer and radiographs, had PH training, graduated in the 1960's or 1970's, or worked in local public health practice were less likely to use a sharp explorer during caries detection.

Specific Hypotheses

Cross tabulation, chi-square tests, Fisher's exact tests, Cochran-Mantel-Haenszel analyses, and Wilcoxon rank-sum test were used to test the study-specific hypotheses, as presented below. Results of bivariate analysis suggested that some specific hypotheses were supported by the study while others were not, as described below

The specific hypotheses for this study were:

1. A higher proportion of dentists with PH post-graduate training believe that MID philosophy meets the standard of care for treatment of primary teeth than dentists without such training.

Results of the study support this hypothesis. PH post-graduate training was a significant factor ($p=0.0408$) found to be positively associated with belief that MID met the standard of care in primary teeth. Regarding PH post-graduate training, 100% of participants who had such training answered that MID met the standard of care for primary teeth, while only 82.5% of those who did not have PH training held this belief.

2. A higher proportion of dentists who have heard more about MID believe that MID philosophy meets the standard of care for treatment of a) primary and b) permanent teeth than dentists who have heard little or nothing about MID.

Results support this hypothesis and significant associations were found between belief that MID meets the standard of care for primary teeth and that dentists had heard about MID. The data showed that respondents who answered that they had heard about MID much or very much were more likely to believe that MID met the standard of care for primary teeth (93.8%, p=0.0103).

In addition, significant associations were found between belief that MID meets the standard of care for permanent teeth and dentists having heard about MID (p=0.0102). The data showed that respondents who answered that they had heard about MID much or very much were more likely to believe that MID met the standard of care for permanent teeth (86.4%).

3. A smaller proportion of dentists with PH post-graduate training use a sharp explorer during caries detection than dentists without such training.

Results of this study support this hypothesis and significant associations were found between use a sharp explorer during caries detection and PH post-graduate training (p=0.0017). The data showed that respondents who answered having had PH post-graduate training were less likely to use a sharp explorer during caries detection. Results showed that only 28.8% of dentists with PH training would use a sharp explorer during caries detection compared to 71.2% of dentists without such training.

4. A higher proportion of dentists who worked in federal dental clinics use a sharp explorer during caries detection than of dentists who work in other settings.

Results of this study support this hypothesis and significant associations were found between use of a sharp explorer during caries detection and type of practice (p=0.0027). Regarding type of practice, more dentists who worked in federal (77.1%) and

private (57.2%) settings used a sharp explorer for caries detection than for locally-based public health practices (50%).

5. A majority of dentists who believe that ART meets the standard of care for primary teeth in the U.S. also believe that MID meets it for permanent teeth.

Results of this study support this hypothesis, as significant associations were found between beliefs on ART meeting the standard of care for primary teeth and MID meeting the standard of care for permanent teeth (p=0.0002). The data showed that respondents who answered that they believe ART is a very effective or effective treatment for primary teeth were more likely to believe that MID met the standard of care for permanent teeth (83.7% vs. 38.5%).

However, this study's data did not support some of the specific hypotheses. No significant association was found between the following variables.

1. A higher proportion of female than male dentists believe that MID philosophy meets the standard of care for treatment of a) primary and b) permanent teeth.

Results of this study do not support this hypothesis. No significant associations were found between gender and belief on MID meeting the standard of care for treatment of primary (p= 0.8004) or permanent teeth (p= 0.3303).

2. A higher proportion of dentists who graduated in the past three decades, believe that MID philosophy meets the standard of care for treatment of a) primary and b) permanent teeth than of dentists who graduated more than 30 years ago.

Results of this study do not support this hypothesis. No significant associations were found between years since graduated from dental school and MID meeting the standard of care for treatment of primary (p= 0.8925) and permanent teeth (p= 0.7374).

3. A higher proportion of dentists with Pediatric Dentistry training believe that MID philosophy meets the standard of care for treatment of primary teeth than of dentists without such training.

Results of this study do not support this hypothesis. No significant associations were found between dentists with Pediatric Dentistry training status and belief that MID meets the standard of care for treatment of primary ($p= 0.1163$).

4. A higher proportion of dentists with General Practice Residency training than of dentists without such training believe that MID philosophy does not meet the standard of care for treatment of primary teeth.

Results of this study do not support this hypothesis. No significant associations were found between dentists with General Practice Residency training status and belief that MID philosophy does not meet the standard of care for treatment of primary teeth ($p= 1.00$).

5. A higher proportion of dentists who received MID training during dental school believe that MID philosophy meets the standard of care for treatment of a) primary and b) permanent teeth than of dentists who did not receive MID training during dental school.

Results of this study do not support this hypothesis. No significant associations were found between dentists receiving MID training during dental school and belief on MID meeting the standard for primary teeth ($p= 1.00$) and permanent teeth ($p= 0.6814$).

6. A higher proportion of dentists who received MID training in a didactic format believe that MID philosophy meets the standard of care for treatment of a) primary and b) permanent teeth than of dentists who did not receive MID training during dental school.

Results of this study do not support this hypothesis. No significant associations were found between dentists receiving MID training in a didactic format and belief on MID meeting the standard for primary teeth ($p= 0.4681$) and permanent teeth ($p= 0.0555$).

7. A higher proportion of dentists who treat a large proportion of Medicaid patients do not believe that MID philosophy meets the standard of care for treatment of a)

primary and b) permanent teeth than of dentists who see small proportion of Medicaid patients.

Results of this study do not support this hypothesis. No significant associations were found between dentists treating a large proportion of Medicaid patients and belief on MID meeting the standard for primary teeth (p= 0.8972) and permanent teeth (p= 0.8594).

8. A higher proportion of dentists who worked in federal dental clinics believe that MID philosophy meets the standard of care for treatment of a) primary and b) permanent teeth than of dentists who work in other settings.

Results of this study do not support this hypothesis. No significant associations were found between dentists working in federal dental clinics and belief on MID meeting the standard for primary teeth (p= 0.3516) and permanent teeth (p= 0.2464).

9. A smaller proportion of dentists who graduated recently, in the past three decades, use a sharp explorer during caries detection than do dentists who graduated more than 30 years ago.

Results of this study do not support this hypothesis. Significant associations were found between use a sharp explorer during caries detection and years since graduation from dental school (p= 0.0194). Dentists who graduated less than 30 years ago, for instance, in the 1980's (69.4%), in the 1990's (73.7%) and in the 2000's (74.2%) were more likely to use a sharp explorer than those who graduated more than 30 years ago , in the 1960's and 1970's (41.4%). Thus, these study findings showed that a larger proportion of younger dentists used a sharp explorer for caries detection, in contrast to the hypothesis.

Logistic Regression Analyses

Variables showing significant ($p \leq 0.10$) associations in bivariate analyses with each primary outcome (i.e., use of MID as a standard of care for a) primary or b)

permanent teeth and c) use of sharp explorer during caries detection) were considered as candidates for developing final models using forward and backward stepwise logistic regression analysis. All possible two-way interactions were examined for all variables in each final model.

As discussed in the chapter 3, “neither agree nor disagree”, “I don’t know this technique”, and “not applicable” responses were excluded and those variables with resultant loss of more than 20% of the responses were not considered further for inclusion in multiple logistic regression models.

Forward and backward stepwise logistic regression analyses were conducted in this study. However, for the first dependent variable, MID meeting the standard of care for primary teeth, the backward stepwise initial logistic regression analysis produced a warning message indicating that the validity of the model fit was questionable. For the second dependent variable, MID meeting the standard of care for permanent teeth, both procedures yielded the same significant results and Goodness-of-Fit tests were identical ($p=0.9712$). For the third variable, use of a sharp explorer during caries detection, the same significant variables were identified and the Goodness-of-Fit tests were similar, with $p= 0.6491$ for the backward procedure and $p=0.6717$ for the forward procedure. Thus, primarily the forward stepwise logistic regression results are discussed in this thesis.

Multiple Logistic Regression Analysis for Use of MID as a Standard of Care for Primary Teeth

Table D41 displays results from the final logistic regression model exploring the association of independent variables with MID meets the standard of care for primary teeth using forward stepwise logistic regression analysis. Twelve variables that showed significant ($p<0.10$) results in the bivariate analyses were considered as candidates for the logistic model building: heard about MID, MID is a standard of care for permanent teeth,

how effective is ART as caries treatment for primary teeth? , how effective is Sandwich Technique as caries treatment for primary teeth?, how effective is fluoride varnish as caries treatment for primary teeth?, how effective is ART as caries treatment for permanent teeth?, how effective is Sandwich Technique as caries treatment for permanent teeth?, small cavity prep compromise materials' retention, ART does not meet the standard of care in the U.S., ART could be used with high caries risk children and rampant caries patients, PH post-graduate training and other specialty than PH.

Three variables did not presented response rates of 80% or greater, so they were excluded: small cavity prep compromise materials' retention, ART does not meet the standard of care in the U.S., and ART could be used with high caries risk children and rampant caries patients.

Therefore the nine variables ($p<0.10$) included in the model were: heard about MID, MID is a standard of care for permanent teeth, how effective is ART as caries treatment for primary teeth? , how effective is Sandwich Technique as caries treatment for primary teeth?, how effective is fluoride varnish as caries treatment for primary teeth?, how effective is ART as caries treatment for permanent teeth?, how effective is Sandwich Technique as caries treatment for permanent teeth?, PH post-graduate training and other specialty than PH.

From those nine variables, the final forward stepwise logistic regression analysis indicated that those who viewed MID as meeting the standard of care for permanent teeth ($p=0.0005$), felt that fluoride varnish was effective/very effective as caries treatment for primary teeth ($p=0.0203$), or that the Sandwich technique was effective/very effective as caries treatment for permanent teeth ($p=0.0224$) were significantly more likely to report that they viewed MID as meeting the standard of care for primary teeth. No significant 2-way interactions were found.

Using odds ratios from the final logistic regression to estimate relative risks, subjects who viewed MID as meeting the standard of care for permanent teeth were 14.51

times as likely to view MID as meeting the standard of care for primary teeth, compared with those who did not view MID as meeting the standard of care for primary teeth. Subjects who believed the use of fluoride varnish for caries treatment for primary teeth to be effective/effective were 6.98 times as likely to view MID as meeting the standard of care for primary teeth, compared with those who recognized the use of fluoride varnish for caries treatment for primary teeth as ineffective/very ineffective. Moreover, subjects who felt the Sandwich technique was effective/very effective caries treatment for permanent teeth were estimated to be 13.1 times as likely to view MID as meeting the standard of care for primary teeth as those who viewed the Sandwich technique as ineffective or very ineffective.

When developing the final logistic regression model, multicollinearity diagnostics were conducted to examine the effects of the significant correlations between all nine explanatory (independent) variables on the results of regression. Variance inflation factor (VIF) and eigenvalue analysis were used, and both revealed that there were no two or more independent variables that were highly correlated with one another among variables in the model.

Backward stepwise regression analysis was also conducted to verify the results of forward stepwise analysis. However, the backward stepwise procedure resulted in a warning message “The validity of the model fit is questionable”. In addition, the forward procedure resulted in a better model fit than the backward procedure as assessed by Hosmer and Lemeshow Goodness-of-Fit tests, with $p=0.8319$ and $p=0.5047$, respectively. Therefore, only the results of forward stepwise logistic regression were reported.

Multiple Logistic Regression Analysis for Use of MID as a Standard of Care for Permanent Teeth

Table D42 displays results from the final logistic regression model exploring the significant association of variables with the belief that MID met the standard of care for permanent teeth using forward stepwise logistic regression analysis.

There were twelve significant ($p<0.10$) variables from bivariate analyses: heard about MID, where was MID training? Continue Education, MID training format, MID is a standard of care for primary teeth?, how effective is ART as caries treatment for primary teeth, how effective is fluoride varnish as caries treatment for primary teeth?, how effective is ART as caries treatment for permanent teeth?, how effective is fluoride varnish as caries treatment for permanent teeth?, how effective is topical fluoride at home as caries treatment for permanent teeth?, tunnel prep should be used instead of proximal box in adults, small cavity prep compromise materials' retention, and ART does not meet the standard of care in the U.S.

After excluding the variables due to the response rate less than 80%. Seven of ten variables that showed significant results ($p<0.10$) in the bivariate analyses were considered as candidates in the final model: heard about MID, where was MID training? Continue Education, MID training format, MID is a standard of care for primary teeth?, how effective is fluoride varnish as caries treatment for primary teeth?, how effective is fluoride varnish as caries treatment for permanent teeth?, and how effective is topical fluoride at home as caries treatment for permanent teeth?.

From the seven variables, results of forward stepwise analysis indicated that those who had continuing education ($p=0.0342$), felt MID met the standard of care for primary teeth ($p=0.0011$), or felt that ART was effective/very effective as caries treatment for permanent teeth ($p=0.0058$) were significantly more likely to report that they viewed MID as meeting the standard of care for permanent teeth. No significant 2-way interactions were found.

Using odds ratios from the final logistic regression model to estimate relative risks, subjects who had continuing education were 4.04 times as likely to view MID as meeting the standard of care for permanent teeth, compared with those who did not. Subjects who viewed MID as meeting the standard of care for primary teeth were 13.89 times as likely to view MID as meeting the standard of care for permanent teeth, compared with those who did not view MID as meeting the standard of care for permanent teeth. Moreover, subjects who viewed ART as effective/very effective as caries treatment for permanent teeth were estimated to be 5.18 times as likely to view MID as meeting a standard of care for permanent teeth compared to those who viewed ART as very ineffective/ineffective.

It is again important to mention that, when developing the final logistic regression model, multicollinearity diagnostics were conducted to examine the effects of the significant correlations between all the seven explanatory (independent) variables on the results of regression. Variance inflation factor (VIF) and eigenvalue analysis were used, and both revealed that no two or more variables were highly correlated with one another among variables in the model.

Forward stepwise logistic regression analysis was conducted and verified using backward elimination in the initial logistic regression analysis. Both procedures yielded exactly the same significant results as well as the same goodness of fitness ($p=0.9712$ for both instances). Thus, we only reported the results of forward stepwise logistic regression analysis in this thesis.

Multiple Logistic Regression Analysis for Use of Sharp Explorer during Caries Detection

Table D43 displays results from the final logistic regression model exploring the significant association of variables related to use of sharp explorer during caries detection using forward stepwise logistic regression analysis.

Thirteen variables that showed significant results in the bivariate analyses ($p<0.10$): how effective is fluoride varnish as caries treatment for permanent teeth?, do you use an explorer that is not sharp for caries detection?, do you use radiographs for caries detections?, tunnel prep should be used instead of proximal box in adults, small cavity prep compromise materials' retention, ART could be used with high caries risk children and rampant caries patients, age (categorical variable), years since graduation from dental school (categorical variable), practice type, PH post-graduate training, age(continuous variable), years since graduation from dental school (continuous variable), and direct patient care hours per week.

Three variables were excluded due to response rate for the specific question was less than 80%. After collinearity was diagnosed between age and years since graduation from dental school, two more variables were excluded: years since graduation from dental school (categorical variable), and years since graduation from dental school (continuous variable).

Thus, eight of thirteen variables that showed significant ($p<0.10$) results in the bivariate analyses were included in the logistic model: how effective is fluoride varnish as caries treatment for permanent teeth?, do you use an explorer that is not sharp for caries detection?, do you use radiographs for caries detections?, age (categorical variable), practice type, PH post-graduate training, age (continuous variable), and direct patient care hours per week.

From the eight variables, the forward stepwise analysis results indicated that those who sometimes or never used non-sharp explorer during caries detection ($p=0.0022$), used radiographs for caries detection ($p=0.0434$), and worked longer hours per week for direct patient care ($p=0.0018$) were significantly more likely to report that they used a sharp explorer during caries detection. No significant 2-way interactions were found.

Using odds ratios from the final logistic regression model to estimate relative risks, respondents who sometimes or never used a non-sharp explorer during caries

detection were estimated to be 3.75 times as likely to report use of sharp explorer during caries detection, compared with those who always, most of the time or often used a non-sharp explorer. The odds of use of sharp explorer during caries detection for subjects who used radiographs for caries detection were 10.01 times that of subjects who did not use radiographs. Regarding the chance of using of sharp explorer during caries detection, the adjusted odds ratios increased 1.05 times for each hour spend in patient care per week.

As with the previous models, when developing the final logistic regression model, multicollinearity diagnostics were conducted to examine the effects of the significant correlations between the eight significant explanatory (independent) variables on the results of regression. Variance inflation factor (VIF) and eigenvalue analysis were used. Strong correlation was found between age and years since graduation from dental school variables. Thus, we used age in the final logistic regression model.

Forward stepwise logistic regression analysis was conducted and verified using backward elimination logistic regression analysis. Both procedures yielded the same significant results; however, the forward stepwise procedure resulted in a slightly better model fit than the backward procedure, with p=0.6717 and p=0.6491, respectively. The results of both the forward and backward stepwise logistic regression analyses are presented because there were slight differences between the two models (Tables D43 and D44).

Summary of Multivariable Analyses

Based on the final model using forward stepwise logistic regression analysis, PH dentists who felt that MID met the standard of care for permanent teeth were more likely to report that they felt that MID met the standard of care for primary teeth. Subjects who felt that fluoride varnish was effective/very effective as caries treatment for primary teeth and dentists who believed that the Sandwich technique is an effective technique as caries

treatment for permanent teeth were more likely to view MID as meeting the standard of care for primary teeth.

Dentists who had continuing education courses in MID were more likely to report that they believed MID met the standard of care for permanent teeth. Dentists who felt MID met the standard of care for primary teeth and subjects who believed that ART is very effective as caries treatment for permanent teeth were more likely to view MID as meeting the standard of care for permanent teeth.

In addition, PH dentists who sometimes or never used non-sharp explorers during caries detection were more likely to report use of sharp explorers during caries detection, compared with those who always, most of the time or often used a non-sharp explorer. Dentists who used radiographs for caries detection were more likely to use a sharp explorer during caries detection. Lastly, the use of sharp explorer during caries detection was associated with more hours spent in patient care per week as demonstrated by the adjusted odds ratios that showed that the odds of sharp explorer use increased 1.05 times for each hour spend in patient care per week.

Summary of Results

Regarding bivariate analyses significant results, of 54 independents variables tested for association with each of the three depended variables, only 12 variables showed significance with MID meeting the standard of care for primary teeth, 12 with MID meeting the standard of care for permanent teeth and 13 variables with the use of sharp explorer during caries detection.

Regarding bivariate results for the dependent variable, MID meeting the standard of care for primary teeth, the prominent positive associations related to MID and type of procedures were found with the agreement of the use of fluoride varnish for caries treatment of children, use of Sandwich technique for adult treatment, and agreement with the statement that small cavity preparations would not compromise material retention.

Related to provider characteristics, dentists who had PH post-graduate training were found to be more likely to believe that MID meets the standard of care for primary teeth. Significant results in the logistic models for MID meeting the standard of care for primary teeth were found with the agreement of the use of fluoride varnish for children, Sandwich technique for caries treatment of adults and that MID meets the standard of care for permanent teeth.

For the dependent variable, MID meeting the standard of care for permanent teeth, bivariate analyses found that the prominent independent variables that showed positive association related to MID and type of procedures were the agreement with the use of fluoride varnish for caries treatment of children and adults, use of high fluoride toothpaste for adult treatment, and tunnel cavity preparations. No association was found among variables related to provider characteristics for this specific dependent variable. A significant result in the logistic model for MID meeting the standard of care for permanent teeth was use of ART for adult patients. In other words, dentists who agreed that ART should be used for caries treatment of adult patients were more likely to believe that MID meets the standard of care for permanent teeth.

Bivariate results for dependent variable, use of sharp explorer during caries detection showed positive association with the use of conservative cavity preparations, such as small and tunnel. Other associations revealed that dentists who used radiographs for caries detection were more likely to use a non-sharp explorer during caries detection. Regarding associations with provider characteristics, those who had PH training, graduated from dental school in the 1960's or 1970's, or worked in local public health practice were less likely to use a sharp explorer during caries detection. Significant variables in the logistic models for the use of sharp explorer during caries detection included greater use of radiographs and greater providers' hours per week with direct patient care. In other words, dentists who used radiographs for caries detection were more likely to use a sharp explorer during caries detection. Lastly, the use of sharp explorer

during caries detection was associated with more hours spent in patient care per week as demonstrated by the adjusted odds ratios that showed that the odds of sharp explorer use increased 1.05 times for each hour spend in patient care per week.

CHAPTER V

DISCUSSION

Overview

The primary objectives of this study were to determine if Minimally Invasive Dentistry (MID) is considered to meet the standard of care among dentists working in public health settings in the United States and to identify factors associated with beliefs that MID meets the standard of care.

Results demonstrated that there were significant variations in the characteristics of dentists, patients and practices associated with respondents' beliefs regarding the MID philosophy.

Response Rates

The response rate for this study, as the result of two e-mails, was 37.5%. Even though the response rate overall was low, it was reasonable compared to response rates of other studies[89,114,115]. Gaskin & others[89] achieved a response rate of 31.0% in their study which analyzed the knowledge, attitudes, and behaviors of federal service and civilian dentists concerning Minimal Intervention Dentistry. They assumed their low response rate was due to the fact that the first mailing was sent before a holiday period. The response rate was also similar to a web-based dental survey on changes in dental students' empathy training reported by Yarascavitch et al.,[114] which had a response rate of 36.5%. The authors believed the response rate was a limitation in their study. Another earlier study that used a web-based survey among dentists achieved a very low response rate of 6.3%[115]and was focused on dentists' molar restoration choices and restoration longevity.

The methods used to improve the response rate for this study included pre-testing of the questionnaire among University of Iowa College of Dentistry faculty; sending the survey more than 2 weeks after a holiday; an introductory e-mail inviting dentists to

participate in the study and one reminder e-mail. The reminder e-mail was sent to improve response rates based on Parashos & others'study[116]; the authors of that study found their response rate improved after each contact. In their study, the response rate for the first mailing was 49%, increasing to 71% after the second mailing, 79% after the third mailing, and 87% after the fourth contact, which was by telephone[116].

With the present study's first mailing, a problem occurred with the survey link, as all participants were not able to open the link. This issue was detected and fixed immediately and another e-mail was sent to all participants with the correct link and a short note apologizing for the inconvenience. Thus, a total of three e-mails were sent to participants. The problem with the incorrect link may have contributed to the low response rate after the first e-mail, 22.7% (83).

Most of the present study's respondents were dentists from federal services, which represented 61.9% (83) of all responses. It was a higher proportion of dentists from federal services compared to Gaskin and colleagues'study[89], which included only 15.3% (138) respondents from federal services. The likely reason that more federal service dentists responded was because federal oral health programs are the main focus of the NNOHA and AACDP associations. Thus, it was expected that the study would have more federal service dentists than local and private dentists. It could also be that local or state clinic dentists were too busy to respond or were not as interested in the topic compared to federal service dentists.

Demographic Differences

Overall, 52.9% of respondents were male and 47.1% were female dentists. Most dentists with PH or MPH post-graduate training, which represented 16.5% of respondents, believed that MID met the standard of care only for primary teeth and they did not use a sharp explorer for detecting caries. Those with PH or MPH post-graduate training had greater tendencies toward using MID techniques than did those without such

training. Overall 46.8% of participants responded that they had completed post-graduate training, which was similar to Gaskin et al.[89] who reported that 58.1% of respondents completed post-graduate training.

In contrast to Gaskin et al.[89], this study found that more recent graduates and younger dentists (year of graduation from dental school from the 1980's to the 2000's) tended to use sharp explorers more for caries detection, which is a practice contrary to the MID philosophy. Gaskin et al. [89] found that more recent graduates and younger dentists tended to more frequently use MID practices. In addition, the present study found that a larger percentage of federal service dentists (77.1%) used a sharp explorer as a caries detection technique than local and private dentists (50% and 57.2%, respectively). This is also contrary to Gaskin's study, which suggested that federal service dentists used more MID techniques and philosophy than civilian dentists.

Similar to Gaskin et al.'s study[89], this study found that 48.5% responded that they had heard very much or much about MID compared to 41.5% in Gaskin et al.'s[89].

Principal Findings

Regarding the dependent variables of this study, 85.8% of participants answered that they considered that MID met the standard of care for primary teeth and 77.2% reported this philosophy met the standard of care for adult patients as well. This is in contrast to Gaskin et al.'s findings[89] which concluded that MID was considered mainly for children among federal and civilian dentists, and that MID technique would be considered by their study population as inappropriate treatment for adult populations. Possible explanations for this finding are that MID techniques have become more accepted recently, or because in federal settings, such as the Army there is a need to deploy soldiers and for this reason dentists would prefer to have more definitive treatment, because it is often not possible to monitor treatment of these patients. Note

also that Gaskin and colleagues' study[89] was actually completed in 2006, so that the differences may be due to greater acceptance since that time.

Another dependent variable was the use of sharp explorer during caries detection. Based on this study's results, 64.7% of respondents would use this approach always, most of the time, or often. Even though there is strong evidence in the literature showing that that the use of sharp explorers for caries detection can cause traumatic defects on hard tissue leading to future caries lesions[109]; that the use of a sharp explorer can lead to the transfer of microorganisms from one fissure to another[112]; and that the use of a sharp explorer does not improve caries diagnosis accuracy[110, 111], a majority of respondents may not practice consistent with the literature with regard to use of sharp explorer for caries detection. There are no studies identified in the literature that analyzed the association between use of a sharp explorer and the general MID approach or about factors related to explorer use.

Significant associations were found between MID meeting the standard of care for primary teeth and whether respondents had heard about MID. The data showed that respondents who heard much or very much were more likely to believe that MID met the standard of care for primary teeth. This study found that 48.5% of respondents had heard much or very much about MID, which aligns with Gaskin et al.'s study[89] that 41.5% of participants had heard much or very much about MID and also found that those who had heard much or very much about MID were more likely to apply MID concepts.

In addition, those who believed MID met the standard of care for permanent teeth were also more likely to believe MID met the standard of care for primary teeth. Both of these findings make sense because, by receiving more knowledge about a specific subject, people are more likely to understand its concepts and applications and consequently be more likely to believe its application is appropriate. Also, dentists who believe that MID is an optimal philosophy to treat adults are likely to have greater knowledge about MID philosophy and better understand its techniques and advantages of

this kind of treatment, so they are more likely also to believe in its application for children. In contrast, people who are unfamiliar with a concept are less likely to apply it. There are no studies available that investigated the MID approach which considered associations between children's and adults' treatment. However, Gaskin's et al [89] findings suggested that MID was considered mainly for children among federal and civilian dentists, and that MID technique would be considered inappropriate treatment for adult populations.

The results of this study indicated that higher proportions of respondents who individually recognized the effectiveness of ART, fluoride varnish and Sandwich techniques were more likely to agree that treating children with MID philosophy met the standard of care in the U.S. This also makes sense since ART, fluoride varnish and Sandwich techniques are MID techniques. Also, this finding is not surprising for primary teeth because ART and Sandwich techniques are normally performed more frequently for children than adults. Studies have shown that MID techniques and concepts such as use of fluoride varnish, chlorhexidine, pit-and fissure sealants and resin base composite restoration have become more widely used in recent years[32, 117]. For instance, Fiset and colleagues'[32] survey in Washington state showed that 35% of private dentists used fluoride varnish and 100% used resin-based composite restorations suggesting that these procedures met the standard of care.

This study found that higher proportions of respondents who agreed that a small cavity preparation does not compromise materials' retention and those who agreed that ART meets the standard of care in the U.S. also agreed that MID met the standard of care for primary teeth in the U.S. In addition, PH post-graduate trained dentists were more likely to believe that MID met the standard of care in primary teeth. As mentioned previously, small cavity preparations and ART are MID techniques, so it is natural that people who believed in the effectiveness of these treatments also would be more likely to agree that MID meets the standard of care in dentistry, and specifically in children. Also,

ART is more widely used for children and small cavity preparations would minimize the possibilities of compromising the pulp, which is significantly larger in children than adults, so these factors may have influenced the results. A study by Domejean-Orliaguet and colleagues[87] found that resin-based composite is the second most common choice of material used among French general private dentists in cases with large posterior restoration, showing that 49% of dentists would prefer amalgam, 40% resin-based composite and 12% resin-modified glass ionomer. However, as mentioned previously, Fiset and colleagues'[32] survey in Washington state showed that 100% of general dentists used resin-based composite restorations.

Regarding PH trained dentists and MID beliefs for primary dentition treatment, this result was expected because PH dentists are trained in prevention philosophies and techniques more than are most other dentists. In addition, Traebert and colleagues[95] reported in 2005 that, among Brazilian dentists, dentists with any post-graduate training tended to have a more conservative restorative approach than dentists without such training. No other studies in the literature reported on the specific association between PH post-graduate training and MID philosophy.

Most of the respondents who considered MID to meet the standard of care for children also considered it to do so for adults' care (85.2%). Significant results of this study showed that ART, fluoride varnish and highly concentrated fluoride toothpaste are considered effective as adult preventive treatments. Therefore, dentists who are familiar with MID philosophy and techniques are more likely to apply its concepts for their patients, both children and adults, because they likely have a better understanding of the demineralization and remineralization processes of tooth structure and prognoses. Similarly, most of these dentists likely believe that the use of fluoride varnish and highly concentrated toothpaste will help in the remineralization process of incipient carious lesions and transform active lesions into arrested lesions. Gaskin et al.'s study[89] found that 41.9% of dentists surveyed in their study used topical fluoride and 20.1% prescribed

5,000 ppm fluoride toothpaste, which is similar to the percentage in this study who strongly agreed that topical fluoride was effective(53.9%).

Related to restorative approaches, dentists who agreed that ART and tunnel cavity preparations are effective treatments for adults were more likely to agree that MID met the standard of care for permanent teeth in the U.S. These findings also make sense because ART prioritizes partial removal of the carious lesions, primarily in the peripheral area of the lesions, rather than in the deeper center of the lesion. This gives time for the body's response to this inflammatory process and creates reparative dentin in order to avoid possible pulp exposure. The tunnel cavity preparation also is a technique that applies the MID concepts by preserving the marginal ridge of the tooth in question, which would reduce the probability of restoration breakdown and marginal infiltration because it avoids removing the marginal ridge as in the traditional box cavity preparations. Domejean-Orliaguet and colleagues[87] reported that, when French general private dentists were asked about proximal caries lesions, of the 230 enamel lesions, only 12 lesions were restored using tunnel cavity design. It is important to mention that dentists have the common sense that tunnel cavity preparations are more conservative than conventional class II cavity preparations; however, when it comes to utilization, not many dentists use this technique. It might be because dentists are unfamiliar with such procedures or that they would rather do conventional preparations in order to have better access and make sure no carious lesion is left that might lead to recurrent caries.

The results also indicated that those who viewed MID as meeting the standard of care for permanent teeth also felt that fluoride varnish was effective as caries treatment for primary teeth, and those who felt that the Sandwich technique was effective as caries treatment for permanent teeth were more likely to report that they viewed MID as meeting the standard of care for primary teeth. All of the techniques cited above are part of the MID philosophy, so it is natural that dentists who believe and use this approach will be more likely to believe that MID is also an optimal treatment for children and

adults. Gaskin et al.'s[89] study reported that 96.7% of federal and civilian dentists in the U.S. agreed that fluoride varnish was effective for treatment of caries in adult patients. In this study, we found that 81.6% of respondents agreed or strongly agreed that fluoride varnish was effective for caries treatment in adults.

Significantly more dentists who reported having CE courses about MID ($p=0.0342$), or felt ART was effective as caries treatment for permanent teeth ($p=0.0058$) were more likely to report that they viewed MID as meeting the standard of care for permanent teeth. The main explanation for these results is because the more knowledge dentists obtain through CE courses, the more familiar dentists will be with MID concepts and the more likely they will be to apply them and believe that its techniques are effective to treat children and adult patients. This is consistent with a study by Fiset and colleagues[32] which surveyed 532 general dentists in Washington state and reported that 41 to 56% of these dentists reported to have adopted caries-control agents in their private practices because of receiving information in continuing educations courses.

Regarding the use of a sharp explorer as a caries detection technique, the respondents who used radiographs during caries diagnosis were more likely to use a sharp explorer for detecting caries. A possible explanation for this finding is that dentists who used radiographs to diagnose dental caries may see a questionable lesion or artifact in the radiographs which may lead the dentist to use a sharp explorer to make sure there are no cavitated lesions in the radiolucent areas. Another possible explanation is that some dentists may have been trained in more traditional approaches which relied on both explorer probing and frequent radiographs, so that these techniques may often be used together.

The French study by Domejean-Orliaguet and colleagues[87] demonstrated that treatment decisions were associated primarily with probing or use of explorer, followed by visual inspection and radiographic analyses. Thus, routine use of a sharp explorer during the caries detection was frequently (40% of respondents) reported in the 2009

study[87] and the present study's findings are similar, as a sharp explorer was reported to be used by 65% of the respondents to this thesis.

Also, the respondents who strongly disagreed or disagreed that tunnel cavity preparation should be used instead of a proximal box in adults or ART should not be used for high caries risk children and rampant caries patients were more likely to use a sharp explorer for detecting caries. Again, use of ART and tunnel cavity preparations are parts of MID philosophy, so dentists who believe in these techniques would be expected to avoid the use of a sharp explorer for caries detection because it goes against the MID principles. There are no studies in the literature that associated use of a sharp explorer during caries detection and tunnel cavity design. Domejean-Orliaguet and colleagues'[87] study in which only 12 of 230 proximal lesions confined to enamel were restored using tunnel cavity design suggested that dentists have the common sense that tunnel cavity preparations are a conservative approach, but they seem to not use this procedure often in their daily practice. Therefore, it is expected that dentists who believe that tunnel preparations should not be used instead of conventional class II preparations will have a more invasive approach and will be more likely to use a sharp explorer during caries detection.

The overall mean age of respondents was 46.8 years, but those who used a sharp explorer were significantly ($p=0.035$) younger (45.2 years) on average than those who did not use a sharp explorer (49.7 years), which was the opposite direction than expected. Perhaps, younger dentists are not employing certain MID concepts such as not using a sharp explorer during caries detection and are over-treating patients because of lack of knowledge and experience to use other caries diagnostic methods. The MID diagnostic process may take longer if the dentist is not familiar with this process and younger dentists may not want to spend the time, particularly if they are paid by procedure. This finding is in contrast to Riley et al.[88] who found that the use of preventive agents was

associated with younger dentists and Gaskin et al.[89] who reported that more recent graduates and younger dentists tended to more frequently use MID practices.

In addition, dentists who provided more direct patient care were found to be more likely to use sharp explorers. A possible explanation would be that dentists with higher volumes of patients do not take the time to use visual-only techniques, so they would be more inclined to use a sharp explorer for caries detection. Finally, the results indicated that those who worked longer hours per week with direct patient care were significantly more likely to report that they used a sharp explorer during caries detection ($p=0.0018$). This was an unexpected result, but might be explained by the idea that dentists with more patients do not want to take the time to do visual-only diagnosis, and could be more inclined to pick up the explorer. However, another explanation would be that, by using a sharp explorer, the provider would be more likely to find cavitated lesions and diagnose more lesions, particularly if they are paid by procedure. There are no studies available in the literature that investigated the association between hours per week in direct patient care and use of a sharp explorer during caries detection.

Study Strengths

This was the first study of its kind to survey United States Dental Public Health dentists about MID philosophy. This is the study's greatest strength.

The second strength was that it investigated MID philosophy responses related to children's and adults' dental treatment. For instance, Gaskin & others[89] investigated MID practices only related to the adult patient population, which was considered one of the limitations of their study.

Another consideration is that there was a statement in the beginning of the survey that gave the participants a brief definition of Minimally Invasive Dentistry. We included this definition because we believed that, without a clear definition, it would be possible that some respondents indicated they knew none or little about the term "MID", even

though they might be using procedures related to it in their offices. As mentioned by Gaskin et al.[89], it was a limitation in their study to not have provided a definition of Minimal Intervention Dentistry and it was reported to be a suggestion made by the participants in their survey.

Study Limitations

While the study was unique and had several strengths, there also were limitations. It was not possible to gain access to a large number of dentists with formal public health training, which was the first intention of this research. Due to this limitation, the focus of this research was broadened to include all dentists working in public health settings. In addition, another limitation was to select only dentists from the NNOHA and AACDP membership lists. The initial intention of this study was to survey all PH dentists in the U.S.; however, the American Dental Association (ADA) denied providing the list of members who worked in PH and we did not have access to any other lists of PH dentists on a nationwide level. Therefore, we chose to target the National Network for Oral Health Access (NNOHA) and American Association of Community Dental Programs (AACDP), because we believed these two entities would be the next best representation of PH dental professionals in the United States. Therefore, this study population was not fully representative of all PH dentists in the U.S.

As stated above, the survey was intended for only those with Dental Public Health background. However, only about 17% of respondents declared having Public Health training, followed by 11% with GPR, 7.4% with AEGD, and 6.6% with Pediatric Dentistry training. Thus, this mix of backgrounds of respondents may have diluted the PH focus of the study.

This study also did not specify that dentists had to be engaged in clinical practice, but also included dentists involved only in public health program administration. Some respondents, for instance administrators, replied to the invitation e-mail saying that they

were not in clinical practice and did not see patients and asked if it was relevant for the study their participation. So, we replied that their opinion was very important for the study since they could be responsible, in many cases, for directing or monitoring programs that might include components of MID. Some of non-practicing administrators chose not to participate, while others chose to participate by partially completing the survey, leaving some or all the clinical questions blank. However, all responses were included in the analyses. Dentists without clinical practice experience may not have had informed opinions about MID, which may have affected the study's results. However, as shown in Tables D19 and D28, the mean number of hours with direct patient care did not differ between those who believed that MID meets the standard of care for primary teeth and permanent teeth and those who did not.

As discussed in the Chapter 3, "neither agree nor disagree", "I don't know this technique", and "not applicable" responses were excluded and those variables with resultant loss of more than 20% of the responses were not considered further for inclusion in multiple logistic regression models. Therefore, several variables were excluded from consideration for inclusion in the final models. For instance, only 9 variables from 12 significant variables were used in the first final model, 7 from 12 in the second model and 8 of 13 variables in the third model. The final logistic models did not consider these variables which were significant in the bivariate analysis because of responses rates less than 80%. In addition, some variables were highly correlated. For example, age and years since graduation from dental school were highly correlated so that only age was included in the model regarding the use of sharp explorer during caries detection variable. These exclusion criteria were used in order to have better model fit; however, it might have altered the results. Some significant variables from bivariate analyze that were excluded from the regression might have changed the results; however, we do not know how different the models would have been. For instance, the category "neither agree nor disagree" could have been merged with strongly disagree and disagree, thus increasing

the sample size and consequently improving the power of the study. Another option could have been to create a third category, such as “neither agree nor disagree”; however, this may not have been feasible because for many variables the number of responses in the neutral categories was very small. Nevertheless, including those neutral responses may have produced different results. Also, regarding data analyses, these neutral responses were excluded and those variables with a resultant loss of more than 20% of the responses were not considered further for inclusion in multiple logistic regression models. Thus, if these excluded variables were re-coded, different variables may have been included in the models. For instance, the category “neither agree nor disagree” could be merged with strongly disagree and disagree, thus increasing sample size and increasing the number of variables for potential inclusion in the regression models.

We also considered conducting analyses of the data by practice setting, but this was not done because of the distribution of responses. We had 61.9% (83) in federal, 19.4% (26) in local, but only 5.2% (7) in the private setting category. A larger sample size and increased study power may have allowed us to do the analyses by federal, local and private practice settings and provided better insights into differences among these settings. We could have analyzed federal service dentists versus others; however, the sample size for local and private setting dentists was small and such comparisons may have lacked meaning since local health clinics and private practices are often quite different and thus, inappropriate to group together.

Another weakness of the study was the inability to investigate non-response bias because in this anonymous survey the participants were not identified. The study had a potential for response bias, as those more familiar with or having more favorable views of MID may have been more likely to respond than others with less knowledge or less favorable views. In addition, we had limited information about the two entities surveyed. For instance, we did not have information about each organization’s profile, such as gender, age or dental practice type (federal, local, private). Thus, there was no way to

compare the respondents to non-respondents. The response rate for this study was 37.5% (136), which also led to low power and a higher chance of β-error than desirable. Therefore, caution is needed in interpreting and generalizing all results.

Another weakness of the study was lack of question validity; we did not validate the survey instrument, so it is possible that some items did not accurately measure certain factors. There may also have been inconsistent interpretation of various terminologies, which may have led to inaccurate responses which could have affected study results. For example, some respondents may not have been familiar with the term "sandwich technique" or may have been uncertain about the meaning of "tunnel cavity preparation". Similarly,some respondents may not have been familiar with terms regarding newer caries diagnostic methods, such as FOTI or QLF.

In addition, due to the multiple aspects of MID, some respondents may have had favorable views of some MID approaches, but not others, and thus may or may not have viewed MID as favorable overall. This study was not able to assess the relative importance of different MID components. To do so, an alternative approach could have been to use conjoint analysis, a statistical procedure to determine how people value different features that influence decisions. Conjoint analysis helps to determine what combination of factors may influence respondent choices or decisions.

Finally, it should be noted that no explicit standards of care for dentistry are in the literature, so the approach used in this study was to leave it to the participants to decide whether they believed that MID met the standard of care for dentistry in the U.S. This may have resulted in very different interpretations of standards of care, which may have produced different results than if standards of care were defined by the survey or as may be the case in other countries.

Possible Changes to the Study If It Were Repeated

If this study were repeated, several changes could be incorporated. One such change would be to reduce the number of questions in the survey. There may have been too much information to be answered by participants, which may have limited the response rate. In particular, questions related to Electrical Caries Monitor (ECM), Quantitative Light-induced Fluorescence (QLF), and Infrared Laser Fluorescence (IRLF) could have been omitted since these techniques are new and mostly experimental and thus were not recognized by most dentists.

In a similar vein, questions 11, 12, and 13 asked about the level of agreement with MID treatment philosophy statements such as: there is a direct relationship between carious lesions and intake of refined carbohydrates (Question #11); when possible, a tunnel preparation design for proximal caries lesions should be used instead of a traditional proximal box in adults (Question #12); and small, minimal cavity preparations compromise materials' retention (Question #13). These questions possibly could be reworded and combined in order to reduce number of survey questions, creating only one question with responses that would be consistently and concisely in line with MID concepts. Concentrating on one or two areas would have given more focus to the study.

Because some neutral responses to some questions led to the exclusion of some variables from regression analyses, if the study were repeated, such questions could be written without including the neutral options. For example, instead of 5 response options of " strongly agree", "agree", "neither agree nor disagree", "disagree" and "strongly disagree", the neither category could be excluded so that the 4 responses categories could be collapsed to agree and disagree categories. This would potentially, avoid having to exclude such variables from analyses or artificially assigning the neutral category responses to either the agree or disagree categories. Alternatively, all 5 categories could be used or the neutral categories could have been assigned to one of the dichotomous categories.

Regarding the low response rate after two e-mailings, the proposed changes would include: shortening the questionnaire, use of incentives, and an additional contact by telephone either before or after e-mailing the questionnaire. It is also possible to have used identifiers in the survey so that non-responders could be targeted with more follow-up e-mails, which would also allow for analyses of non-response bias. We believe that these are actions that would have improved the response rate.

While the two organizations in the present study provided useful information, future studies could target additional organizations such as the American Board of Dental Public Health, the American Association of Public Health Dentistry, or the Community Dentistry section of the American Public Health Association. Also, as mentioned previously, future studies could try to obtain mailing lists from the American Dental Association to target those dentists who identify themselves as working in dental public health settings.

In addition, related to being able to discriminate elements of MID, as described previously, conjoint analysis could be used to determine how people value different features that influence respondent choice or decision making. Also, better explanation of terms used in the questions may reduce misinterpretation that might affect study results. Lastly, more effort could be made to formally validate key items in the questionnaire.

Clinical Relevance of the Study

The results of this study suggest that younger dentists used sharper explorers during caries diagnosis in their clinical practice more than older dentists, contrary to other studies such as Gaskin et al. [89], which found that younger dentists might be more conservative in their clinical practice. This is evidenced by the finding that younger dentists made more use of sharp explorers than did older dentists and that younger dentist were less likely to employ certain MID concepts. The use of sharp explorers is not a MID or conservative procedure because, if it is applied with pressure in areas of demineralized

enamel, it can cause tooth cavitation. On the other hand, the use of MID in clinical practice teaches preserving tooth structure, reducing the number of restorations and educating patients about the significance of caries prevention.

Perhaps, younger dentists are not employing certain MID concepts such as not using a sharp explorer during caries detection and are over-treating patients because they lack knowledge and experience to use other caries diagnostic methods. In addition, some dentists in PH settings might be over-treating patients in order to improve the financial programs' production in which they work by performing more invasive treatments than preventive ones. It may happen because dentistry continues to be a procedure-driven profession and because of the lack of diagnostic codes in dentistry, providers are not reimbursed by diagnosing disease (prevention=treating the disease cause), but mainly by doing procedures (curative=treating disease symptoms).

Another significant and clinically relevant finding of this study is that dentists who had heard much or very much about MID were more likely to believe that MID met the standard of care for children and adults. Thus, by providing more information about MID though CE courses and other means, dentists will increase their knowledge about this philosophy and will consequently be more likely to apply its concepts in their clinical practices.

Future Directions

In addition to all possible changes to the study if it were repeated, there are several other areas of research that could be conducted regarding MID. Minimally Invasive Dentistry is a very broad and still emerging area of dentistry. In general, additional studies need to be done related to the MID philosophy. These should include clinical studies associated with strengthening tooth structure and efforts should focus toward educating the public about prevention. Other studies to evaluate costs associated

with MID procedures compared to costs from traditional procedures in public health settings are also needed.

Additional research is needed on the acceptance of the MID approach among other dentists, such as general dentists and pediatric dentists, and in assessing the knowledge, attitudes and behavior concerning MID concepts and application. In addition, more studies need to be done in order to understand why use of sharp explorer persists when other concepts of MID seem to have been more widely adopted by dental practitioners.

More studies about MID might encourage health insurance and other third party payers to modify their policies to promote a more conservative approach. As a result, eventually dentists would use more conservative procedures, because they would be reimbursed for them. In addition, changes in state board and licensure requirements focused on more conservative approaches may also help to bring about such changes.

Because this study surveyed PH dentists in the U.S. and predominantly trained in the United States, these results might not be applicable to other parts of the world. Thus, there is need for comparative studies from other parts of the world.

Despite the development of this modern approach and the leading role PH dentists play in advocating prevention, there have been no published studies that evaluated U.S. public health dentists' knowledge, attitudes, and behavior concerning MID. This study is the first to provide such information, and findings may provide guidance for future studies.

CHAPTER VI

CONCLUSIONS

This study assessed PH dentists' knowledge, attitudes and behavior concerning Minimally Invasive Dentistry (MID), because little was known about its use or acceptance in the U.S., particularly in public health settings.

The study survey was sent electronically to 363 dentist members of the National Network for Oral Health Access (NNOHA) and American Association of Community Dental Programs (AACDP). The questionnaire asked questions about dentists' familiarity with the MID approach, practitioner characteristics and practice characteristics. Specific questions focused on diagnostic and preventive techniques, and whether MID was considered to meet the standard of care in the U.S. separately for child and adult patients.

The results revealed that approximately 86% of respondents believed MID met the standard of care for primary teeth, 77% believed it did for permanent teeth, and 65% used a sharp explorer as routine during the caries detection process.

The study found that those with more favorable opinions of fluoride were more likely to believe that MID met the standard of care for children and adults. In addition, dentists who completed PH post-graduate training and older practitioners were less likely to use a sharp explorer during caries diagnostic process.

According to logistic regression modeling that considered only significant bivariate ($p<0.10$) factors with 80% or greater completed responses, dentists who had continuing education courses in MID were more likely to report that MID met the standard of care for permanent teeth. Those who believed that the Sandwich technique is effective as caries treatment for permanent teeth were more likely to view MID as meeting the standard of care for primary teeth, and dentists who frequently used

radiographs during the caries diagnostic process or had more hours per week with direct patient care were more likely to use a sharp explorer.

This study supported the general hypotheses that the majority of public health dentists believed that MID meets the dental professional standard of care for primary and permanent teeth in the United States and that there are factors related to beliefs that MID meets the standard of care for primary and permanent teeth. Specifically, the factors related to MID meeting the standard of care for primary teeth were how much the dentist had heard about MID, beliefs that fluoride varnish was efficacious, and having had PH post-graduate training. Significant factors related MID meeting the standard of care for permanent teeth were how much the dentist had heard about MID, having had CE courses about MID, and beliefs that fluoride varnish and highly concentrated fluoride toothpaste used at home were effective. Finally, the use of sharp explorer was associated with use of radiographs for caries detection, no PH post-graduate training, dental practice type (more in federal setting), younger age, more recent graduation from dental school, and more hours of direct patient care per week.

This study also supported the specific hypotheses that a higher proportion of dentists with dental public health or public health post-graduate training believed that MID philosophy meets the standard of care for treatment of primary teeth than dentists without such training, that a higher proportion of dentists who have heard more about MID believe that MID philosophy meets the standard of care for treatment of primary and permanent teeth than dentists who have heard little or nothing about MID, that a smaller proportion of dentists with dental public health or public health post-graduate training used a sharp explorer during caries detection than dentists without such training, that a larger proportion of dentists who graduated more recently (in the past three decades) used a sharp explorer during caries detection than did dentists who graduated more than 30 years ago, and that a higher proportion of dentists who worked in federal

dental clinics used a sharp explorer during caries detection than dentists who worked in other settings.

In conclusion, study results suggest that there is a paradigm shift toward MID philosophy, as evidenced by the finding that most PH dentists believed that MID met the standard of care for primary and permanent teeth. However, the use of a sharp explorer was still used routinely during the caries detection for the majority of respondents, suggesting that some aspects of the MID approach have not been adopted by public health dentists.

Additional research is needed on the acceptance of the MID approach among other dentists, such as general dentists and pediatric dentists. In addition, more studies need to be done in order to understand why use of sharp explorer persists when other concepts of MID seem to have been more widely adopted by dental practitioners.

APPENDIX A

INTRODUCTORY EMAIL

survey @iowa

FOR IRB USE ONLY
APPROVED BY: IRB-01
IRB ID #: 200911750
APPROVAL DATE: 01/22/10
EXPIRATION DATE: N/A

We invite you to participate in a research study. The purpose of this research study is to determine your familiarity with the restorative approach, Minimally Invasive Dentistry (MID). The study results may help us understand how Dental Public Health (DPH) dentists have incorporated MID concepts into their practices. To date, there are no published studies that evaluate the DPH dentists' familiarity with these concepts.

We are inviting you to be in this study because you are a member of the National Network for Oral Health Access (NNOHA) or the American Association Community Dental Programs (AACDP). Approximately 600 people will participate in this study.

If you agree to participate, we would like you to answer a brief questionnaire about Minimally Invasive Dentistry. You are free to skip any questions that you prefer not to answer. It will take approximately 10 minutes to complete the survey.

Your responses will be completely anonymous and will be returned to us without any individual identifying information. Participation is completely voluntary. If you have questions about this survey, please contact Deise Oliveira, Dental Public Health Resident, or Dr. John Warren, Thesis Advisor, by email at deise-oliveira@uiowa.edu or john-warren@uiowa.edu.

If you have questions about the rights of research subjects, please contact the Human Subjects Office, 300 College of Medicine Administration Building, The University of Iowa, Iowa City, IA 52242, (319) 335-6564, or e-mail irb@uiowa.edu.

If you are unable to open the link, simply copy and paste the link into your web browser. Your participation will improve the validity and reliability of this master's thesis research study.

http://survey.uiowa.edu/wsb.dll/1109/MIDapproachDentalPublicHealth.htm

Thank you very much for your consideration!

Deise Oliveira, DDS
Preventive & Community Dentistry/ Operative Dentistry
College of Dentistry
University of Iowa

APPENDIX B

QUESTIONNAIRE

Minimally Invasive Dentistry Approach in Dental Public Health

Minimally Invasive Dentistry (MID) is an approach to caries management based on: 1) early diagnosis; 2) a modified classification of caries based on first assessing the site and size of each lesion, and then determining whether remineralization of the lesions are possible; 3) reduction of cariogenic bacteria; and 4) minimally invasive cavity preparation design through appropriate techniques and restorative material selections.
The *first part* of this survey will ask you about your familiarity with MID approach, while the *second part* will gather information about you and your practice.
Thank you for your participation!

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1) **Part I:** How much have you heard about **Minimally Invasive Dentistry (MID)**?

- ○ Very much
- ○ Much
- ○ Some
- ○ Little
- ○ None

2) Have you had training in MID?

- ○ Yes
- ○ No

3) If yes, in what setting did you receive most of this training? (Please check all that apply)

- ☐ During dental school
- ☐ During graduate program/residency
- ☐ CE courses
- ☐ Not applicable
- ☐ Other (please specify)

If you selected other, please specify:

4) What was the format for the MID training?

- ○ Didactic only (lectures)
- ○ "Hands-on" only (clinical)
- ○ Both
- ○ Not applicable
- ○ Other (please specify)

If you selected other, please specify:

5) In your opinion, does MID meet the dental professional standard of care for **PRIMARY TEETH** in the United States?

- ○ Yes
- ○ No

6) In your opinion, does MID meet the dental professional standard of care for **PERMANENT TEETH** in the United States?

- ○ Yes
- ○ No

7) How effective do you consider each of the following techniques for the treatment of caries in **PRIMARY TEETH?** Please check all that apply.

	Very effective	Effective	Ineffective	Very Ineffective	I don't know this technique
a) ART (Atraumatic Restorative Treatment)	○	○	○	○	○
b) "Sandwich Technique" (Glass ionomers + composite)	○	○	○	○	○
c) Remineralization with fluoride varnish or other office topical fluoride products	○	○	○	○	○
d) Remineralization with topical high concentration fluoride at home	○	○	○	○	○
e) Amorphous Calcium Phosphate-ACP (i.e., MI paste ®)	○	○	○	○	○

8) How effective do you consider each of the following techniques for the treatment of caries in **PERMANENT TEETH**? Please check all that apply.

	Very effective	Effective	Ineffective	Very Ineffective	I don't know this technique
a) ART (Atraumatic Restorative Treatment)	○	○	○	○	○
b) "Sandwich Technique" (Glass					

ionomers + composite)	○	○	○	○	○
c) Remineralization with fluoride varnish or other office topical fluoride products	○	○	○	○	○
d) Remineralization with topical high concentration fluoride at home	○	○	○	○	○
e) Amorphous Calcium Phosphate-ACP (i.e., MI paste ®)	○	○	○	○	○

9) How much have you heard about each of the following techniques for caries detection?

	Very much	Much	Some	Little	None
a) ECM (Electrical Caries Monitor)	○	○	○	○	○
b) QLF (Quantitative Light-induced Fluorescence)	○	○	○	○	○
c) Infrared Laser Fluorescence (IRLF)	○	○	○	○	○
d) Light transmission (FOTI: Fiber-optic Transillumination, Diagnodent)	○	○	○	○	○

10) For caries detection during an exam, for what proportion of your patients do you use each of the following techniques? Please choose one answer for each technique.

	Always (100%)	Most of the time (75-99%)	Often (50-74%)	Sometimes (10-49%)	Never or rarely (0-9%)
a) Use of sharp explorer	○	○	○	○	○
b) Use of explorer that is not sharp	○	○	○	○	○
c) Magnification (e.g.,loupes)	○	○	○	○	○
d) Radiographs	○	○	○	○	○
e) ECM (Electrical Caries Monitor)	○	○	○	○	○
f) QLF (Quantitative Light-induced	○	○	○	○	○

Fluorescence)					
g) Infrared Laser Fluorescence (IRLF)	○	○	○	○	○
h) Light transmission (FOTI: Fiber-optic Transillumination)	○	○	○	○	○
i) Compressed air drying with illumination	○	○	○	○	○

11) Please indicate your level of agreement with each of the following statements.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a) There is a direct relationship between carious lesions and intake of refined carbohydrates.	○	○	○	○	○
b) Fluoride is an essential agent in the tooth remineralization process.	○	○	○	○	○
c) Sealants are not very effective in prevention of pit and fissure caries.	○	○	○	○	○
d) Sealants should be used as a routine procedure for high caries risk children.	○	○	○	○	○

12) Please indicate your level of agreement with each of the following statements.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a) When possible, a tunnel preparation design for proximal caries lesions should be used instead of a traditional proximal box in adults.	○	○	○	○	○
b) Preventive dentistry is more important for children than adults.	○	○	○	○	○
c) Caries risk assessment should be conducted with all patients.	○	○	○	○	○

d) Dietary habits should be assessed for all patients.	○	○	○	○	○

13) Please indicate your level of agreement with each of the following statements.

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a) Small, minimal cavity preparations compromise materials' retention.	○	○	○	○	○
b) Dentists should recommend that high caries risk patients receive diet counseling.	○	○	○	○	○
c) Atraumatic Restorative Treatment (ART) does not meet the standard of care for dentistry in the U.S.	○	○	○	○	○
d) The use of a closed sandwich technique (layered combination of resin-based composites or amalgam covering the glass ionomers close to the pulp) is an appropriate technique for children and adults.	○	○	○	○	○
e) Atraumatic Restorative Treatment (ART) could often be used with high caries risk children and rampant caries patients.	○	○	○	○	○

14) How likely are you to perform the following for each NEW patient?

	Very likely	Likely	Unlikely	Very unlikely	Not applicable
a) Caries risk assessment for adult patients.	○	○	○	○	○
b) Caries risk assessment for children.	○	○	○	○	○
c) Evaluate the patients' dietary habits.	○	○	○	○	○
d) Identify current exposures to fluoride.	○	○	○	○	○
e) Review medical history	○	○	○	○	○

and lifestyle.

f) Plan restorative materials and techniques based on the patient's caries risk assessment.	○	○	○	○	○

15) **Part II:** What is your gender?

- ○ Male
- ○ Female

16) What is your age in years?

[ ]

17) In which year did you graduate from dental school?

[ ]

18) In which states was your dental school located?

[▼]

19) Approximately, how many hours per week do you provide direct patient care?

[ ]

20) Which best describes the main location where you practice? (Please check all that apply)

- ☐ Federally Qualified Health Center (FQHC)
- ☐ Indian Health Service
- ☐ Military
- ☐ National Health Service Corps
- ☐ Other U.S federal service
- ☐ Locally funded clinic
- ☐ State dental program
- ☐ Academic institution
- ☐ Private practice
- ☐ Other (please specify)

If you selected other, please specify:

[ ]

21) Have you completed post-graduate training in Dental Public Health or Public Health?

- ○ Yes
- ○ No

22) If you answered yes to the previous question, which of the following best describes the type of training program?

- ☐ MS

- ☐ PhD
- ☐ Dental Public Health Residency
- ☐ MPH
- ☐ I started training, but I did not finish it
- ☐ No applicable
- ☐ Other (please specify)

If you selected other, please specify:

23) Have you completed post-graduate training in any specialty other than Dental Public Health?

- ○ Yes
- ○ No

24) If you answered yes to the previous question, what type(s)? (Please check all that apply)

- ☐ Advanced Education in General Dentistry (AEGD)
- ☐ Endodontics
- ☐ General Practice Residency (GPR)
- ☐ Geriatric Dentistry
- ☐ Operative / Restorative Dentistry
- ☐ Oral and Maxillofacial Pathology
- ☐ Oral and Maxillofacial Radiology
- ☐ Oral and Maxillofacial Surgery
- ☐ Orthodontics
- ☐ Pediatric Dentistry
- ☐ Periodontics
- ☐ Prosthodontics
- ☐ Special Care Dentistry
- ☐ Not applicable

25) In which state is your **MAIN** dental clinic/ practice located?

26) Please describe your **MAIN** dental clinic/practice location:

- ○ Metro area (more than 1 million)
- ○ Metro area (250,000- 1 million)
- ○ City (50,000- 249,999)
- ○ Small city (20,000- 49,999)
- ○ Small Town (2,500- 19,999)
- ○ Rural (Less than 2,500)

27) How many professionals work in your dental practice? Please include all full- and part-time employees.

Dentists

Dental Hygienists

Dental Assistants

Administrative staff (receptionist, accountant, office manager, etc.)

28) How many patients attend this dental clinic per week?

- 1-49
- 50-99
- 100-249
- 250-500
- > 500

29) What is the approximate percentage distribution of patients' ages in your clinic/practice? The percentages need to sum to 100%.

Young children (0-4 yr)

Children (5-12 yr)

Teenagers (13-19 yr)

Adults (20-65 yr)

Elderly (> 65 yr)

30) What is the approximate percentage distribution of patients' insurance coverage in your clinic/practice? The percentages need to sum to 100%.

Medicaid

SCHIP

Private insurance

No insurance/ out of pocket

Other

Thank you for your willingness to participate in this study!

Submit Survey

APPENDIX C

DEPENDENT AND INDEPENDENT VARIABLES

Dependent Variables

Question #	Variables	Relevant Question	Operational Definition	Type of Variable	Variable intervals/ options
5	MID meets the standard of care for primary teeth	In your opinion, does MID meet the dental professional standard of care for PRIMARY TEETH in the US?	MID techniques meets the standard of care for primary teeth in the U.S.	Dichotomous	Yes; No
6	MID is a standard of care for permanent teeth	In your opinion, does MID meet the dental professional standard of care for PERMANENT TEETH in the U.S.?	MID techniques meets the standard of care for permanent teeth in the U.S.	Dichotomous	Yes; No
10 a	Use of a sharp explorer for caries detection	For caries detection during an exam, for what proportion of your patients do you use sharp explorer? Please choose one answer.	Proportion of use of a sharp explorer for caries detection	Ordinal/ Dichotomous	Always (100%); Most of the time (75-99%); Often (50-74%); Sometimes (10-49%); Never or rarely (0-9%)

Independent Variables

Question #	Variables	Relevant Question	Operational Definition	Type of Variable	Variable intervals/ options
2	MID training	Have you had training in MID?	MID training	Dichotomous	Yes; No
15	Gender	What is your gender?	Selection of male or female	Dichotomous	Male; Female

21	PH post-graduate training	Have you completed post-graduate training in PH or Public Health?	Completion of post-graduate training in PH or Public Health	Dichotomous	Yes; No
23	Other post graduate training	Have you completed post-graduate training in any specialty other than PH?	Completion of post-graduate training in areas other than PH	Dichotomous	Yes; No
16	Age (in years)	What is your age in years?	The age of the dentist in years	Continuous	N/A
17	Year of graduation	In which year did you graduate from dental school?	The year of graduation from dental school	Continuous	N/A
19	Direct Patient care	How many hours per week do you provide direct patient care?	Percentage of direct patient care per week	Continuous	N/A
27	Dental clinic staff	How many professionals work in your dental practice? Please include all full and part-time employees	Number of professionals	Continuous	Dentists; Dental Hygienists; Dental Assistants; Administrative staff
28	Dental clinic demand per week	How many patients attend this dental clinic per week?	Number of patients per week	Ordinal	1-49; 50-99; 100-249; 250-500; >500
26	Dental practice location size	Please describe your dental clinic/practice location:	Location of dental practice in relation to population size and area	Nominal/ Ordinal	Metro area (more than 1 million); Metro area (250,000-1million); City (50,000-249,999); Small City (20,000-49,999); Small Town (2,500-19,999); Rural (less than 2,500)
3	MID training setting	If yes, in what setting did you receive most of this training?	Majority of MID training received in which setting of education	Nominal	During dental school; During grad program/residency; CE courses; Not applicable; Other (please specify)

4	MID training format	What was the format for the MID training?	Type of MID training	Nominal	Didactic only (lectures); "Hands-on" only (clinical); Both; Not applicable; Other (please specify)
18	State of dental school	In which state was your dental school located?	State of dental school	Nominal	All states of the U.S.
20	Type of practice	Which best describes the main location where you practice?	The type of dental practice	Nominal	Federal; Local; Private
22	Type of PH or Public Health post-graduate training	If you answered yes to the previous question, which of the following best describes the type of post-graduate training program?	Type of post-graduate training in PH or Public Health	Nominal	MS; PhD; PH residency; MPH; I started training, but I didn't finish it; Not applicable; Other (please specify)
24	Type of other post-graduate training	If you answer yes to the previous question, what type(s)? Please check all that apply.	Type of post-graduate training in dentistry, other than PH or Public Health	Nominal	AEGD; Endodontics; GPR; Geriatric Dentistry; Operative Dentistry; Oral Pathology; Oral Radiology; Oral Surgery; Orthodontics; Pediatric Dentistry; Periodontics; Prosthodontics; Special Care Dentistry; Not applicable
25	Dental clinic state	In which state is your main dental clinic/practice located?	State of dental clinic/practice	Nominal	All states of the U.S.
7	Perceived effectiveness of techniques for treatment of caries in primary teeth	How effective do you consider each of the following techniques for the treatment of caries in PRIMARY TEETH? Please check all that apply.	Effectiveness of techniques for the treatment of caries in primary teeth	Ordinal	Very effective; Effective; Ineffective; Very ineffective; I don't know this technique.

8	Perceived effectiveness of techniques for treatment of caries in permanent teeth	How effective do you consider each of the following techniques for the treatment of caries in PERMANENT TEETH? Please check all that apply.	Effectiveness of techniques for the treatment of caries in permanent teeth	Ordinal	Very effective; Effective; Ineffective; Very ineffective; I don't know this technique.
10	Use of techniques for caries detection	For caries detection during an exam, for what proportion of your patients do you use each of the following techniques? Please choose one answer for each.	Frequency of usage of techniques during caries detection	Ordinal	Always (100%); Most of the time (75-99%); Often (50-74%); Sometimes (10-49%); Never or rarely (0-9%)
29	Dental clinic patients' ages	What is the approximate percentage distribution of patients' ages in your clinic/practice? The percentages need to sum 100%.	Percentage of patients per age interval	Ordinal	Young children (0-4yr); Children (5-12yr); Teenager (13-19yr); Adult (20-65yr); Elderly(>65yr)
30	Dental clinic patients' insurance	What is the approximate percentage distribution of patients' insurance coverage in your clinic/practice? The percentages need to sum 100%.	Percentage of patients by insurance coverage type	Ordinal	Medicaid; SCHIP; Private insurance; No insurance/ out of pocket; Other

APPENDIX D

TABLES

Table D 1 – Descriptive Statistics for Demographic Characteristics of PH Dentists

Variable	**Valid Percent (n)**
Gender	
Male	52.9 (72)
Female	47.1 (64)
Age	
39 yrs or younger	33.1 (44)
40-54 yrs	35.3 (47)
55 yrs or older	31.6 (42)
Year of Graduation from Dental School	
1960's and 70's	21.6 (29)
1980's	26.9 (36)
1990's	23.1 (31)
2000's	28.4 (38)
Dental School State	
Region 1 – Northeast	19.4 (26)
Region 2 – Midwest	41.8 (56)
Region 3 - South	21.6 (29)
Region 4 – West	12.7 (17)
Non-US dental school	4.5 (6)
Dental Public Health or Public Health Post-Graduate Training	
Yes	16.5 (22)
No	83.5 (111)
PH or PH Type of Training Program*	
MS	2.9 (4)
PhD	0.7 (1)
PH residency	2.9 (4)
MPH	12.5 (17)
Specialty Other than PH	
Yes	30.3 (40)
No	69.7 (92)

Table D1 – continue

Dental specialty*	
GPR	11.0 (15)
AEGD	7.4 (10)
Pediatric Dentistry	6.6 (9)
Oral Surgery	1.5 (2)
Endodontics	0.7 (1)
Orthodontics	0.7 (1)
Periodontics	0.7 (1)
Geriatric Dentistry, Operative/Restorative Dentistry, Oral Pathology, Oral Radiology, Prosthodontics, Special Care Dentistry	0.0 (0)

***Responded "Yes" or "No" for each category and respondents were allowed to choose more than one option.**

Table D 2 – Descriptive Statistics for Age and Years Since Graduation of PH Dentists

Variable	N	Mean	Standard Deviation	Median	Minimum	Maximum
Age	133	46.8	12.1	49	27	74
Year since Graduation	134	20.1	12.0	20	1	50

Table D 3 – Descriptive Statistics for Practice Characteristics of PH Dentists

Variable	Valid Percent % (n)
Practice Characteristics	
Direct Patient Care (hours per week)	
No patient care	8.7 (11)
19h or less	11.9 (15)
20-29h	15.9 (20)
30-39h	38.9 (49)
40h or more	24.6 (31)
Dental Clinic Region	
Region 1 – Northeast	11.0 (14)
Region 2 – Midwest	42.5 (54)
Region 3 – South	19.7 (25)
Region 4 – West	26.8 (34)
Dental Practice Location Size	
Metro area (more than a 1 million)	17.3 (22)
Metro area (250,000 - 1 million)	18.9 (24)
City (50,000 – 249,999)	29.1 (37)
Small City (20,000-49,999)	9.5 (12)
Small Town (2,500-19,999)	14.2 (18)
Rural (less than 2,500)	11.0 (14)
Number of patients per week in the dental practice	
1-49	7.5 (9)
50-99	20.0 (24)
100-249	37.5 (45)
250-500	24.2 (29)
>500	10.8 (13)

Table D 4 – Descriptive Statistics for MID Training of PH Dentists

Variable	Valid Percent % (n)
MID Training	
Heard about MID	
Very much	16.9 (23)
Much	31.6 (43)
Some	37.5 (51)
Little	11.0 (15)
None	2.9 (4)
Training in MID	
Yes	46.7 (63)
No	53.3 (72)
Where was most of MID training?*	
Dental School	16.9 (23)
Graduate Program/Residency	5.9 (8)
CE Courses	39.0 (53)
N/A	22.8 (31)
Other	8.1 (11)
MID Training Format	
Didactic only (lectures)	50.0 (56)
"Hands-on" (clinical)	0.9 (1)
Both (didactic and hands-on)	17.9 (20)
N/A	30.3 (34)
Other	0.9 (1)

***Responded "Yes" or "No" for each category and respondents were allowed to choose more than one option**

Table D 5 – Descriptive Statistics for Practice Characteristics

Variable	N	Mean	Standard Deviation	Median	Minimum	Maximum
Direct patient care (hours per week)	126	28.0	13.2	32	0	45
Number of Dentists	125	5.3	10.0	3	0	100
Number of Dental Hygienists	122	2.3	2.3	2	0	15
Number of Dental Assistants	123	7.8	10.1	5	0	70
Number of Administrative Staff	122	5.0	7.7	3	0	69

Table D 6 – Descriptive Statistics for Patients' Characteristics

Patients' Age Group						
Variable	**N**	**Mean (%)**	**Std Deviation (%)**	**Median (%)**	**Minimum (%)**	**Maximum (%)**
Young children(0-4yr)	108	13.3	10.0	10	0	50
Children (5-12 yr)	109	25.7	18.5	20	0	95
Teenager (13-19yr)	107	17.8	9.4	20	0	70
Adults (20-65yr)	108	35.2	21.3	35	0	100
Elderly (>65yr)	102	10.2	7.6	10	0	40
Patients' Insurance Coverage						
Medicaid	111	47.8	25.6	50	0	100
SCHIP	68	11.9	16.0	5	0	85
Private insurance	97	12.6	15.2	10	0	70
No insurance/ out of pocket	104	33.1	24.0	30	0	100
Other	47	14.6	19.3	8	0	100

Table D 7 – Descriptive Statistics for Dependent Variables

Variable	**Valid Percent (n)**
MID Meets the Standard of Care for Primary Teeth	
Yes	85.8 (109)
No	14.2 (18)
MID Meets the Standard of Care for Permanent Teeth	
Yes	77.2 (98)
No	22.8 (29)
Use of Techniques During Caries Detection: Sharp Explorer	
Always (100%)	27.9 (38)
Most of the time (75-99%)	23.5 (32**)** 64.7 (88)=YES
Often (50-74%)	13.2 (18)
Sometimes (10-49%)	11.8 (16) 35.3 (48)= NO
Never or Rarely (0-9%)	23.5 (32)

Table D 8 – Summary of PH Dentists Responses Regarding Effectiveness of Techniques on Primary and Permanent Teeth (Valid Percent (n))

Caries Treatment for Primary Teeth					
Variable	**Very Effective**	**Effective**	**Ineffective**	**Very Ineffective**	**I don't know this technique**
ART (Atraumatic Restorative Treatment)	22.8 (31)	47.1 (64)	7.3 (10)	2.2 (3)	20.6 (28)
Sandwich technique	22.1 (30)	52.2 (71)	8.1 (11)	2.2 (3)	15.4 (21)
Fluoride varnish	22.8 (31)	63.2 (86)	11.8 (16)	1.5 (2)	0.7 (1)
Topical high concentration fluoride at home	10.3 (14)	52.9 (72)	27.2 (37)	4.4 (6)	5.1 (7)
MI paste	8.8 (12)	44.1 (60)	14.7 (20)	1.5 (2)	30.9 (42)
Caries Treatment for Permanent Teeth					
ART (Atraumatic Restorative Treatment)	10.3 (14)	43.4 (59)	19.5 (27)	5.9 (8)	20.6 (28)
Sandwich technique	21.3 (29)	59.6 (81)	2.9 (4)	1.5 (2)	14.7 (20)
Fluoride varnish	14.7 (20)	66.9 (91)	16.2 (22)	2.2 (3)	0.0 (0)
Topical high concentration fluoride at home	10.3 (14)	59.6 (81)	25 (34)	3.7 (5)	1.5 (2)
MI paste	8.8 (12)	47.0 (64)	12.5 (17)	2.2 (3)	29.4 (40)

Table D 9 – Summary of PH Dentists Responses Regarding Knowledge about Techniques for Caries Detection (Valid Percent (n))

Variable	**Very Much**	**Much**	**Some**	**Little**	**None**
ECM (Electrical Caries Monitor)	2.9 (4)	5.9 (8)	27.2 (37)	19.8 (27)	44.1 (60)
QLF (Quantitative Light-Induced Fluorescence)	2.9 (4)	9.6 (13)	27.2 (37)	24.3 (33)	36.0 (49)
IRLF (Infrared Laser Fluorescence)	2.9 (4)	6.6 (9)	21.3 (29)	25.0 (34)	44.1 (60)
FOTI (Fiber Optic Light Transmission)	14 (9)	25.7 (35)	36.8 (50)	16.2 (22)	7.3 (10)

Table D 10 – Summary of PH Dentists Responses Regarding Use of Techniques during Caries Detection (Valid Percent (n))

Variable	**Always (100%)**	**Most time (75-99%)**	**Often (50-74%)**	**Sometimes (10-49%)**	**Never/Rarely (0-9%)**
Sharp explorer (Dependent variable)	27.9 (38)	23.5 (32)	13.2 (18)	11.8 (16)	23.5 (32)
Explorer (not sharp)	8.3 (11)	17.3 (23)	15.8 (21)	20.3 (27)	38.3 (51)
Magnification(loupes)	37. 8 (51)	13.3 (18)	4.4 (6)	11.8 (16)	32.6 (44)
Radiographs	47.8 (65)	36.0 (49)	8.8 (12)	2.2 (3)	5.1 (7)
ECM (Electrical Caries Monitor)	0.0 (0)	1.5 (2)	0.0 (0)	0.7 (1)	97.8 (133)
QLF (Quantitative Light-Induced Fluorescence)	0.0 (0)	0.0 (0)	0.7 (1)	1.5 (2)	97.8 (133)
IRLF (Infrared Laser Fluorescence)	0.0 (0)	0.0 (0)	0.0 (0)	0.7 (1)	99.3 (135)
FOTI (fiber Optic Light Transmission)	5.1 (7)	3.7 (5)	6.6 (9)	16.2(22)	68.4 (93)
Compressed air drying w/ illumination	25.7 (35)	21.3 (29)	12.5 (17)	19.1(26)	21.3 (29)

Table D 11 – PH Dentists Level of Agreement with Preventive and Restorative Statements (Valid Percent (n))

Variable	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
There is a direct relationship between carious lesions and intake of refined carbohydrates	61.0 (83)	32.3 (44)	4.4 (6)	0.7 (1)	1.5 (2)
Fluoride is an essential agent in the tooth remineralization process	56.6 (77)	36.0 (49)	5.1 (7)	2.2 (3)	0.0 (0)
Sealants are not very effective in prevention of pit and fissures caries	2.2 (3)	3.7 (5)	4.4 (6)	39.7 (54)	50.0 (68)
Sealants should be used as a routine procedure for high caries risk children	67.6 (92)	22.1 (30)	5.1 (7)	3.7 (5)	1.5 (2)
When possible a tunnel preparation design for proximal caries lesions should be used instead of a traditional proximal box in adults	8.1 (11)	26.5 (36)	39.7 (54)	16.9 (23)	8.8 (12)
Preventive dentistry is more important for children than adults	7.3 (10)	17.6 (24)	14.7 (20)	36.8 (50)	23.5 (32)
Caries risk assessment should be conducted with all patients	47.1 (64)	37.5 (51)	10.3 (14)	2.2 (3)	2.9 (4)
Dietary habits should be assessed for all patients	46.3 (63)	36.0 (49)	10.3 (14)	5.1 (7)	2.2 (3)
Small minimal cavity preparations compromise materials' retention	3.7 (5)	12.5 (17)	25 (34)	47.1 (64)	11.8 (16)
Dentists should recommend that high caries risk patients receive diet counseling	42.6 (58)	41.2 (56)	16.2 (22)	0.0 (0)	0.0 (0)
ART does not meet the standard of care for dentistry in the U.S.	1.5 (2)	6.6 (9)	36.0 (49)	41.2 (56)	14.7 (20)
The use of a closed sandwich technique is appropriate for children and adults	20.6 (28)	54.4 (74)	22.8 (31)	2.2 (3)	0.0 (0)
ART could be often used with high caries risk children and rampant caries patients	22.8 (31)	30.9 (42)	35.3 (48)	7.3 (10)	3.7 (5)

Table D 12 – Summary of PH Dentists Responses on the Likelihood of Performing Procedures for Each New Patient (Valid Percent (n))

Variable	**Very likely**	**Likely**	**Unlikely**	**Very unlikely**	**Not applicable**
Caries risk assessment for adults	30.1 (41)	37.5 (51)	19.1 (26)	5.9 (8)	7.3 (10)
Caries risk assessment for children	51.5 (70)	34.6 (47)	8.1 (11)	1.5 (2)	4.4 (6)
Evaluate the patients' dietary habits	38.2 (52)	40.4 (55)	16.2 (22)	2.2 (3)	2.9 (4)
Identify current exposures to fluoride	39 (53)	44.8 (61)	11.0 (15)	2.2(3)	2.9 (4)
Review medical history and lifestyle	75.7 (103)	22.1 (30)	0.0 (0)	0.0 (0)	2.2 (3)
Plan restorative materials and techniques based on the patient's caries risk assessment	54.4 (74)	31.6 (43)	5.9 (8)	1.5 (2)	6.6 (9)

Table D 13 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and MID Training

Variable (n)	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109)* %	No (n=18)* %	
Heard about MID			**0.0103**
Very Much/ Much (65)	93.8	6.2	
Some/Little/ None (62)	77.4	22.6	
Training in MID			0.1457
Yes (62)	90.3	9.7	
No (64)	81.3	18.7	
Where was MID training?			
Dental School			0.2503
Yes (23)	78.3	21.7	
No (104)	87.5	12.5	
Residency			1.0000
Yes (8)	87.5	12.5	
No (119)	85.7	14.3	
Continue Education			0.2201
Yes (52)	90.4	9.6	
No (75)	82.7	17.3	
MID Training Format			0.4681
Didactic only (lectures) (56)	89.3	10.7	
"Hands-on" (clinical) (1)	100.0	0.0	
Both (didactic and hands-on) (19)	78.9	21.0	
N/A (31)	77.4	22.6	
Other (1)	100.0	0.0	
MID meeting the standard of care for permanent teeth			**< 0.0001**
Yes (97)	94.8	5.2	
No (29)	55.2	44.8	

***Actual numbers vary slightly by independent variable and row.**

Table D 14 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and Effectiveness of MID Techniques**

Variable (n)	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109)* %	No (n=18)* %	
How effective is ART as caries treatment for primary teeth?			**< 0.0001**
Very Effective/Effective (92)	94.6	5.4	
Ineffective / Very ineffective (13)	38.5	61.5	
How effective is Sandwich technique as caries treatment for primary teeth?			**0.0661**
Very Effective/Effective (93)	90.3	9.7	
Ineffective / Very ineffective (20)	71.4	28.6	
How effective is Fluoride Varnish as caries treatment for primary teeth?			**0.0047**
Very Effective/Effective (109)	89.9	10.1	
Ineffective/ Very ineffective (17)	64.7	65.3	
How effective is topical high concentration fluoride at home as caries treatment for primary teeth?			0.7334
Very Effective/Effective (80)	90.0	10.0	
Ineffective / Very ineffective (41)	78.1	21.9	
How effective is MI paste as caries treatment for primary teeth?			0.4513
Very Effective/Effective (69)	89.9	10.1	
Ineffective / Very ineffective (22)	81.1	18.2	
How effective is ART as caries treatment for permanent teeth?			**< 0.0001**
Very Effective/Effective (70)	95.7	4.3	
Ineffective / Very ineffective (35)	71.4	28.6	
How effective is Sandwich technique as caries treatment for permanent teeth?			**0.0224**
Very Effective/Effective (102)	90.2	9.8	
Ineffective / Very ineffective (6)	50.0	50.0	
How effective is Fluoride Varnish as caries treatment for permanent teeth?			0.2058
Very Effective/Effective (105)	87.6	12.4	
Ineffective / Very ineffective (22)	77.3	22.7	
How effective is topical high concentration fluoride at home as caries treatment for permanent teeth?			0.2661
Very Effective/Effective (90)	87.8	12.2	
Ineffective / Very ineffective (35)	80.0	20.0	

Table D 14 – Continue

How effective is MI paste as caries treatment for permanent teeth?			0.6974
Very Effective/Effective (73)	89.0	11.0	
Ineffective / Very ineffective (20)	85.0	15.0	

***Actual numbers vary slightly by independent variable and row.**
**** Independent variable excludes "I don't know this technique" category.**

Table D 15 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and Caries Detection Techniques

Variable (n)	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109)* %	No (n=18)* %	
Do you use a sharp explorer for caries detection?			0.4636
Always/ Most time/ Often (82)	84.2	15.8	
Sometime/ Never (45)	88.9	11.1	
Do you use an explorer that is not sharp for caries detection?			0.5794
Always/ Most time/ Often (70)	83.6	16.4	
Sometime/ Never (55)	97.1	12.9	
Do you use magnification (e.g., loupes) for caries detection?			0.7152
Always/ Most time/ Often (68)	86.8	13.2	
Sometime/ Never (58)	84.5	15.5	
Do you use radiographs for caries detection?			1.0000
Always/ Most time/ Often (118)	85.6	14.4	
Sometime/ Never (9)	88.9	11.1	
Do you use compressed air drying with illumination for caries detection?			0.9640
Always/ Most time/ Often (77)	85.7	14.3	
Sometime/ Never (50)	86.0	14.0	

***Actual numbers vary slightly by independent variable and row.**

Table D 16 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and Opinions on Restorative/Preventive Techniques**

Variable (n)	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109)* %	No (n=18)* %	
Tunnel prep should be used instead of proximal box in adults.			0.1303
Strongly Agree/ Agree (43)	88.4	11.6	
Strongly Disagree/ Disagree (32)	75.0	25.0	
Preventive dentistry is more important for children than adults.			0.7158
Strongly Agree/ Agree (32)	84.4	15.6	
Strongly Disagree/ Disagree (77)	87.0	13.0	
Small cavity prep compromise materials' retention.			**0.0030**
Strongly Agree/ Agree (21)	66.7	33.3	
Strongly Disagree/ Disagree (74)	91.9	8.1	
ART does not meet the standard of care in the U.S.			**< 0.0001**
Strongly Agree/ Agree (11)	36.4	63.6	
Strongly Disagree/ Disagree (73)	94.5	5.5	
ART could be used with high caries risk children and rampant caries patients.			**0.0015**
Strongly Agree/ Agree (71)	94.4	5.6	
Strongly Disagree/ Disagree (15)	60.0	40.0	
How likely are you to perform caries risk assessment for adult patients?			0.6265
Very Likely/Likely (87)	87.4	12.6	
Very Unlikely/ Unlikely(31)	83.9	16.1	
How likely are you to evaluate patients' dietary habits?			0.5221
Very Likely/Likely (100)	85.0	15.0	
Very Unlikely/ Unlikely(24)	91.7	8.3	

***Actual numbers vary slightly by independent variable and row.**

**** Independent variable excludes "Neither agree nor disagree" and "Not applicable" categories.**

Table D 17 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and Characteristics of PH Dentist

Variable (n)	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109)* %	No (n=18)* %	
Gender			0.8004
Male (67)	86.6	13.4	
Female (60)	85.0	15.0	
Age			0.2634
39 yrs or younger (42)	78.6	21.4	
40-54 yrs (44)	90.9	9.1	
55 yrs or older (38)	86.8	13.2	
Year of Graduation from Dental School			0.8925
1960's and 1970's (25)	88.0	12.0	
1980's (35)	88.6	11.4	
1990's (30)	83.3	16.7	
2000's (35)	82.9	17.1	
Practice Location			0.3516
Federal (77)	83.1	16.9	
Local (25)	92.0	8.0	
Private (16)	71.4	28.6	
Other (7)	93.8	6.2	
PH Post-Graduate Training			**0.0408**
Yes (21)	100.0	0.0	
No (103)	82.5	17.5	
Specialty Other than PH			**0.0668**
Yes (39)	76.9	23.1	
No (85)	89.4	10.6	
Dental Specialty: GPR			1.0000
Yes (14)	85.7	14.3	
No (113)	85.8	14.2	
Dental Specialty: Pediatric			0.1163
Yes (9)	66.7	33.3	
No (118)	87.3	12.7	

***Actual numbers vary slightly by independent variable and row.**

Table D 18 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and Characteristics of PH Dentist (Continuous Variables)

	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109)	No (n=18)	
Dentists' Age Mean	47.2	44.2	0.3135
Year since Graduation from Dental School Mean	20.4	17.6	0.3026

Table D 19 – Bivariate Results for MID as a Standard of Care for Primary Teeth in the U.S and Respondents' Practice Characteristics

	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109)	No (n=18)	
Number of Direct patient care (hours/week) Mean	27.5	30.3	0.3476
Number of Dentists Mean	5.9	3.6	0.3324
Number of Dental Hygienists Mean	2.4	2.2	0.9294
Number of Dental Assistants Mean	8.5	6.2	0.2575
Number of Administrative Staff Mean	5.3	3.4	0.3252

Table D 20 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and Patients' Age Distribution

	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109) %	No (n=18) %	
Proportion of Young children (0-4yr) Mean	13.1	13.7	0.9602
Proportion of Children (5-12 yr) Mean	26.0	25.5	0.9573
Proportion of Teenagers (13-19yr) Mean	18.4	15.7	0.3681
Proportion of Adults (20-65yr) Mean	35.7	31.7	0.6624
Proportion of Elderly Patients(>65yr) Mean	10.5	9.5	0.4056

Table D 21 – Bivariate Results for MID Meeting the Standard of Care for Primary Teeth in the U.S and Patients' Insurance Coverage

	MID Meeting the Standard of Care for Primary Teeth		p-value
	Yes (n=109) %	No (n=18) %	
Proportion with Medicaid Mean	48.4	49.3	0.8972
Proportion with SCHIP Mean	12.2	11.2	0.1994
Proportion with Private Insurance Mean	13.5	10.3	0.1232
Proportion with No Insurance/ Out-of-pocket Mean	33.8	27.4	0.2667
Proportion with Other Insurance Mean	13.6	16.1	0.3619

Table D 22 – Bivariate Results for MID Meeting the Standard of Care for Permanent Teeth in the U.S and MID Training

Variable (n)	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98)* %	No (n= 29)* %	
Heard about MID			**0.0102**
Very Much/ Much (66)	86.4	13.6	
Some/Little/ None (61)	67.2	32.8	
Training in MID			0.3366
Yes (64)	80.7	19.3	
No (62)	73.4	26.6	
Where was MID training?			0.6814
Dental School			
Yes (23)	73.9	26.1	
No (104)	77.9	22.1	
Residency			1.0000
Yes (8)	75.0	25.0	
No (119)	77.3	22.7	
Continuing Education			**0.0361**
Yes (75)	86.5	13.5	
No (52)	70.7	29.3	
MID Training Format			**0.0555**
Didactic only (lectures) (55)	83.6	16.4	
"Hands-on" (clinical) (1)	0.0	100.0	
Both (didactic and hands-on) (20)	75.0	25.0	
N/A (31)	61.2	38.7	
Other (1)	100.0	0.0	
MID Meeting the Standard of care for primary teeth			**< 0.0001**
Yes (98)	85.2	14.8	
No (29)	27.8	72.2	

***Actual numbers vary slightly by independent variable and row.**

Table D 23 – Bivariate Results for MID Meeting the Standard of Care for Permanent Teeth in the U.S and Effectiveness of MID Techniques**

Variable (n)	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98)* %	No (n= 29)* %	
How effective is ART as caries treatment for primary teeth?			**0.0002**
Very Effective/Effective (92)	83.7	16.3	
Ineffective / Very ineffective (13)	38.5	61.5	
How effective is Sandwich technique as caries treatment for primary teeth?			0.7352
Very Effective/Effective (93)	77.4	22.6	
Ineffective / Very ineffective (14)	71.4	28.6	
How effective is Fluoride Varnish as caries treatment for primary teeth?			**0.0433**
Very Effective/Effective (109)	80.7	19.3	
Ineffective / Very ineffective (17)	58.8	41.2	
How effective is topical high concentration fluoride at home as caries treatment for primary teeth?			0.1454
Very Effective/Effective (79)	82.3	17.7	
Ineffective / Very ineffective (41)	70.7	29.3	
How effective is MI paste as caries treatment for primary teeth?			0.5917
Very Effective/Effective (69)	78.3	21.7	
Ineffective / Very ineffective (22)	72.7	27.3	
How effective is ART as caries treatment for permanent teeth?			**< 0.0001**
Very Effective/Effective (70)	90.0	10.0	
Ineffective / Very ineffective (35)	54.3	45.7	
How effective is Sandwich technique as caries treatment for permanent teeth?			0.1353
Very Effective/Effective (102)	78.4	21.6	
Ineffective / Very ineffective (6)	50.0	50.0	
How effective is Fluoride Varnish as caries treatment for permanent teeth?			**0.0263**
Very Effective/Effective (105)	81.0	19.1	
Ineffective / Very ineffective (22)	59.1	40.2	
How effective is topical high concentration fluoride at home as caries treatment for perm teeth?			**0.0032**
Very Effective/Effective (90)	84.4	15.6	
Ineffective / Very ineffective (35)	60.0	40.0	

Table D 23 – Continue

How effective is MI paste as caries treatment for permanent teeth?			0.8732
Very Effective/Effective (73)	76.7	23.3	
Ineffective / Very ineffective (20)	75.0	25.0	

***Actual numbers vary slightly by independent variable and row.**
**** Independent variable excludes "I don't know this technique" category.**

Table D 24 – Bivariate Results for MID Meeting the Standard of Care for Permanent Teeth in the U.S and Caries Detection Techniques

Variable (n)	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98)* %	No (n= 29)* %	
Do you use a sharp explorer for caries detection?			0.5729
Always/ Most of the time/ Often (82)	75.6	24.4	
Sometime/ Never (45)	80.0	20.0	
Do you use an explorer that is not sharp for caries detection?			0.3054
Always/ Most of the time/ Often (54)	74.1	25.9	
Sometime/ Never (71)	81.7	18.3	
Do you use magnification (e.g., loupes) for caries detection?			0.9596
Always/ Most of the time/ Often (69)	76.8	23.2	
Sometime/ Never (57)	77.2	22.8	
Do you use radiographs for caries detection?			0.6831
Always/ Most of the time/ Often (118)	76.2	23.7	
Sometime/ Never (9)	88.9	11.1	
Do you use compressed air drying with illumination for caries detection?			0.5397
Always/ Most of the time/ Often (77)	75.3	24.7	
Sometime/ Never (50)	80.0	20.0	

***Actual numbers vary slightly by independent variable and row.**

Table D 25 – Bivariate Results for MID Meeting the Standard of Care for Permanent Teeth in the U.S and Opinions Restorative/Preventive Techniques**

Variable (n)	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98)* %	No (n= 29)* %	
Tunnel prep should be used instead of proximal box in adults.			**0. 0315**
Strongly Agree/ Agree (44)	88.6	11.4	
Strongly Disagree/ Disagree (32)	68.8	31.3	
Preventive dentistry is more important for children than adults.			0.4779
Strongly Agree/ Agree (33)	72.7	27.3	
Strongly Disagree/ Disagree (76)	78.6	21.1	
Small cavity prep compromise materials' retention.			**0.0906**
Strongly Agree/ Agree (21)	71.4	28.6	
Strongly Disagree/ Disagree (74)	87.8	12.2	
ART does not meet the standard of care in the U.S.			**< 0.0001**
Strongly Agree/ Agree (11)	36.4	63.6	
Strongly Disagree/ Disagree (73)	86.3	13.7	
ART could be used with high caries risk children and rampant caries patients.			1.0000
Strongly Agree/ Agree (71)	80.3	19.7	
Strongly Disagree/ Disagree (15)	80.0	20.0	
How likely are you to perform caries risk assessment for adult patients?			0. 6516
Very Likely/Likely (87)	78.2	21.8	
Very Unlikely/ Unlikely(31)	74.2	25.8	
How likely are you to evaluate patients' dietary habits?			0.7523
Very Likely/Likely (100)	78.0	22.0	
Very Unlikely/ Unlikely(24)	75.0	25.0	

***Actual numbers vary slightly by independent variable and row.**

**** Independent variable excludes "Neither agree nor disagree" and "Not applicable" categories.**

Table D 26 – Bivariate Results for MID Meeting the Standard of Care for Permanent Teeth in the U.S and Characteristics of PH Dentist

Variable (n)	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98)* %	No (n= 29)* %	
Gender			
Male (67)	80.6	19.4	0.3303
Female (60)	73.3	26.7	
Age			0.9709
39 yrs or younger (42)	76.2	23.8	
40-54 yrs (45)	77.8	22.2	
55 yrs or older (37)	78.4	21.6	
Year of graduation from Dental School			0.7374
1960's and 1970's (25)	72.0	28.0	
1980's (34)	73.5	26.5	
1990's (30)	83.3	16.7	
2000's (36)	77.8	22.2	
Practice Location			0.2464
Federal (77)	76.6	23.4	
Local (25)	68.0	32.0	
Private (16)	71.4	28.6	
Other (7)	93.8	6.3	
PH Post-Graduate Training			0.1556
Yes (21)	90.5	9.5	
No (104)	74.0	26.0	
Specialty Other than PH			0.1396
Yes (39)	69.2	30.8	
No (85)	81.1	18.8	
Dental Specialty: GPR			0.7357
Yes (14)	71.4	28.6	
No (113)	77.9	22.1	
Dental Specialty: Pediatric			0.4256
Yes (9)	66.7	33.3	
No (118)	78.0	22.0	

***Actual numbers vary slightly by independent variable and row.**

Table D 27 – Bivariate Results for MID Meeting the Standard of Care for Permanent Teeth in the U.S and Characteristics of PH Dentist (Continuous Variables)

	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98)	No (n= 29)	
Dentists' Age Mean	46.6	46.7	0.8812
Year since Graduation from Dental School Mean	19.4	21.3	0.4843

Table D 28 – Bivariate Results for MID as a Standard of Care for Permanent Teeth in the U.S and Practice Characteristics

	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98)	No (n= 29)	
Number of Direct patient care (hours/week) Mean	27.6	28.1	0.6232
Number of Dentists Mean	6.1	4.0	0.7164
Number of Dental Hygienists Mean	2.3	2.5	0.4342
Number of Dental Assistants Mean	8.9	5.9	0.3865
Number of Administrative Staff Mean	5.8	3.0	0.1535

Table D 29 – Bivariate Results for MID Meeting the Standard of Care for Permanent Teeth in the U.S and Patients' Age Distribution

	MID Meeting the Standard of Care for Permanent Teeth		p-value
	Yes (n= 98) %	No (n= 29) %	
Proportion of Young children (0-4yr) Mean	13.6	12.1	0.3055
Proportion of Children (5-12 yr) Mean	27.0	22.6	0.4700
Proportion of Teenagers (13-19yr) Mean	17.9	17.5	0.8503
Proportion of Adults (20-65yr) Mean	35.5	33.5	0.7702
Proportion of Elderly Patients(>65yr) Mean	10.4	10.2	0.9717

Table D 30 – Bivariate Results for Association between MID Meeting the a Standard of Care for Permanent Teeth in the U.S and Patients' Insurance Coverage

	MID is a standard of Care for Permanent Teeth		p-value
	Yes (n= 98) %	No (n= 29) %	
Proportion with Medicaid Mean	47.6	50.8	0.8594
Proportion with SCHIP Mean	11.7	12.9	0.3697
Proportion with Private Insurance Mean	12.5	14.3	0.3251
Proportion with No Insurance/ Out-of-pocket Mean	33.0	32.2	0.7286
Proportion with Other Insurance Mean	14.5	13.0	0.9400

Table D 31 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and MID Training

Variable (n)	Use of Sharp Explorer		p-value
	Yes (n= 88)* %	No (n= 48)* %	
Heard about MID			0.1834
Very Much/ Much (66)	59.1	40.2	
Some/Little/ None (70)	70.0	30.0	
Training in MID			0.6139
Yes (63)	66.7	33.3	
No (72)	62.5	37.5	
Where was MID training?			0.3107
Dental School			
Yes (23)	73.9	26.1	
No (113)	62.3	37.2	
Residency			0.7121
Yes (8)	75.0	25.0	
No (128)	64.1	35.9	
Continue Education			0.9138
Yes (53)	64.2	35.8	
No (83)	65.1	34.9	
MID training format			0.4458
Didactic only (lectures) (56)	67.9	32.1	
"Hands-on" (clinical) (1)	0.0	100.0	
Both (didactic and hands-on) (20)	65.0	35.0	
N/A (34)	64.7	35.3	
Other (1)	0.0	100.0	
MID Meeting the standard of care for primary teeth			0.4636
Yes (109)	63.3	36.7	
No (18)	72.2	27.8	
MID Meeting the standard of care for permanent teeth			0.5729
Yes (98)	63.3	36.7	
No (29)	69.0	31.0	

***Actual numbers vary slightly by independent variable and row.**

Table D 32 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and Effectiveness of MID Techniques**

Variable (n)	Use of Sharp Explorer		p-value
	Yes (n= 88)* %	No (n= 48)* %	
How effective is ART as caries treatment for primary teeth?			0.3625
Very Effective/Effective (95)	60.0	40.0	
Ineffective / Very ineffective (13)	76.9	23.1	
How effective is Sandwich technique as caries treatment for primary teeth?			0.1337
Very Effective/Effective (101)	61.4	38.6	
Ineffective / Very ineffective (14)	85.7	14.3	
How effective is Fluoride Varnish as caries treatment for primary teeth?			0.2934
Very Effective/Effective (117)	63.3	36.7	
Ineffective / Very ineffective (18)	77.8	22.2	
How effective is topical high concentration fluoride at home as caries treatment for primary teeth?			0.8949
Very Effective/Effective (86)	66.3	33.7	
Ineffective / Very ineffective (43)	67.4	32.6	
How effective is MI paste as caries treatment for primary teeth?			0.5482
Very Effective/Effective (72)	61.1	39.9	
Ineffective / Very ineffective (22)	68.2	31.8	
How effective is ART as caries treatment for permanent teeth?			0.5856
Very Effective/Effective (73)	60.3	39.7	
Ineffective / Very ineffective (35)	65.7	34.3	
How effective is Sandwich technique as caries treatment for permanent teeth?			1.0000
Very Effective/Effective (110)	64.6	35.4	
Ineffective / Very ineffective (6)	66.7	33.3	
How effective is Fluoride Varnish as caries treatment for permanent teeth?			**0.0765**
Very Effective/Effective (111)	61.3	38.7	
Ineffective / Very ineffective (25)	80.0	20.0	
How effective is topical high concentration fluoride at home as caries treatment for permanent teeth?			0.3388
Very Effective/Effective (95)	63.2	36.8	
Ineffective / Very ineffective (39)	71.8	28.2	

Table D 32 – Continue

How effective is MI paste as caries treatment for permanent teeth?			0.1180
Very Effective/Effective (76)	59.2	40.8	
Ineffective / Very ineffective (20)	80.0	20.0	

***Actual numbers vary slightly by independent variable and row.**
**** Independent variable excludes "I don't know this technique" category.**

Table D 33 – Bivariate Results for Use of Sharp Explorer and Caries Detection Techniques

Variable (n)	Use of Sharp Explorer		p-value
	Yes (n= 88)* %	No (n= 48)* %	
Do you use an explorer that is not sharp for caries detection?			**0.0088**
Always/ Most of the time/ Often (88)	50.2	49.1	
Sometimes/ Never (48)	73.1	26.9	
Do you use magnification (e.g., loupes) for caries detection?			0.6862
Always/ Most of the time/ Often (75)	66.7	33.3	
Sometimes/ Never (60)	63.3	36.7	
Do you use radiographs for caries detection?			**0.0038**
Always/ Most of the time/ Often (126)	68.2	31.7	
Sometime/ Never (10)	20.0	80.0	
Do you use compressed air drying with illumination for caries detection?			0.3779
Always/ Most of the time/ Often (81)	61.7	38.3	
Sometimes/ Never (55)	69.1	30.9	

***Actual numbers vary slightly by independent variable and row.**

Table D 34 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and Restorative and Opinions on Preventive Techniques**

Variable (n)	Use of Sharp Explorer		p-value
	Yes (n= 88)* %	No (n= 48)* %	
Tunnel prep should be used instead of proximal box in adults.			**0.0373**
Strongly Agree/ Agree (47)	61.7	38.3	
Strongly Disagree/ Disagree (35)	82.9	17.1	
Preventive dentistry is more important for children than adults.			0.7062
Strongly Agree/ Agree (34)	64.7	35.3	
Strongly Disagree/ Disagree (82)	61.0	39	
Small cavity prep compromise materials' retention.			**0.0024**
Strongly Agree/ Agree (22)	90.9	9.1	
Strongly Disagree/ Disagree (80)	56.2	43.7	
ART does not meet the standard of care in the U.S.			0.1874
Strongly Agree/ Agree (11)	81.8	18.2	
Strongly Disagree/ Disagree (76)	56.6	43.4	
ART should be used with high caries risk children and rampant caries patients.			**0.0474**
Strongly Agree/ Agree (73)	50.7	49.3	
Strongly Disagree/ Disagree (15)	80.0	20.0	
How likely are you to perform caries risk assessment for adult patients?			0.2732
Very Likely/Likely (92)	66.3	33.7	
Very Unlikely/ Unlikely(34)	76.5	23.5	
How likely are you to evaluate patients' dietary habits?			0.5298
Very Likely/Likely (107)	67.4	34.6	
Very Unlikely/ Unlikely(25)	72.0	28.0	

***Actual numbers vary slightly by independent variable and row.**

**** Independent variable excludes "Neither agree nor disagree" and "Not applicable" categories.**

Table D 35 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and Characteristics of PH Dentist

Variable (n)	Use of Sharp Explorer		p-value
	Yes (n= 88)* %	No (n= 48)* %	
Gender			0.8823
Male (72)	65.3	34.7	
Female (64)	64.1	35.9	
Age			**0.0685**
39 yrs or younger (44)	72.7	27.3	
40-54 yrs (47)	68.1	31.9	
55 yrs or older (42)	50.0	50.0	
Year of graduation from Dental School			**0.0194**
1960's and 1970's (29)	41.4	58.6	
1980's (36)	69.4	30.6	
1990's (31)	73.7	26.3	
2000's (38)	74.2	25.8	
Practice Type			**0.0027**
Federal (83)	77.1	22.9	
Local (26)	50.0	50.0	
Private (18)	57.2	42.8	
Other (7)	38.9	61.1	
PH post-graduate training			**0.0017**
Yes (22)	36.4	63.6	
No (111)	71.2	28.8	
Specialty Other than PH			0.4869
Yes (40)	60.0	40.0	
No (92)	66.3	33.7	
Dental specialty: GPR			0.3285
Yes (15)	53.3	46.7	
No (121)	66.1	33.9	
Dental specialty: Pediatric			0.2782
Yes (9)	44.4	55.6	
No (127)	66.1	33.9	

***Actual numbers vary slightly by independent variable and row.**

Table D 36 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and Characteristics of PH Dentist (Continuous Variables)

	Use of Sharp Explorer		**p-value**
	Yes (n= 88)	**No (n= 48)**	
Dentists' Age Mean	45.2	49.7	**0.0355**
Years since Graduation from Dental School Mean	18.2	23.8	**0.0101**

Table D 37 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and Practice Characteristics

	Use of Sharp Explorer		**p-value**
	Yes (n= 88)	**No (n= 48)**	
Number of Direct patient care (hours/week) Mean	30.9	21.8	**0.0026**
Number of Dentists Mean	4.5	6.9	0.2065
Number of Dental Hygienists Mean	2.2	2.4	0.3997
Number of Dental Assistants Mean	7.3	8.8	0.1856
Number of Administrative Staff Mean	4.1	6.5	0.6325

Table D 38 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and Patients' Age Distribution

	Use of Sharp Explorer		p-value
	Yes (n= 88) %	No (n= 48) %	
Proportion of Young children (0-4yr)			0.4837
Mean	12.3	15.3	
Proportion of Children (5-12 yr)			0.1332
Mean	22.7	32.3	
Proportion of Teenagers (13-19yr)			0.1795
Mean	18.5	16.3	
Proportion of Adults (20-65yr)			0.3559
Mean	36.7	31.6	
Proportion of Elderly Patients(>65yr)			0.5355
Mean	10.4	9.7	

Table D 39 – Bivariate Results for Use of Sharp Explorer for Detecting Caries and Patients' Insurance Coverage

	Use of Sharp Explorer		p-value
	Yes (n= 88) %	No (n= 48) %	
Proportion with Medicaid			0.4660
Mean	48.8	45.7	
Proportion with SCHIP			0.6258
Mean	12.4	11.1	
Proportion with Private Insurance			0.6942
Mean	11.6	15.2	
Proportion with No Insurance/ Out-of-pocket			0.2469
Mean	34.7	29.6	
Proportion with Other Insurance			0.3999
Mean	13.0	17.7	

Table D 40 – Summary of independent variables associations with the three dependent variables ($p<0.05$)

Independent variables	**MID meeting the standard of care for primary teeth in the U.S.**	**MID meeting the standard of care for permanent teeth in the U.S.**	**Use of a sharp explorer for detecting caries**
Heard about MID	0.0103	0.0102	
Where was MID training? Continue Education		0.0361	
MID as a standard of care for primary teeth		< 0.0001	
MID as a standard of care for permanent teeth	< 0.0001		
How effective is ART as caries treatment for primary teeth?	< 0.0001	0.0002	
How effective is Fluoride Varnish as caries treatment for primary teeth?	0.0047	0.0433	
How effective is ART as caries treatment for permanent teeth?	< 0.0001	< 0.0001	
How effective is Sandwich technique as caries treatment for permanent teeth?	0.0224		
How effective is Fluoride Varnish as caries treatment for permanent teeth?		0.0263	
How effective is topical high concentration fluoride at home as caries treatment for permanent teeth?		0.0032	
Do you use an explorer that is not sharp for caries detection?			0.0088
Do you use radiographs for caries detection?			0.0038
Tunnel prep should be used instead of proximal box in adults.		0. 0315	0.0373
Small cavity prep compromise materials' retention.	0.0030		0.0024
ART meets the standard of care in the U.S.	< 0.0001	< 0.0001	
ART should be used with high caries risk children and rampant caries patients.	0.0015		0.0474
Year of graduation from Dental School (categorical)			0.0194
Practice location			0.0027
PH post-graduate training	0.0408		0.0017
PH Dentists' Ages - continuous			0.0355
Year since Graduation from Dental School - continuous			0.0101
Direct patient care (hours/week)			0.0026

Table D 41 – Multiple forward stepwise logistic regression model for use of MID meeting the standard of care for primary teeth (final model, with odds ratio adjusted for other variables in the model)

Variable (n)	MID meeting the standard of care for primary teeth N=127 (%)		Odds ratio 95%CI	P- value
	Yes (n=109)*	No (n=18)*		
MID meeting the standard of care for permanent teeth				0.0005
Yes (97)	92 (94.85%)	5 (5.15%)	14.51 (3.21, 65.62)	
No (29)	16 (55.17%)	13 (44.83%)		
Effectiveness of use of Fluoride Varnish as caries treatment for primary teeth				0.0203
Very Effective/Effective (109)	98 (89.91%)	11 (10.09%)	6.98 (1.35, 35.95)	
Ineffective/ Very ineffect. (17)	11 (64.71%)	6 (35.29%)		
Effectiveness of use of Sandwich technique as caries treatment for permanent teeth				0.0224
Very Effective/Effective (102)	92 (90.20%)	10 (9.80%)	13.10 (1.44, 119.22)	
Ineffective / Very ineffective (6)	3 (50.00%)	3 (50.00%)		

Hosmer and Lemeshow Goodnees-of-Fit Test (p=0.8319)
***Actual numbers vary slightly by independent variable and row.**

Table D 42 – Multiple forward stepwise logistic regression model for use of MID meeting the standard of care for permanent teeth (final model, with odds ratio adjusted for other variables in the model)

Variable (n)	MID meeting the standard of care for permanent teeth N=127 (%)		Odds ratio 95%CI	P- value
	Yes (n=98)*	No (n=29)*		
Continue Education				0.0342
Yes (75)	45 (86.54%)	7 (13.46%)	4.04 (1.11, 14.68)	
No (52)	53 (70.67%)	22 (29.33%)		
MID Meeting the Standard of care for primary teeth				0.0011
Yes (98)	92 (85.19%)	16 (14.81%)	13.89 (2.86, 67.40)	
No (29)	5 (27.78%)	13 (72.22%)		
Effectiveness of use of ART as caries treatment for perm teeth				0.0058
Very Effective/Effective (70)	63 (90.00%)	7 (10.00%)	5.18 (1.61, 16.70)	
Ineffective / Very ineffective (35)	19 (54.29%)	16 (45.71%)		

Hosmer and Lemeshow Goodnees-of-Fit Test (p=0.9712)
***Actual numbers vary slightly by independent variable and row.**

Table D 43 – Multiple forward stepwise logistic regression model for use of sharp explorer technique during caries detection (final model, with odds ratio adjusted for other variables in the model)

Variable (n)	Use of sharp explorer during caries detection N=136 (%)		Odds ratio 95%CI	P- value
	Yes (n=88)*	No (n=48)*		
Use of non-sharp explorer for caries detection				0.0022
Sometime/Never (78)	57 (73.08%)	21 (26.92%)	3.75 (1.61, 8.75)	
Always/Most Time/Often (55)	28 (50.91%)	27 (49.09%)		
Use of radiographs for caries detection				0.0434
Yes (126)	86 (68.25%)	40 (31.75%)	10.01 (1.07, 93.60)	
No (10)	2 (20.00%)	8 (80.00%)		
Hours per week for direct patient care				0.0018
Mean hours	30.9	21.8	1.05 (1.02, 1.09)	

Hosmer and Lemeshow Goodnees-of-Fit Test (p=0.6717)
***Actual numbers vary slightly by independent variable and row.**

Table D 44 – Multiple backward stepwise logistic regression model for use of sharp explorer technique during caries detection (final model, with odds ratio adjusted for other variables in the model)

Variable (n)	Use of sharp explorer during caries detection (N=136)		Odds ratio 95%CI	P- value
	Yes (n=88)*	No (n=48)*		
Use of non-sharp explorer for caries detection				0.0018
Sometime/Never (78)	57 (73.08%)	21 (26.92%)	4.01 (1.67, 9.60)	
Always/Most Time/Often (55)	28 (50.91%)	27 (49.09%)		
Use of radiographs for caries detection				0.0388
Yes (126)	86 (68.25%)	40 (31.75%)	10.67 (1.13, 100.79)	
No (10)	2 (20.00%)	8 (80.00%)		
Hours per week for direct patient care				0.0012
Mean hours	30.9	21.8	1.06 (1.02, 1.09)	

Hosmer and Lemeshow Goodnees-of-Fit Test (p=0.6491)
***Actual numbers vary slightly by independent variable and row.**

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