Guest Editorial

The Advanced Dental Hygiene Practitioner Model

By Christine Nathe, RDH, MS

This issue of the *Journal of Dental Hygiene (JDH)* will introduce the first article of a series regarding the Advanced Dental Hygiene Practitioner (ADHP) model. The American Dental Hygienists' Association (ADHA) recognized the need to develop a mid-level provider following the Surgeon General's Call to Action Report in 2003, which specifically requested an increase in the oral health workforce diversity, capacity and flexibility. Following the ADHA House of Delegates recommendation, a task force was appointed to develop a model for the ADHP that included specific competencies and a sample curriculum. The ADHP Competency Document was published by ADHA in 2008.

At present, several states are working to include the ADHP model in their practice acts. Several states are in the stages of studying how this model may be adapted to their own populations' oral health needs. Many stakeholders and dental providers continue to have questions about the ADHP model so the *JDH* is taking the lead and publishing articles that will further explain and define this mid-level provider model.

The first article in the series will focus on the reasons that it is necessary for this provider to be educated at the graduate level. This is an important topic, since other mid-level health care providers are educated at the graduate level, whether it be at the Master's level or the Doctoral level. The term "mid-level" actually describes a provider who is "in between" a doctor and those health

care providers who are educated at the undergraduate or certification level. In fact, many new provider models that are also being developed to address the Surgeon General's call are innovative models, but do not specifically address the niche that the ADHP addresses, which is a graduate educated, *mid-level* provider.

In subsequent issues, other articles will address the legislative initiatives and public policies that need to be accomplished for the ADHP to become a reality. These steps will undoubtedly occur in our individual states and federal agencies. In order for ADHPs to practice, state legislatures will need to add this practice to their state dental statutes, universities will need to add curriculum to their existing graduate programs or develop new Master's level programs in dental hygiene to establish the new provider, and state and federal agencies will need to set policies so that the ADHP can help serve the citizens.

Topics such as the integration of the Healthy People objectives and the Surgeon General's recommendations into the ADHP model will be presented to further describe the model's relationship with the public's health. The topic of how the ADHP model will advocate for the underserved populations who continue to be dentally underserved will be discussed. In addition, information about how this model can reach out to those in need and manage their care within dental care delivery will be presented.

The overall vision statement for the ADHP is to extend primary oral health care to all. The development of the ADHP is a significant advancement for the dental hygiene profession, but most importantly it can help those populations that need dental care the most. Millions of Americans struggle to obtain access to oral health care services; the ADHP model should be able to provide a range of preventive, restorative, and prescriptive services that will help to alleviate patients' pain, manage their infections, and get patients in the pipeline for additional treatment. This model can be part of the solution to make our dental care delivery system more effective and efficient.

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Predicting Tooth Loss in Periodontal Patients

Karen B. Williams, RDH, PhD

The purpose of Linking Research to Clinical Practice is to present evidence-based information to clinical dental hygienists so that they can make informed decisions regarding patient treatment and recommendations. Each issue will feature a different topic area of importance to clinical dental hygienists with A BOTTOM LINE to translate the research findings into clinical application.

Eickholz Peter, Kaltschmitt J, Berbig J, Reitmeir P, Pretzl B. Tooth loss after active periodontal therapy: patient-related factors for risk, prognosis and quality of outcome. J Clin Periodontol. 2008;35(2):165-174.

Objectives: Assessment of patient-related factors contributing (1) to tooth loss and (2) to the quality of treatment outcome 10 years after initiation of anti-infective therapy.

Material and Methods: All patients who had received active periodontal treatment 10 years ago by the same examiner were recruited consecutively until a total of 100 patients were re-examined. Re-examination was performed by a second examiner and included clinical examination, test for interleukin-1 (IL-1) polymorphism, smoking history, review of patients' files (e.g. regularity of supportive periodontal therapy: SPT). Statistical analysis included Poisson and logistic regressions.

Results: Fifty-three patients attended SPT regularly, 59 were females, 38 were IL-1 positive. Poisson regressions identified mean plaque index during SPT ($p<0.0001$), irregular attendance of SPT ($p<0.0001$), age ($p<0.0001$), initial diagnosis ($p=0.0005$), IL-1 polymorphism ($p=0.0007$), smoking ($p=0.0053$), and sex ($p=0.0487$) as factors significantly contributing to tooth loss. Additionally, mean plaque index during SPT ($p=0.011$) and irregular SPT ($p=0.002$) were associated with a worse periodontal status 10 years after initiation of therapy.

Conclusion: The following risk factors for tooth loss were identified: ineffective oral hygiene, irregular SPT, IL-1 polymorphism, initial diagnosis, smoking, age and sex.

Commentary

The primary aim of surgical and nonsurgical periodontal treatment is to control loss of attachment and retain teeth over the person's lifetime. Over the past three decades, considerable research has explored factors that are associated with an increase risk for tooth loss, and those that predict progressive loss of attachment. Following definitive periodontal treatment, numerous variables have been shown to influence stability of the periodontium. Regular supportive periodontal therapy (SPT) has been shown to be crucial for long-term management of patients. Other variables have been identified as important predictors of advancing disease, as well. While this field of inquiry has identified multiple risk factors, many of the classic studies were retrospective in design or only used clinical characteristics of disease progression as surrogate markers of tooth loss. One premise of the current study is that since the goal of periodontal treatment is to preserve the dentition, evaluating the relationship of predictors of tooth loss is important in understanding the multifactorial nature of periodontal progression. In addition, recent evidence on the importance of genetic predisposition as a predictor of tooth loss has been controversial. This study was uniquely designed, using a prospective approach, to model the periodontal outcomes, tooth loss and disease progression, 10 years following initial therapy. Predictors of these two outcomes included baseline clinical findings and associated prognosis, IL-1 polymorphism testing, smoking history, diabetes status, and reason for previous tooth loss.

Subjects in this study were 100 patients who had received either surgical or nonsurgical (SRP under local anesthesia) treatment at the periodontal clinic at the University of Heidelberg by a single trained periodontist beginning in 1992. Subjects had to have complete radiographs and clinical records obtained prior to treatment in order to be included in the 10-year re-examination.

At the 10-year (±6 months) re-examination period, gingival bleeding, plaque score, pocket depth, clinical attachment levels, suppuration and, where relevant, furcation involvement were assessed at 6 sites per tooth by a single examiner. Complete periapical radiographs were obtained and the amount of bone loss measured at the most severely affected site using a Schei ruler. Based on that measurement, teeth were categorized into 1 of 5 groups based on severity of bone loss. In addition, interproximal sites

with the most severe loss were also characterized as to whether there was an infrabony defect or not. Where present, infrabony pockets were grouped as to shallow, moderate or deep defects. These data were used to assign a prognostic rating to each tooth in the mouth that was categorized as either hopeless (bone loss >75%), questionable (bone loss between 50% and 75% or presence of an angular defect or furcation involvement), or good (bone loss <50% with no angular defect or furcation involvement). Based on these tooth-level ratings, a patient prognosis index was computed by summing the number of questionable teeth and hopeless teeth and subjects subsequently divided into 3 prognostic categories: (A) Prognosis Index <0.27; (B) 0.27 ≤ Prognosis Index <0.5, and (C) Prognosis Index >0.5. All patients were tested for Interleukin – 1 polymorphism using the IAI ParoGen Test. Patients who had lost teeth during the 10-year period were queried as to the reason. Smoking status was also obtained and subjects categorized as to current, former (quit smoking at least 5 years prior) and never.

Patients' charts were also examined to extract information that reflected home and professional care during the 10-year period. Mean scores were computed for gingival and plaque indices that had been documented at SPT visits, and irregularity of SPT determined by whether the patient had extended the SPT recall interval by more than twice at any point over 10 years. Lastly, each individual was assigned to 1 of 4 levels of periodontal treatment outcome using a composite of clinical findings proposed by the Swiss Dental Society.

The primary outcome variable used for statistical analyses was tooth loss after Active Periodontal Treatment (APT). One hundred forty-five patients who had been treated 10 years before were invited to participate; however, 42 were unwilling to be re-examined and 3 did not have sufficient data for inclusion. Patients, who ranged in age from 15 to 67 at initial therapy, were reexamined at the 10-year period. Fifty-nine were female, and 53 participants received regular SPT. Overall, 89 were classified as well maintained, with the remainder categorized as downhill or extremely downhill.

Data were analyzed using Poisson regression analysis to predict tooth loss as a function of multiple variables, including irregular SPT, Interleukin – 1 polymorphism, severity of initial diagnosis, smoking, plaque control over 10 years, age, gender and presence of diabetes. This analytical technique allows for the assessment of each variable's contribution to predicting tooth loss while controlling for other variables. Results showed that regular SPT had a protective effect against tooth loss, whereas IL-1 polymorphism, age, female gender, smoking and diagnosis of aggressive or severe disease increased the risk of tooth loss. Of particular interest was the protective effect of SPT. Fifty-three individuals who received regular SPT lost on average 0.55 (±0.99) teeth compared to 2.68 (±4.44) for those not receiving regular SPT. Also, 38 patients were determined to be IL-1 positive and they lost on average 2.24 (±4.82) teeth compared to 1.13 (±1.74) for the IL-1 negative patients. The Prognosis Index did not have a significant association with tooth loss; however, a high level of risk at the start of SPT was associated with increased tooth loss during the 10-year period. Lastly, logistic regression was used to predict periodontal treatment outcome classification as a function of multiple variables. Only regular SPT and average plaque control over time were statistically significant predictors of better periodontal outcomes.

These results have important implications for the dental hygienist. Results from the Poisson regression showed that several nonmodifiable risk factors are associated with tooth loss, including age, gender and IL-1 polymorphism. Knowledge of this information can assist the clinician in selecting appropriate SPT intervals and encouraging adherence on the part of patient. Moreover, for each 10% increase in average plaque score over the 10-year period, there was a 58% increased risk for tooth loss.

Improving plaque control over time is an important modifiable risk factor that is well within the dental hygienist's scope of influence. Recent findings in health psychology suggest that changing patients' behavior rather than providing authoritative information should be the goal of clinician-patient communication.[1-6] When patients are ready for change, providing information can be beneficial in supporting improved health behavior. However, many periodontal patients are not ready for change and can become resistant when clinicians use overt persuasion. Strategies such as motivational interviewing may have utility for changing patient behavior and reducing risk of tooth loss associated with poor plaque control.

Matuliene G, Pjetursson BE, Salvi GE, Schmidlin K, Bragger U, Zwahlen M, Lang NP. Influence of residual pockets on progression of periodontitis and tooth loss: results after 11 years of maintenance. J Clin Periodontol. 2008;35(8):685-695.

Background: Limited evidence exists on the significance of residual probing pocket depth (PPD) as a predictive parameter for periodontal disease progression and tooth loss.

Objective: The aim of this study was to investigate the influence of residual PPD ≥5 mm and bleeding on probing (BOP) after active periodontal therapy (APT) on the progression of periodontitis and tooth loss.

Material and Methods: In this retrospective cohort, 172 patients were examined after APT and supportive periodontal therapy (SPT)

for 3–27 years (mean 11.3 years). Analyses were conducted using information at site, tooth and patient levels. The association of risk factors with tooth loss and progression of periodontitis was investigated using multilevel logistic regression analysis.

Results: The number of residual PPD increased during SPT. Compared with PPD≤3 mm, PPD=5 mm represented a risk factor for tooth loss with odds ratios of 5.8 and 7.7, respectively, at site and tooth levels. The corresponding odds ratios for PPD=6 mm were 9.3 and 11.0 and for PPD≥7 mm 37.9 and 64.2, respectively. At patient level, heavy smoking, initial diagnosis, duration of SPT and PPD≥6 mm were risk factors for disease progression, while PPD≥6 mm and BOP≥30% represented a risk for tooth loss.

Conclusion: Residual PPD≥6 mm represents an incomplete periodontal treatment outcome and requires further therapy.

Commentary

Preventing tooth loss in periodontal patients continues to be the goal of periodontal therapy. While many researchers have attempted to identify risk factors that influence that natural history of progressive periodontal attachment loss and tooth loss, few studies have examined the impact of residual pockets following active treatment on meaningful outcomes. Researchers at the University of Bern in Switzerland recently explored the influence of residual periodontal pockets and bleeding on probing on progression of periodontitis and tooth loss. The study team used a retrospective approach to identify patients who had been treated by periodontal residents at that institution between the years 1978 and 2002. A total of 392 patients were identified, and of those, 199 agreed to participate and be re-examined. Inclusion criteria for participation stipulated that subjects must have two complete sets of periodontal and radiographic records; one obtained prior to active periodontal therapy and one from the end of active treatment. Of the original 199 patients, 122 met these criteria. The sample consisted of 55.2% women, and subjects' mean age was 45 (±11) years.

Data on prevalence of residual pockets of varying depths and bleeding on probing was obtained from the post-APT records. These data were also used to retrospectively classify patients as having Level 1 or Level 2 periodontitis. Level 1 was defined as presence of proximal attachment loss of ≥3 mm in two or more teeth. Patients were classified as Level 2 if they had proximal attachment loss of ≥5 mm in at least 30% of teeth. Active treatment delivered by the residents consisted of scaling and root planing (SRP) under anesthesia, if needed. Periodontal surgery was performed following re-evaluation if indicated by response to SRP. Subjects requiring prosthetic therapy received treatment by either implants or fixed prostheses. All subjects, including those who had received or who had refused surgery, received SPT following APT by their private dentist or at the University of Bern.

At the re-examination appointment, patients were asked about their smoking habits and frequency of SPT over the post-APT period and then reclassified as being progressive or not. The criterion for determining "progressive" was having at least 2 teeth with additional attachment loss of ≥3 mm. The average time period between APT and re-examination ranged from 3 to 27 years, with an average of 11.3 (±4.9) years. Patients' average age at re-evaluation was 56.6 (±11 years).

An advanced statistical analysis (multilevel logistic regression) was used to account for periodontal sites, clustered within teeth, which were clustered within patient in assessing tooth loss. This strategy accounts for the fact that sites and teeth are not independent of the patient, thus improving the validity of statistical decisions made about relationships of risk factors to periodontal outcomes. Because progression of periodontitis is a patient-level outcome, a more straightforward analytical approach (logistic regression) was used in this analysis.

After APT, 98 patients received their SPT at the university, whereas 73 returned to their private dentist. Patients' self-report of SPT visits showed that the SPT intervals were significantly ($p < .0001$) shorter for subjects attending the university clinic, with 95% receiving SPT at least twice or more times per year compared to 68% in the private sector.

At the end of active treatment (APT), approximately 29% of patients had no residual pockets ≥5 mm, 40% had 1 to 4, 16 % had 5 to 8 and 15% with ≥9 sites. At the reexamination period (again, on average 11 years later) these values had shifted to 19% with no sites ≥5mm, 41% with 1 to 4 sites, 18% with 5 to 8 sites and 23% with 9 or more sites. Of particular note, the percent of patients with >9 sites in smokers increased from 31% to 52% between active treatment and re-examination. In nonsmokers, the increase was considerably smaller, from 7% to 15%. The trend for full-mouth bleeding scores was similar, with more bleeding on probing on average noted at re-examination.

At the tooth level, results showed that the odds of tooth loss at re-examination increased dramatically as a function of increasing residual pocket depth present at end of treatment, and that this effect was dramatically influenced by presence of bleeding at that site. When the analysis was conducted at the patient level, the picture of risk for tooth loss became clearer. Patient-level factors that were significantly predictive of tooth loss included full-mouth bleeding scores >30%, a diagnosis of Level 2 disease, the years of SPT over 10 years and presence of residual pockets >6 mm after APT.

Smoking habits, health status, gender and age were not significant predictors of tooth loss. However, when periodontal progression was modeled as the outcome, heavy smoking was a predictor of progression along with SPT exceeding 10 years, Level 2 diagnosis, presence of at least 1 site >6 mm, or >9 sites with pocket depths of ≥5 mm at the end of APT.

These results contribute new information to our understanding of periodontal progression and tooth loss over time. The authors argue effectively that the true measure of periodontal therapy success should be preventing loss of teeth. While measuring periodontal pocket depth and attachment loss over time (e.g., periodontal progression) is the focus of periodontal supportive therapy and maintenance, the importance of these data lies in their predictive value rather than in the data themselves. One shortcoming of the current study is that reason for tooth loss was not explicitly tied to progression of periodontal disease. It is likely that some teeth may have been extracted during the study period as a result of caries, fracture or endodontic problems. The impact of this source of error on results is not known; however, it could attenuate the predictive strength of the patient-level and site-level factors on tooth loss. Additionally, patients in this study were treated by a number of dentists during the study period. As philosophies and subsequent treatments may have differed, it is possible that clinician decisions to maintain versus extract teeth may have varied as well. Despite this, the concordance of these findings to those reported by other authors gives additional support to concern regarding the potential negative consequences of not retreating bleeding residual pockets following active therapy.

The Bottom Line

Periodontal disease continues to be the number one reason for tooth loss in the U.S. *Oral Health in America: A Report of the Surgeon General* (Department of Health and Human Services, 2000) reports that approximately 22% of individuals have destructive periodontal disease.[7] Beyond the financial and quality of life impact periodontal disease has on individuals, there is also a concomitant economic impact on society in terms of lost productivity and revenue. Dental hygienists commonly spend a great amount of time attending to the needs of individuals and communities with gingival and periodontal diseases with the intent of reducing the burden of disease. However, it is not uncommon in private practice for dental hygienists to attend to the direct patient care issues (SRP) and lose sight of how residual disease might affect tooth retention. In many dental offices, the amount of time allotted for dental hygiene treatment, along with third-party reimbursement limitations, can force the clinician to make compromises in the extent and frequency of dental hygiene care. Dental hygienists are fortunate if they have 60-minute appointments in which to provide care. This timeframe has become a standard appointment interval, and was originally supported by the findings of Schallhorn and Snider.[8] In 1981, Schallhorn and Snider determined that routine dental hygiene care consisted of the following: patient greeting, health history update, dental screening, periodontal assessment and recording, plaque index, oral hygiene review, polishing and flossing, scaling and root planing, assessment of caries and defective restorations, chemical therapy (if needed), fluoride rinse, dismissal and reappointment of the patient.[8] In their assessment, no consideration was given to degree of residual disease present, and this study was conducted prior to the development of universal precautions for infection control as well as before adjunctive treatments such as local drug delivery. This begs the question of whether adequate and appropriate periodontal supportive care can be provided within a 60-minute dental hygiene appointment. While these studies do not directly address this dilemma nor suggest what treatment should be rendered, they do provide good longitudinal evidence supporting the need to more aggressively treat residual bleeding pockets. More importantly, they suggest that "watching" a tooth with residual bleeding pockets is not a valid strategy when the goal of therapy is to retain teeth. The results of these two studies do, however, provide evidence to support the following conclusions:

- The primary goal of periodontal treatment is maintenance of a functional dentition and prevention of tooth loss.
- Over time, factors including regular SPT and good plaque control can reduce the odds of periodontal disease progression and tooth loss.
- Following active periodontal treatment, the presence of residual periodontal pockets (both bleeding and non-bleeding) significantly increases the odds for future periodontal attachment loss and tooth loss.
- Interleukin – 1 (IL-1) polymorphism increases the odds of disease progression and tooth loss.

Summary

The practice of dental hygiene is frequently constrained by expectations of the supervising employer and third-party coverage related to procedures and recall intervals. This can put the clinician in a compromising situation where short-term, procedure-based goals outweigh the long-term goal of preserving the dentition. Examining the long-term consequences of residual dis-

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ease (following active treatment) and irregular SPT provides a strong rationale for re-evaluating our current standards of practice. Ultimately, the dental hygienist must advocate on behalf of the patient for effective and appropriate care. This may involve having critical discussions with other members of the dental team about modifying office standards and policy to ensure that new evidence is considered in the provision of treatment and long-term management of patients. As I have stated in previous columns, it is often the dental hygienist who is charged with providing nonsurgical periodontal care and evaluating the results of such care. This puts the dental hygienist in the important role of influencing best practice standards in the dental office. This is most effectively achieved by being knowledgeable of current and developing evidence, focusing on desired outcomes, and being an active advocate for patients in the dental practice.

Keeping an eye on the evolution of scientific evidence is critical if our primary goal is to improve the health status of individuals and communities. Remaining current is no longer an option for clinicians. Engaging in outdated practice standards and relying on knowledge acquired years ago to guide clinical decisions not only threatens oral health of individuals, but threatens the viability of the profession of dental hygiene.

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Research

Cold Plasma Technology:

Bactericidal Effects on *Geobacillus Stearothermophilus* and *Bacillus Cereus* Microorganisms

Angela D. Morris, RDH, MS; Gayle B. McCombs, RDH, MS; Tamer Akan, PhD; Wayne Hynes, PhD; Mounir Laroussi, PhD; and Susan L. Tolle, RDH, MS

Abstract

Introduction: Cold plasma, also known as Low Temperature Atmospheric Pressure Plasma (LTAPP) is a novel technology consisting of neutral and charged particles, including free radicals, which can be used to destroy or inactivate microorganisms. Research has been conducted regarding the effect of cold plasma on gram-positive bacteria; however, there is limited research regarding its ability to inactivate the spore-formers *Geobacillus stearothermophilus* and *Bacillus cereus*.

Purpose: The purpose of this study was to determine if cold plasma inactivates *G. stearothermophilus* and *B. cereus* vegetative cells and spores.

Methods: Nine hundred eighty-one samples were included in this study (762 experimental and 219 controls). Experimental samples were exposed indirectly or directly to cold plasma, before plating and incubating for 16 hours. Control samples were not exposed to cold plasma. The percentage-kill and cell number reductions were calculated from Colony Forming Units (CFU). Data were statistically analyzed at the .05 level using one-way ANOVA, Kruskal Wallis and Tukey's tests.

Results: There was a statistically significant difference in the inactivation of *G. stearothermophilus* vegetative cells receiving indirect and direct exposure (p=0.0001 and p=0.0013, respectively), as well as for *B. cereus* vegetative cells and spores (p=0.0001 for direct and indirect). There was no statistically significant difference in the inactivation of *G. stearothermophilus* spores receiving indirect exposure (p=0.7208) or direct exposure (p=0.0835).

Conclusion: Results demonstrate that cold plasma exposure effectively kills *G. stearothermophilus* vegetative cells and *B. cereus* vegetative cells and spores; however, *G. stearothermophilus* spores were not significantly inactivated.

Key Words: Cold plasma, Low Temperature Atmospheric Pressure Plasma (LTAPP), bacteria, spores, sterilization

Introduction

Low temperature atmospheric pressure plasma (LTAPP), also known as "cold" or nonthermal plasma, is an innovative technology that has the potential to destroy microorganisms.[1] Most of the visible universe is made up of plasma, referred to as the fourth state of matter, which is a partly ionized gas comprised of molecules, atoms, electrons and ions. The remaining 1% of the visible universe consists of three other states of matter: solids, liquids and gases. Most plasmas are very hot, with temperatures up to thousands of degrees centigrade; however, cold plasma denotes technology that operates at or near room temperature.

Plasma technology can be thought of as cold combustion producing highly reactive free radicals via electron-neutral collisions instead of using heat.[2] Researchers have investigated plasma technology for a wide spectrum of biomedical and commercial applications including decontamination of food and military equipment and sterilization of medical/dental instruments, as well as the killing of airborne and surface pathogens.[3] The development of an alternative to traditional sterilization methods that is safer, faster, and more cost effective would have far-reaching implications for the dental and medical professions. Moreover, cold plasma has the potential to impact the health care profession beyond sterilization purposes; in particular, inactivating microorganisms associated with oral diseases and wound infections.

Numerous studies have been conducted investigating the effectiveness of cold plasmas to inactivate strains of bacteria, such as *Bacillus atrophaeus* (previously called *Bacil-*

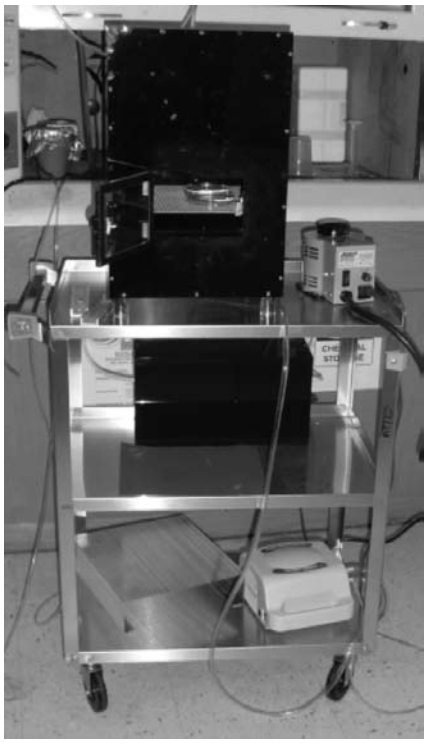

Figure 1. Indirect Cold Plasma Chamber

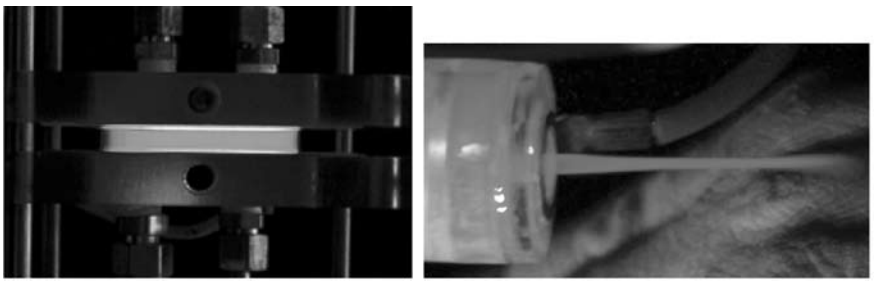

Figure 2. Direct Cold Plasma Plume

lus subtilis), *Escherichia coli*, and *Staphylococcus aureus*.[4-7] However, there is limited research regarding the inactivation of *Geobacillus stearothermophilus*, formerly called *Bacillus stearothermophilus*, and *Bacillus cereus*. The two microorganisms chosen for this study were selected because of their distinct differences. *G. stearothermophilus* is commonly found on biological indicator test strips to verify steam or chemical vapor sterilization of resistant microorganisms, whereas *B. cereus* is associated with food poisoning; both are extremely resistant to heat at the spore stage.[8,9]

Cold plasma may be utilized to inactivate microorganisms via indirect or direct methods. Indirect or "remote" cold plasma exposure requires the bacteria to be placed away from the plasma discharge; therefore, the samples are placed in an adjacent chamber (Figure 1). Conversely, direct cold plasma exposure occurs when the samples are placed directly under (within inches of) the plasma plume discharge (Figure 2).[4,10,11]

The purposes of this investigation were to (1) evaluate the effectiveness of cold plasma in destroying *G. stearothermophilus* and *B. cereus*, (2) determine which type of cold plasma exposure (indirect or direct) has the greatest kill and, (3) assess the minimum time needed to achieve a statistically significant reduction in the number of bacterial colonies.

Review of the Literature

Sterilization and decontamination are essential components of infection control within the dental and medical communities. Ensuring that sterilization techniques are effective is a major concern to health care professionals. Sterilization occurs when all microorganisms, spores and viruses are destroyed or inactivated.[12-14] Cold plasma technology has the potential to become a more cost effective and less time-consuming procedure, as well as produce less toxic waste when compared to the traditional types of sterilization, such as steam, dry heat, ethylene oxide, or chemical vapor methods.[4,12,14]

Cold plasma produces greater structurally damaging effects on gram-negative bacteria, such as *E. coli*, than to gram-positive bacteria.[5] Gram-negative bacteria experience structural damage to the outer membrane following exposure to cold plasma, whereas more resistant gram-positive bacteria do not show the same degree of morphological effects.[15] According to Laroussi and colleagues,[5] even though structural damage was not observed in gram-positive bacteria following exposure, the bacteria remaining were nonviable, suggesting that cold plasma inactivates the microorganisms without changing their structure.

G. stearothermophilus, a gram-positive, aerobic, spore-forming microorganism, is extremely resistant to high heat and pressure.[16] This microorganism is commonly associated with spoiling liquid foods in vending machines, such as coffee, and is incorporated on biological indicator strips as a way to monitor sterilization methods.[16]

B. cereus, a gram-positive, aerobic, spore-forming, microorganism, was chosen because it is an opportunistic pathogen which commonly causes food poisoning and has also been associated with periodontal disease and bacteremias.[17-19] Certain strains of *B. cereus* produce enterotoxins and emetic toxins, resulting in diarrhea and vomiting, the classic characteristics of food poisoning.[19] According to Marsili and colleagues, *B. cereus* microorganisms demonstrate susceptibility to plasma treatment by being inactivated within 10 to 30 seconds of exposure.[20] Moreover, when air was used as the gas for the plasma, a greater inactivation of *B. cereus* occurred after 50 seconds of treatment in comparison to using nitrogen or carbon dioxide gas mixtures. Researchers postulate that this interaction may be due to the ozone and free radicals that are produced in the breakdown of the air gas, causing inactivation of the *B. cereus*.[20]

Exposing bacteria inoculated on different types of media, such as liquid suspension, glass slab, or

Table 1. Sample Distribution and Cold Plasma Treatment Exposure Times

Dependent Variables		Independent Variables		Total
Bacteria and State	**Control (No Exposure)**	**Indirect Exposure**	**Direct Exposure**	**Sample Size**
G. stearothermophilus Vegetative	0 seconds	15, 20, 25 and 30 minutes	1, 2, 4, 5, 6, 8, 10, 15, 20 and 30 minutes	**440**
G. stearothermophilus Spores	0 seconds	15, 20, 25 and 30 minutes	10, 20 and 30 minutes	
Bacillus cereus Vegetative	0 seconds	1, 2, 3, 4, 5, 10, 15, 20, 25 and 30 minutes	10, 20, 30, 40 and 50 seconds and 1, 2, 4, 6, 8 and 10 minutes	**541**
Bacillus cereus Spores	0 seconds	1, 2, 3, 4, 5, 10, 15, 20, 25 and 30 minutes	30 seconds and 1, 2, 3, 4 and 5 minutes	
Total Sample Size	**219**	**344**	**418**	**981**

polypropylene, may also effect inactivation by cold plasma.[4] Laroussi demonstrated that the "survivor curves" of the microorganisms are related to the culture medium. For example, the D-value, or the time that was needed to destroy 90% of the original concentration of *B. atrophaeus* on a glass slab, was much shorter than the time required for inactivation of the same bacteria in a liquid suspension.[4]

The inactivation of resistant gram-positive bacteria, such as *B. atrophaeus*, without causing significant structural damage to the microorganism, suggests that cold plasma has the ability to kill without obvious morphological changes. Moreover, exposing cold plasma to a variety of materials used to manufacture dental and medical instruments may affect the amount of exposure time needed to effectively destroy resistant microorganisms such as *G. stearothermophilus* and *B. cereus*.

Methods and Materials

In the present study, the experimental group consisted of *G. stearothermophilus* and *B. cereus* vegetative cells (<18 hour culture) and spores (48-hour culture) on agar or glass slides, then exposed to either indirect or direct cold plasma. The control group, also referred to as "0 seconds exposure," utilized *G. stearothermophilus* and *B. cereus* vegetative cells and spores that did not receive cold plasma exposure.

Due to the exploratory nature of this study, various exposure times were evaluated for the indirect and direct plasma, resulting in a total sample size of 762 exposed and 219 unexposed control samples (N= 981). The indirect plasma chamber exposed 344 samples and the direct plasma device exposed 418 samples (n=762). The bacteria were purchased from the American Type Culture Collection (ATCC) (*G. stearothermophilus* ATCC 12980 and *B. cereus* ATCC 14579). Various exposure times were selected to evaluate the time points at which noticeable kill occurred as assessed by counting Colony Forming Units (CFU).

Laboratory Procedures

Indirect Plasma Exposure. Before exposure to cold plasma, the microorganisms were cultured in trypticase soy broth (TSB), diluted and plated onto trypticase soy agar (TSA) (Difco/Becton Dickinson Laboratories, Sparks, MD 21152) or Luria Bertani (LB) (Difco/Becton Dickinson Laboratories, Sparks, MD 21152) media for *G. stearothermophilus* and *B. cereus*, respectively. *G. stearothermophilus* vegetative cells and spores were exposed to indirect cold plasma for 15, 20, 25 and 30 minutes, whereas *B. cereus* vegetative cells and spores were exposed for 1, 2, 3, 4, 5, 10, 15, 20, 25 and 30 minutes (see Table 1). Following each exposure time, the cold plasma was turned off and the gases within the chamber were evacuated into a fume hood for 60 seconds. After treatment, the samples were incubated for up to 18 hours, and plates containing between 30 and 300 CFU were counted.

Direct Plasma Exposure. Prior to direct cold plasma exposure, the microorganisms were cultured overnight in TSB, diluted before 10 microliters of the culture was pipetted onto a sterile glass slide. The glass slides were placed directly under the plasma discharge. *G. stearothermophilus* vegetative cells were exposed for 1, 2, 4, 5, 6, 8, 10, 15, 20, and 30 minutes; *G. stearothermophilus* spores were exposed for 10, 20, and 30 minutes; *B. cereus* vegetative cells were exposed for 10, 20, 30, 40, and 50 seconds, as well as 1, 2, 4, 6, 8, and 10 minutes; and *B. cereus* spores were exposed for 30 seconds, 1, 2, 3, 4, and 5 minutes (see Table 1). After exposure, the glass slide was rinsed with sterile saline into a test tube, dilutions were made and the bacteria plated on either TSA or LB media prior to

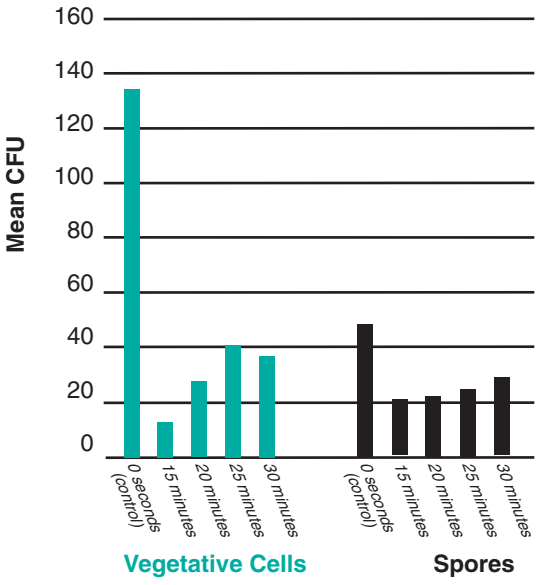

Figure 3. Mean CFU of* G. stearothermophilus *receiving indirect cold plasma

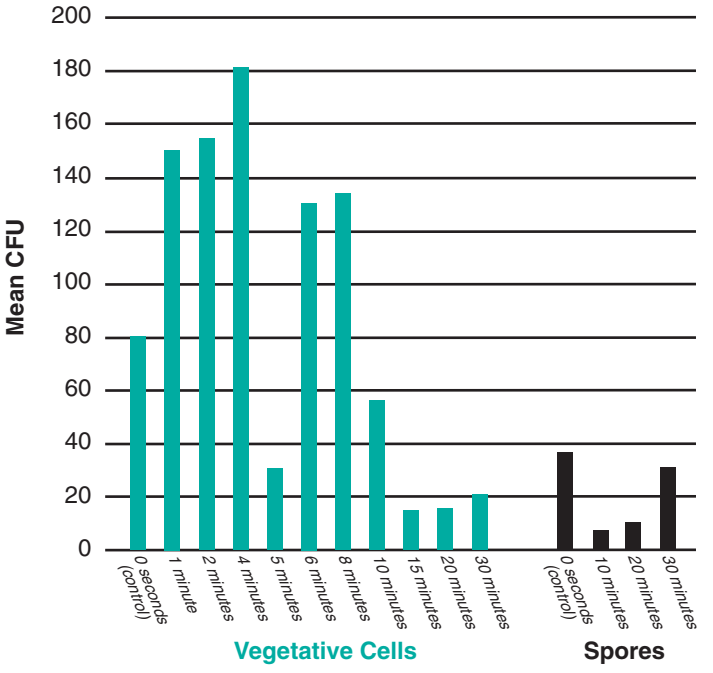

Figure 4. Mean CFU of* G. stearothermophilus *receiving direct cold plasma

incubation for 12-16 hours. Following incubation, CFU were counted.

Statistical Methods

Data were grouped for statistical analysis according to bacteria (*G. stearothermophilus* or *B. cereus*), bacteria state (vegetative or spores), cold plasma exposure (direct or indirect) and cold plasma exposure times (variable). Percentage kill was calculated by obtaining the total CFU for each bacteria, state, exposure type, and time and subtracting this number from each control group's CFU, dividing this total by the control CFU and then multiplying by 100 for the percentage value [i.e., (control CFU – experimental CFU / control CFU) x 100% = percentage kill]. Percentage kill is the proportion of colonies that were killed via cold plasma exposure (experimental group) compared to the number of colonies in the control group. The percentage kill provided the proportion of the bioburden of microorganisms that were effectively inactivated by cold plasma.[21] The concentration of cells (CFU/mL) was also calculated for each bacteria and state, exposure type, and time.

For data that were roughly normally distributed, the parametric test of one-way Analysis of Variance (ANOVA) was used to determine the means and standard deviations, whereas the Kruskal Wallis test was used to analyze data that were not roughly normally distributed. One-way ANOVA and the Kruskal Wallis test analyzed overall significance, and the Tukey's Studentized Range (HSD) test determined which cold plasma treatment times were statistically significant.

Results

Results demonstrate there was a statistically significant kill of *G. stearothermophilus* vegetative cells exposed in the indirect chamber at all time points, as well as direct exposure at 10 minutes (p-value of 0.0001 for indirect and 0.0013 for direct); however, there was not a statistically significant kill in *G. stearothermophilus* spores exposed to indirect or direct cold plasma (p-value of 0.7208 for indirect and 0.0835 for direct).

Data revealed a statistically significant kill of *B. cereus* vegetative cells at all time points for indirect exposure and starting at 50 seconds for direct exposure (p-value of 0.0001 direct and indirect). Statistically significant kill of *B. cereus* spores occurred at all time points for indirect exposure and beginning at 3 minutes for direct cold plasma exposure (p-value of 0.0001 for direct and indirect) (see Figures 3 - 6 for mean CFU and Table 2 for significance).

Discussion

This study was designed to evaluate the bactericidal effect of cold plasma on *G. stearothermophilus* and *B. cereus* vegetative cells and spores. The development of an alternative to traditional sterilization methods, such as cold plasma, would have a positive impact within the medical and dental communities. Furthermore, vegetative cells and spores were specifically tested to determine if differences occurred in the inactivation rates. Since spores

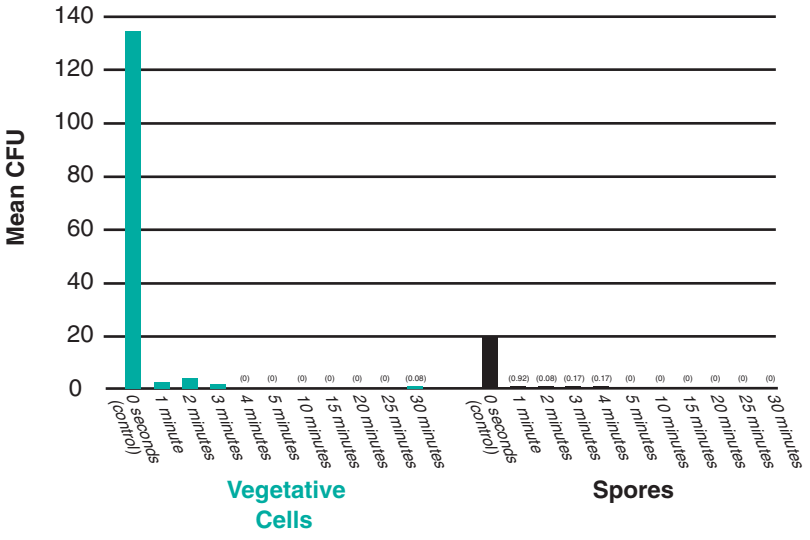

Figure 5. Mean CFU of* B. cereus *receiving indirect cold plasma

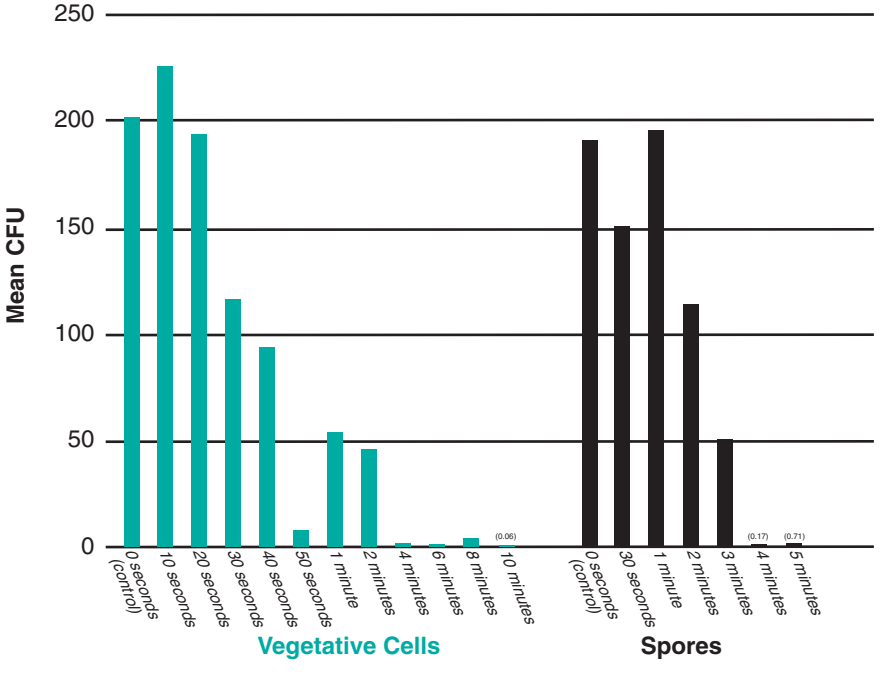

Figure 6. Mean CFU of* B. cereus *receiving direct cold plasma

are more resistant than actively dividing and growing vegetative cells, it was anticipated that vegetative cells would be inactivated at a faster rate than spores.[11,21,22] These findings suggest additional research is needed to determine how to best destroy spores.

G. stearothermophilus spores demonstrate extreme stability and require high heat and pressure for inactivation.[16] These factors may contribute to the difficulty experienced in killing *G. stearothermophilus* spores using cold plasma and may provide suggestions as to why there were no statistically significant reductions in CFU. Since *G. stearothermophilus* spores were more resistant to cold plasma than *B. cereus*, future studies are required to determine if modifications to the cold plasma device would increase its efficacy in killing *G. stearothermophilus* spores.

Exposing bacteria on various types of media, other than agar or glass slides, is recommended. Future studies are needed to compare the type of media and amount of time required for inactivation of *G. stearothermophilus* and *B. cereus*. It has been suggested that the type of media does affect cold plasma exposure times; however, this study did not address this aspect.[4]

The indirect chamber exposed 4 samples (Petri dishes) at one time. Additional research should evaluate variability of sample placement within the chamber. The researchers monitored plate location within the chamber (front left, front right, back left or back right); however, the results were not analyzed differentiating between the locations. Additionally, a distance of 0.25 inches from the direct plasma output to the glass side was utilized for each exposure. A recommendation for future studies would involve assessing the variability of direct exposure by using different distances between the cold plasma output and the culture.

This innovative technology holds commercial promise for a whole host of biomedical and industrial applications. Cold plasma, which could be thought of as room-temperature sterilization, has the potential to change the way we currently apply sterilization techniques. Potentially, cold plasma offers advantages over traditional methods, such as being more cost effective and time efficient, and producing less toxic byproducts than, for instance, ethylene oxide. Plasma technology has far-reaching implications for the development of an efficient and safer means of inactivating pathogenic microorganisms on hard surfaces and skin and in the air, as well as within the oral cavity. Researchers envision the implementation of a cold plasma device that can be used intraorally to inactivate cariogenic and periodontal pathogens, in addition to a device that can be

Table 2. Statistical Significance of Indirect and Direct Cold Plasma Exposure

Bacteria	State	Chamber	Significance
Geobacillus stearothermophilus	Vegetative	Direct	.0013*
		Indirect	.0001*
	Spore	Direct	.0835
		Indirect	.7208
Bacillus cereus	Vegetative	Direct	.0001*
		Indirect	.0001*
	Spore	Direct	.0001*
		Indirect	.0001*
* Denotes statistical significance less than or equal to .05			

used for surface decontamination. The future of plasma technology is wide open and far reaching with tremendous potential for state-of-the-art biomedical and commercial applications.

Despite the limitations of this study, the data support that cold plasma is effective in killing *G. stearothermophilus* vegetative cells, as well as *B. cereus* vegetative cells and spores, for both direct and indirect exposure, at various time intervals. However, data revealed there was not a statistically significant kill in *G. stearothermophilus* spores.

Conclusion

The present study examined the bactericidal effects of direct and indirect cold plasma on *G. stearothermophilus* and *B. cereus* vegetative cells and spores. Results demonstrate that there is a statistically significant reduction in *G. stearothermophilus* vegetative cells and *B. cereus* vegetative cells and spores exposed to cold plasma; however, there is no statistically significant reduction in *G. stearothermophilus* spores. Spores are difficult to inactivate; therefore, further analysis is needed to determine how to penetrate the protective layers by modifications to the cold plasma devices.

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Research

Missing Persons:
African Americans in Dental Hygiene

Elizabeth Onik, RDH, BSDH, MEd

Abstract

Purpose: The purpose of this research was to study some of the reasons why African Americans are underrepresented in dental hygiene. The purpose was to 1) describe African American representation in dental hygiene and dental hygiene education; 2) evaluate the relationship between the percentage of hygienists and the percentage of African Americans by state; and 3) evaluate how the professional practice environment of dental hygienists relates to African American demographics by state.

Methods: This descriptive study cross-linked secondary data from existing education, oral health, and population databases. This study included 1) the historical percentages of African American dental hygiene graduates over the last 10 years; 2) the percentages of dental hygienists per state, cross-referenced with race demographics by state, and 3) the Dental Hygiene Professional Practice Index (DHPPI) cross-linked with African American population statistics. (The DHPPI is a tool that summarizes the professional practice environment of dental hygienists by state.)

Results: 1) Results demonstrate that based on African American dental hygiene graduation rates from 1996 through 2003, and employment projection data from the U.S. Labor Review Board, African Americans will continue to be proportionately underrepresented in dental hygiene. 2) Four of the top five states with the highest density of dental hygienists are in the 10 states with the lowest proportion of African Americans (Vermont, New Hampshire, North Dakota, and Oregon). 3) Of the 10 states (and DC) with the lowest density of dental hygienists, 3 of them have the highest proportion of African Americans (Mississippi, Louisiana, District of Columbia). 4) The 10 states with the highest proportion of African Americans had an average DHPPI score of **28.5%**, which falls in the lowest "Restrictive" practice environment category. The 10 states with the lowest proportion of African Americans had an average DHPPI score of **46.9%**, which scores in the "Favorable" category. 5) Of the 17 states with a higher than average African American population, (>12.1%), 14 were in the Limiting or Restrictive categories, 2 were in the Satisfactory category, 1 was in the Favorable, and none were in the Excellent category.

Conclusions: African Americans are underrepresented in the dental hygiene profession. African Americans live in states that are disproportionately lacking dental hygienists. The professional practice environment for dental hygienists is more restrictive in states with high percentages of African Americans.

Introduction

The rationale for this study is rooted in the first *Surgeon General's Report on Oral Health in America*, which revealed that not only is there an epidemic of oral disease in this country, but that the burden of disease is disproportionately borne by minorities.[1] Among the many reasons cited for this is the fact that there is very little diversity among health care workers in the United States.[2,3]

This paper is inspired by the landmark 2004 Sullivan Commission Report on diversity in the health care workforce, *Missing Persons: Minorities in the Health Professions*, which details the lack of diversity and under-representation of minorities in the health professions.[4] However, the report does not mention the profession of dental hygiene, where lack of African Americans is especially pronounced. African Americans represented 12% of the United States population in 2004, but they represented only 4% of dental hygienists.[5] By 2014, the African American population will be 13.2% of the population.[6] This fact is important when one considers data that shows that not only do minorities disproportionately carry the burden of untreated dental disease, they also are more likely to seek treatment from people of their own race.[7] If there are no health practitioners of one's own race, this can stand as a barrier to access to care. This may be one reason that minorities do not receive the level

of dental care that the Surgeon General's report has set as its goal. Because dental hygienists will continue to be in great demand,[25] it is important to find ways to improve the diversity of this health profession in order to improve access to care for African Americans.

The problem of lack of diversity and underrepresentation of minorities exists in all of the health professions, but is particularly noticeable in the profession of dental hygiene. The problem of underrepresented minorities in the dental hygiene profession crosses educational, regulatory, and oral health care domains. Accountability to the diverse racial and ethnic communities served by these domains is at issue in addressing the Surgeon General's call for action.[1] This paper will look at how educational and regulatory variables might intersect in selecting (or de-selecting) students for dental hygiene education. Although most of the literature looks at minorities as a group when discussing underrepresentation in the health professions, this paper will focus on African Americans, as they are one of the most underrepresented of all the minorities in dental hygiene,[5] and they exhibit a flat graduation growth rate compared to other minorities (Table 1).

Several questions are addressed in this paper. Is lack of access to dental care for African Americans a barrier that translates into lack of exposure to dental hygiene as a career? Do African Americans live in states with low access to preventive care because there are fewer dental hygienists available to provide care? If so, what are some of the reasons that the percent of dental hygienists is lower in some states? Within the context of finding solutions to improving access to dental care, this study will look at reasons why African American students are underrepresented in dental hygiene, and what barriers to care for African Americans might exist based on dental hygiene demographic distribution.

Review of the Literature

Former U.S. Surgeon General David Satcher, MD PhD, stated, "Without oral health, you do not have health."[1] He called upon dental professionals to study the problems of access to care and to find solutions to the astounding fact that 50% of the U.S. population receives no dental care at all.[1] Most of the burden of dental disease rests with underrepresented minorities who face barriers of affordability, transportation, utilization, and health literacy. The Institute of Medicine (IOM) report, *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care,* and its affiliated report *Implications for Academic Health Centers*, has identified lack of diversity in higher education as one of the causes of racial and ethnic disparities in health care.[8] The report points out that minorities (African Americans, Hispanics, and American Indians) together constitute 25% of the U.S. population. However, they only make up 9% of nurses, 6% of physicians, and 5% of dentists.[8] One of the recommendations in the IOM report on increasing diversity in the health professions calls on educators to establish and maintain outreach programs to increase student interest in the field and eligibility for admission.[8]

Table 1. Total Dental Hygienists in U.S. Workforce and Total of New DH Graduates in 2003 by Race

	Total % of Dental Hygienists in 2003	% Dental Hygienists graduated in 2003
African American	4	9
Hispanic	6	15
Native American	n/a	2
Asian	5	11
Caucasian	85	63
Total	100	100

Several authors and studies have recognized the critical benefits of educational diversity among health care workers in improving public health.[1,2,8-10] Tedesco argues for affirmative action in educating dental health professionals because this approach will improve the health status of minorities for several reasons, including the fact that minority health care professionals disproportionately serve minority and other underserved populations.[10] Tedesco also emphasizes that minority professional students are more likely to engage in community service and pro-bono work than white students, which would be a factor in improving the public's health.[10] Edmunds states that individuals in minority communities are more likely to seek treatment from people of their own race.[7] If there are no health practitioners of one's own race, this can stand as a barrier to access to care.[7] Dental practices in which the oral health care providers are black serve a patient population that is 61.8% black, practices in which the providers are Hispanic serve a 45.4% Hispanic population, practices in which the providers are Asian serve a 25% Asian population, and practices in which the providers are white serve a 76.6% white population.[11] Edmunds also points out that increasing diversity in dental schools can help motivate all students, not only minority students, to provide care to the underserved.[7] The IOM report also makes several recommendations to address ethnic and racial health disparities and concurs with Tedesco[3] that increasing the proportion of underrepresented minorities (URMs) in the health care workforce is critical.[8]

Although most of the literature on URMs in the health professions is focused on graduate-level medical and dental education programs, some authors try to extrapolate to dental hygiene.[9,10,12,13] Based on a review of

the literature, what is still missing is analytical information about URMs in *undergraduate* health professions programs such as dental hygiene. However, some of the literature on the nursing profession may be applicable to dental hygiene since they both have similar educational structures and organizations.[14] Both dental hygiene and nursing have various levels of training leading to licensure ranging from two-year community college programs to four-year baccalaureate and graduate degrees. However, dental hygiene has one practice barrier that nursing no longer faces. Unlike nurses, one dominant professional group (dentists) regulates dental hygienists. The American Dental Association promulgates curriculum guidelines and accreditation requirements, and state dental boards composed mainly of dentists and consumers generate licensing criteria regulations. In most states, dental hygienists are one of the few licensed health care professionals who are not self-regulated, and this results in practice laws that limit the scope of dental hygiene practice and access to care.[15]

In reviewing the literature concerning URMs in dental schools, another missing piece in the literature is lack of data that demonstrate the role that dental hygiene undergraduate programs can play as part of the pipeline for dental schools. Some dentists have started their careers in dental hygiene, just as some doctors have started their careers in nursing. If we can improve minority representation in dental hygiene, we may also see an increase in minority representation in dentistry. Although 90% of dental hygiene education programs are in community and technical colleges, most university programs have articulation agreements that allow the dental hygienist to continue the education to the baccalaureate level. Community colleges in general represent a possible pipeline for both advanced dental hygiene education and graduate dental school programs. Although there is not much data regarding dental hygiene minority education, some authors have described recruitment and retention strategies centered around community college articulation agreements, innovative curricula, success predictors, and remediation in dental hygiene higher education programs.[10,12,13]

Eleanor Schiff, in a *Spelling's Report Issue Paper: Preparing the Health Workforce*, noted that community colleges and associate degree programs are often the entry point for many professionals in health care fields.[9] Associate degree programs prepare 60% of the nation's RNs and 90% of our dental hygienists. Considering that 32% of the community college population are students of color,[16] we would expect to find a higher percentage of African Americans in dental hygiene (and nursing) programs. However only 10.2% of all associate degrees (and 8.3% of all bachelor's degrees), were earned by black students in 2000.[17] These figures speak to the low retention rates of African American students in community colleges.

The literature does demonstrate that the workforce adequacy of dental hygienists needs to be a large part of the solution to profound oral health disparities within the population. In order to serve the oral health needs of diverse segments of the population, dental hygiene higher education programs must increase the diversity of students wishing to be integral members of the dental health care workforce.[13,15,18] African Americans in particular have been deprived of educational access to dental hygiene programs, and these barriers may mirror the barriers to accessing personal dental care.

Much data exists that addresses the educational access and achievement gaps affecting minority students' participation in higher education. These include insufficient high school preparation, (including insufficient alignment between K-12), persistent financial barriers, narrow admissions practices, and lack of information about college opportunities.[19] Family income and the quality of high school education are the major factors in access and success in college, 2 factors that are lacking in the lives of many African American students.[17] Although all of these barriers likely affect African American enrollment in dental hygiene programs, other factors may contribute, such as student lack of information about dental hygiene college opportunities, lack of access to care for African Americans, and the related geographic distribution of dental hygienists in the United States.

Confusion about what a dental hygienist is and does may also be a barrier to choosing dental hygiene as a career, just as it is in nursing.[14] Public perception of dental hygiene may include misunderstanding about dental hygiene practice, role stereotypes, gender biases, and lack of mentors. Related to this, the Rand Health group funded a working paper, (nonpeer reviewed), for the U.S. Agency for Healthcare Research and Quality (AHRQ) designed to develop instruments that could rate consumers' dental care experiences.[20] Designed as a set of cognitive interviews, the authors explored the terms individuals use to describe and name dental care providers. Although this was a very small study, most participants identified the "person who cleans the child's teeth as a dentist, a dental assistant, or a nurse; only one participant mentioned the term 'dental hygienist.'" Previous focus groups indicated that the term dental hygienist is not universally used or understood.[18]

Public confusion about the profession of dental hygiene, especially among minority groups, may relate to access to dental care. If students do not have access to care, they may never interface with a dental hygienist, and may not be familiar with the preventive services that dental hygienists provide. Yu et al looked at factors associated with use of dental services among U.S. adolescents and found that lack of an annual dental

visit was associated with male gender; black, Hispanic, or mixed race; and lack of insurance.[21]

Barriers to dental care include lack of finances, but even when financial help does exist, many eligible minorities may not know how to navigate the system. For example, in some states, 80% of children who are eligible for dental benefits under the Medicaid program do not receive them.[22] In all, only 27% of African Americans used the oral health care system in 1996, whereas, 47% of whites visited a dentist.[1] Furthermore, when considering *preventive* care, the percent of low-income African American children and adolescents who received care in 1996 drops to 13%, compared to 25% for white children.[1] That same year, only 4% of hygienists were African American, whereas 87% were white.[23] These preventive visits are the only time low-income children might experience treatment from a dental hygienist.

The purpose of this study was to answer the following questions:

1. What are some of the reasons that African Americans are underrepresented in the profession of dental hygiene?
2. What is the relationship between the percentage of hygienists and the percentage of African Americans by state?
3. How does the Dental Hygiene Professional Practice Index (DHPPI) relate to African American demographics by state?

Methodology

The data sources used for determining African American and dental hygiene educational statistics for this study include the American Council on Education (ACE), the National Center for Educational Statistics (NCES), the American Dental Education Association (ADEA), the U.S. Bureau of Labor statistics, and the Community College Survey of Student Engagement (CCSSE). Statistics regarding African American access to dental care were derived from oral health databases: U.S. Department of Health and Human Services *Healthy People 2010* and the National Center for Health Statistics. Information on dental hygiene demographics was found in ADEA databases, the Health and Human Resources Administration, and the Bureau of Health Professions. In addition, the 2000 U.S. Census Report was accessed to gather data relative to African American population statistics. Secondary data sets were cross-referenced to produce a descriptive analysis of density of dental hygienists relative to density of African Americans by state. Also calculated were percentages of African Americans relative to the dental hygiene professional practice environment using the DHPPI.[24]

Results

I. Demographic Trends of African American Dental Hygienists

To ensure diversity, the proportion of minorities in the health professions should reflect the percentage of minorities in the general population. Figure 1 shows select population trends as derived from the U.S. Census.[6] These data show that the Hispanic population will grow to 15.5% by 2020, and 24.5% by 2050. The Caucasian population will decrease to approximately 61% by 2020, and to 50.1% by 2050. The African American population is slowly increasing and will be about 13.5% by 2020, and 14.6% by 2050.

Although African Americans made up 12.1% of the population in the U.S in 2003, they represented only 4% of dental hygienists (Table 1). This is contrasted with Caucasians who represented 74.6% of the population, but made up 85% of hygienists.[1] Although graduation rates of African American dental hygienists are higher than the current population of African American dental hygienists, the graduation rate increased only 2% in 8 years (Table 2).

As seen in Table 2, dental hygiene graduation rates for African Americans improved only slightly in the 8 years from 1996 to 2003, from 7% of new dental hygiene graduates to 9%.[5] As opposed to some publications, these results reflect African Americans separately from other minority groups, providing a realistic rate of graduation.

By looking at dental hygiene employment projection data from the U.S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review,[25] we can determine what future workforce needs might be. (Table 3). The Monthly Labor Review projects a total need for the dental hygiene workforce to increase from 158,000 in 2004 to 226,000 in 2014, or about a 43% increase. If the African American population increases to about 13.2% of the population,

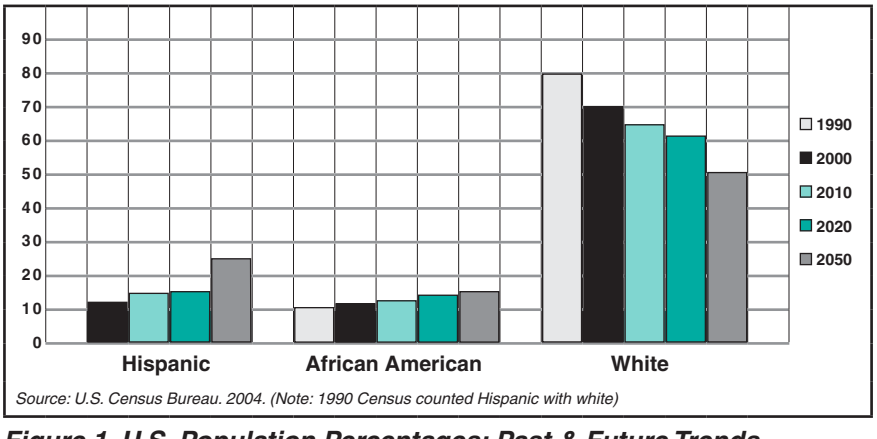

Figure 1. U.S. Population Percentages: Past & Future Trends

Table 2. Dental Hygiene Graduate Rates by Race[5]

	1996	2000	2002	2003
African American	7%	8%	9%	9%
White	67%	69%	64%	63%
Other	26%	23%	27%	28%

then the representative number of African American dental hygienists will need to be 29,832 (13.2% of 226,000). In 2004, there were only 6,320 African American dental hygienists, which suggests that we will need 23,500 more African Americans to enter dental hygiene by 2014 to ensure equitable representation.

II. Density of Dental Hygienists by State Relative to African American Population

Another variable that may influence access to dental hygiene care for African Americans is the density of practicing dental hygienists relative to the African American population (Figure 2). Data from the Health Resources and Services Administration Bureau of Health Professions summarizes the number of dental hygienists per 100,000 of the population for each state.[21] This data was linked with data from the U.S. Census Bureau (2000) that details the percent of blacks or African Americans per state, and the District of Columbia. Results indicate that states with some of the *highest* proportions of dental hygienists have the *lowest* percentages of African Americans. Four of the top 5 states with the highest density of dental hygienists are in the 10 states with the lowest proportion of African Americans. (Vermont, New Hampshire, North Dakota, and Oregon) (Figure 2). Conversely, the 2 states and 1 district that have the highest percentage of African Americans, also have the *lowest* proportions of dental hygienists. Of the 10 states (and DC) with the lowest density of dental hygienists, 3 have the highest proportion of African Americans (Mississippi, Louisiana, District of Columbia (Figure 3). In the 10 states with the lowest proportion of African Americans, the average number of dental hygienists per 100,000 residents is 73.3. In the 10 states with the highest proportion of African Americans, the average density of dental hygienists is 47.67.

Table 3. U.S. Dental Hygiene Employment: Current and Projected

Dental Hygienists	Current[1] 2004	Needed[2] 2014
African American	6,320 (4%)	29,832 (13.2%)
White	134,000 (85%)	142,380 (63%)
Other, Asian & Hispanic	27,680 (11%)	53,788 (24%)
Totals	158,000[1]	226,000[3]

1. *Bureau of Health Professions, 2006*
2. *Author's estimated projections based on Monthly Labor Review total projections*
3. *Total projection, Monthly Labor Review, Nov. 2005*

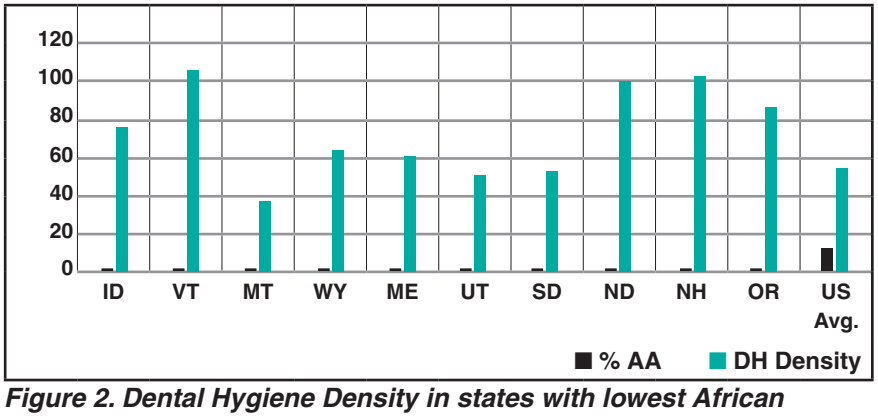

Figure 2. Dental Hygiene Density in states with lowest African American population

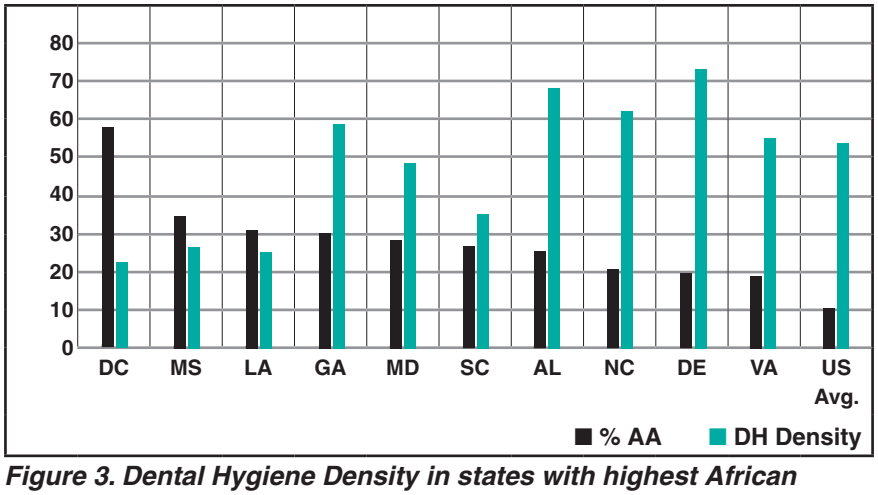

Figure 3. Dental Hygiene Density in states with highest African American population

III. African American Demographics by State: Relationship to the DHPPI

The third purpose of this paper was to evaluate how the professional practice environment of dental hygienists relates to African American demographics by state. The DHPPI is an index that was funded by the Bureau of Health Professions of the Health Resources and Services Administration to document the professional practice environment for the profession in each of the 50 states and the District of Columbia.[24] The index looks at 4 factors that impact the practice environment for dental hygienists: regulatory environment, dental supervision requirements, tasks and services permitted, and the reimbursement environment. These 4 factors are then evaluated and a rating (1-100) is assigned for each state based on the following categories: excellent (80-97), favorable (60-80), satisfactory (40-60), limiting (30-40), or restrictive (10-30). Cross-referencing these ratings with the percentage of African Americans by states found that 14 of the 17 states that have a higher than average African American population (12% or greater) fall into the most restrictive or limiting categories for dental hygiene practice, 2 fall into the satisfactory category, 1 is in the favorable category, and none are in the excellent category. The 10 states with the highest proportion of African Americans had an average DHPPI score of 28.5%, which falls in the lowest "restrictive" practice environment category (Figure 4). This is contrasted with the 10 states having the lowest percentage of African Americans, none of which fall into the restrictive category, and which had an average DHPPI score of 46.9%, which falls in the favorable category (Figure 5). Thirteen of the 17 states that have a higher-than-average African American population (12.1% or greater) fall into the most restrictive or limiting categories for dental hygiene practice, 2 fall into the satisfactory category, 1 is in the favorable category, and none are in the excellent category.

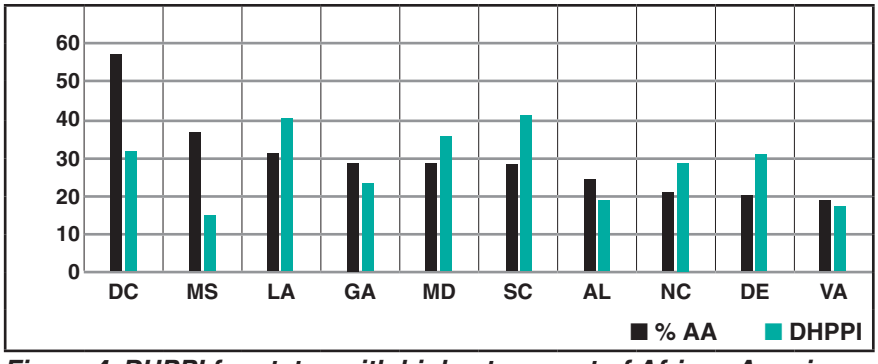

Figure 4. DHPPI for states with highest percent of African Americans

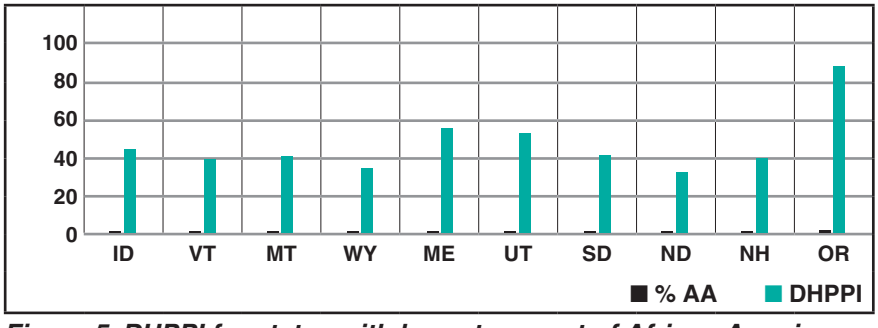

Figure 5. DHPPI for states with lowest percent of African Americans

Discussion

The problem of African Americans missing in dental hygiene has been persistent over time. Although African Americans are not proportionally represented in any of the health professions, they are less represented in dental hygiene than in medicine, nursing, or dentistry, making up only 4% of dental hygienists.[5] Despite the fact that African Americans make up 12.1% of the U.S. population,[6] they continue to be missing in the health care workforce because they are underrepresented in higher education health professions programs. Although African American dental hygiene graduation rates improved to 9% in 2003, these rates are still not keeping up proportionally with projected increases in population. Some authors include African Americans with all minority groups in analyses of minority representation, but combining them together can give the false impression that educational access for African Americans in the dental hygiene profession is improving when in reality it is flat. Based on this data, African Americans will continue to be proportionately underrepresented in dental hygiene.

In looking at DHPPI data, it becomes obvious that the density of dental hygienists in states with more progressive practice environments is high. By linking this data with African American state demographics, we can demonstrate a restrictive practice environment for dental hygienists in states that have a high percentage of African Americans. In other words, African Americans are living in states with the most restrictive environments for the practice of dental hygiene, and this could be viewed as another barrier to access to dental care for this population. The point of linking this data is to demonstrate that the availability of dental hygienists could be

one factor related to access to dental hygiene care for African Americans. Why do areas with the most African Americans have the fewest hygienists in the country? Does this relate to the overall lack of African American dental hygienists? Why are there more hygienists per capita in precisely the states that have the fewest African Americans?

The *Surgeon General's Report* emphasized the importance of oral health to overall health and challenged the dental professions to create solutions to the devastating effects of poor oral health. When considering the African American population, the connections studied between oral diseases and systemic diseases make these solutions even more compelling. Many of these are diseases that are also disproportionately borne by African Americans.[1]

Although dental hygiene was not specifically mentioned in the Sullivan Commission report, this data supports the Commission's findings that without dramatic change, "health professions training will remain entrenched in the status quo and become increasingly out of touch with the demographic realities and health needs of the nation…."[4] Much more needs to be done to improve the total numbers of dental hygienists graduating by 2014 and beyond, as well as increasing the proportion of African American graduates.

When looking at the dearth of African Americans in dental hygiene, one factor to consider is the lack of access to dental care for minorities. If high school students as dental care consumers lack exposure to dental hygienists, such students probably do not have enough information to consider dental hygiene as a possible career. The nursing literature identifies "confusion and misunderstanding about nursing practice" as a barrier to pursuing nursing.[14] This problem may be even more compelling for dental hygiene, since high school students may have more exposure to nurses in schools and emergency rooms than they do to dental hygienists in a clinic setting.

Several programming ideas are being tested that could work in dental hygiene education to increase the student pipeline. For example, the Achieving Diversity in Dentistry and Medicine (AADM) Project[26] has obtained federal funds from HRSA to implement *Kids into Health Careers*.[27] This program has several purposes, including how to inform students and parents about careers in the health professions, create optimism about accessibility of health careers, increase awareness about the need for minorities in the health professions, and increase the applicant pool for health professions training. Based on increased future needs projections for dental hygienists, it remains to be seen if the gap between current numbers and future needs can be narrowed.

The American Dental Education Association also has a website designed to address workforce shortages in the health professions with the mission of solving the problem of under-representation of minorities in the workforce.[28] It is targeted specifically for students to access current information about a variety of health professions including dental hygiene. These are comprehensive websites, but no data could be found to determine whether students in educationally disadvantaged schools have access to such sites.

Strategies to enhance diversity in health professions education has mostly been targeted to medicine, dentistry and nursing. However, ADEA has a policy document detailing 19 different strategies for enhancing diversity, and some are applicable to dental hygiene.[11] For example, recruiting minority faculty, collaborating with other organizations with similar goals, summer education programs and participating in minority career fairs would all be strategies that would help educate African American minority students about the career of dental hygiene. At the same time, the repetitive cycle of no access to dental care and lack of knowledge about dental hygiene careers must be broken if we are to improve access to care for all minority citizens.

Conclusion and Future Research

The lack of African Americans in dental hygiene, the lack of dental hygienists in states with high numbers of African Americans, and the restrictive nature of dental hygiene practice in states with high African American populations are all factors that may contribute to the epidemic of oral disease in this country, which is disproportionately borne by minorities. Strategies to improve the density of dental hygienists and the professional practice environment of dental hygienists (as defined by the DHPPI), in states with high numbers of African Americans need to be studied. Future research may uncover more reasons why the DHPPI is so poor in states with the highest African American populations. The inverse relationship between the African American population and the density of dental hygienists needs to be explored further to determine the reasons why this startling statistic exists. Future research needs include an analysis of how to improve access to dental hygiene education for African Americans, which may help alleviate the epidemic of oral disease borne by African Americans.

Acknowledgement

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Stannous Fluoride Dentifrice with Sodium Hexametaphosphate:

Review of Laboratory, Clinical and Practice-Based Data

Cynthia Sensabaugh, RDH, BS; and Mary Elizabeth Sagel, BS, MA

Abstract

Dentifrice was originally used to promote oral hygiene by cleaning teeth. However, with advances in product formulation, it has become a valuable vehicle for the delivery of agents offering health and cosmetic benefits. Stannous fluoride, introduced in 1955 in dentifrice, is one of the longest established of such agents. The well-known anti-caries efficacy of stannous fluoride is based on its impact on the tooth surfaces and on its antibacterial activity. More recently, the demand for tooth whitening products has increased, and sodium hexametaphosphate has been shown to be helpful in whitening surface stains and in controlling calculus. A dentifrice formulation that combines the benefits of stannous fluoride with those of sodium hexametaphosphate is now available. A review of the evidence shows that in addition to effective anti-caries action, this formulation is effective in fighting plaque, gingivitis, and gingival bleeding while inhibiting calculus and extrinsic stain. A practice-based evaluation including data from over 1,200 dental professionals and 1,000 patients demonstrates the product's benefits and excellent acceptability. Collectively, the research shows this stannous fluoride/sodium hexametaphosphate dentifrice provides multiple benefits to meet the oral health and cosmetic needs of patients.

Key Words: stannous fluoride, dentifrice, gingivitis, caries, sensitivity, calculus

Introduction

Patients today represent one of the most heterogeneous groups in history in terms of age, health status, oral hygiene habits, and other factors. While certain oral health conditions are more prevalent among specific patient groups, such as periodontal disease among diabetic patients,[1] many oral health conditions affect the broad population. According to U.S. surveys, virtually all adult patients have had dental caries, more than half experience gingivitis, and roughly one in three suffers from dental sensitivity.[2-4] Fortunately, home care products are available to help prevent and treat many common oral health conditions in conjunction with routine professional care.

Dentifrice is one important example. Many years ago, the benefits of dentifrice were limited to cleaning and the prevention of tooth decay. It was common for professionals to tell patients to "use any dentifrice with fluoride and the ADA Seal." However, formulators today can design dentifrices to provide numerous other benefits, both for health and cosmetic purposes. In 2005, a stannous fluoride sodium hexametaphosphate (SFSH) formula* was introduced offering protection against a broad range of health and cosmetic conditions commonly experienced by patients.[5] The present report reviews the laboratory, clinical and practice-based assessments evaluating the efficacy of this dentifrice formulation.

*Crest Pro-Health, Procter & Gamble, Cincinnati, OH, USA.

Stabilized Stannous Fluoride/ Sodium Hexametaphosphate Formulation

The SFSH formula combines the therapeutic benefits of 0.454% stabilized stannous fluoride with the calculus and stain-control characteristics of sodium hexametaphosphate in a low-water formulation dentifrice. Stannous fluoride, which unlike sodium fluoride can be used in combination with calcium-based abrasives, has been incorporated in dentifrices since the 1950s to provide protection against caries, pathogenic bacteria, gingivitis, hypersensitivity, and the development of plaque. There is considerable evidence for its efficacy as a therapeutic agent with a wide spectrum of beneficial properties.[6-12] However, its clinical usage was limited because of as-

tringent taste, and in some patients, its use resulted in extrinsic staining of the teeth. Stannous fluoride was also somewhat unstable in aqueous solution. The latter problem was resolved with the introduction of stabilized stannous fluoride in the 1990s, which rendered more available stannous fluoride and resulted in a renewed interest in the wide range of benefits offered by stannous fluoride in dentifrices.[6]

Sodium hexametaphosphate was first introduced in a dentifrice in 2000.[13] It is a chemical whitening agent in the same class as pyrophosphate, which has long been used to inhibit calculus, but the molecule is about 10 times longer than that of pyrophosphate. Sodium hexametaphosphate therefore provides better coverage and retention on the tooth surface, thus increasing its ability to inhibit both calculus and stain formation on the enamel surface.[14] Stability of the dentifrice can be an issue with the inclusion of polyphosphates if ingredients are not properly balanced. Like other polyphosphates, sodium hexametaphosphate does not usually show good long-term stability in aqueous dentifrices. However the novel single-phase SFSH formula, which uses a low-water system in a silica-based formulation, significantly reduces the hydrolysis of sodium hexametaphosphate and helps to maintain effective levels of whitening activity.[5]

The resulting dentifrice has improved esthetic qualities over the original stannous fluoride formulation and delivers a broad range of therapeutic and cosmetic benefits (Figure 1). The remainder of this paper provides a summary review of research on stannous fluoride, sodium hexametaphosphate and, especially, the unique SFSH formulation.

Antibacterial and Anti-Inflammatory Action

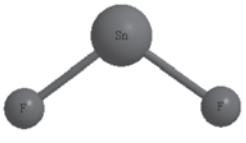
Most of the oral health benefits of stannous fluoride result from its antibacterial efficacy, particularly against bacteria associated with dental caries, periodontal disease, and oral malodor. Laboratory and clinical studies have shown that stannous fluoride, unlike other fluorides, inhibits bacterial growth by a variety of mechanisms, including interference with metabolic pathways, thus reducing bacterial acid formation, and inhibition of bacterial cohesion and adhesion.[15-17] The Plaque Glycolysis and Regrowth Model (PGRM) is an in situ method that allows evaluation of a formulation's biological activity based on its effects on plaque metabolism. Using a PGRM, White et al found a statistically significant reduction in acidogenicity associated with the use of stannous fluoride dentifrice versus a standard sodium fluoride control dentifrice.[18,19] Using the same methodology, Liang et al found that a stannous fluoride dentifrice, as compared to a control placebo, greatly reduced the amount of plaque acid and also inhibited plaque regrowth.[20]

Comparable results have been obtained in studies of the antibacterial action of this SFSH formula. Ramji et al carried out a series of in vitro and in vivo studies of this new formulation.[21] In a Live/Dead assay[21] they found that the new SFSH dentifrice had killed over 90% of the salivary bacteria 16 hours after a single exposure, thus showing strong and lasting antibacterial activity (Figure 2).

In a second study, using PGRM, the SFSH dentifrice produced statistically significant reductions in plaque acid production and plaque regrowth at 15 and 45 minutes after brushing versus a standard sodium fluoride control dentifrice.[21] Other research demonstrated the presence of soluble tin, which serves as a marker for the active stannous fluoride, at levels above the minimum concentration required for the inhibition of salivary bacterial activity.[21]

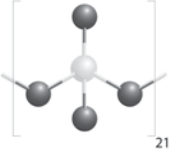
Another related value of stannous fluoride is its effect on inflammatory markers, independent of its action on bacteria. In vivo, antibacterial activity also helps reduce inflammation since the inflammatory response should diminish with reduced levels of pathogenic bacteria. A study was conducted with 16 healthy subjects to measure inhibition of several host and bacterial pro-inflammatory enzymes by stannous fluoride.[22] Following a one-week period of using a standard sodium fluoride paste and manual brush, a baseline supragingival plaque sample was collected

Stannous fluoride



- Provides antibacterial activity against species associated with plaque, gingivitis, cavities and malodor
- Reduces plaque
- Reduces gingival inflammation and bleeding
- Protects against hypersensitivity
- Remineralizes enamel and protects against demineralization

Sodium hexametaphosphate



- Inhibits calculus formation
- Protects against new stain formation
- Removes extrinsic stain

Figure 1. Benefits of stannous fluoride and sodium hexametaphosphate

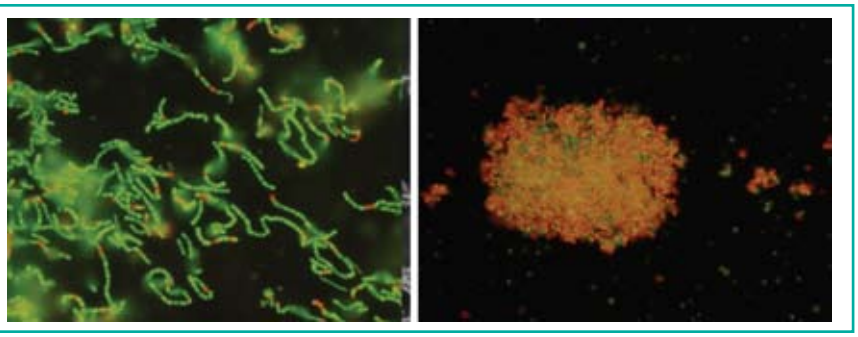


Figure 2. Bactericidal activity assessment 16 hours after exposure. Left; water control. Right; stannous fluoride/sodium hexametaphosphate dentifrice. Green-stained cells are live microbial cells; red-stained cells are dead cells (from Ramji et al [21]).

from subjects. Subjects then rinsed with a slurry of stannous fluoride/sodium hexametaphosphate dentifrice; plaque samples were taken immediately post-rinsing and 12 hours later. An analysis of the samples showed that stannous fluoride inhibited several pro-inflammatory enzymes, including mammalian matrix metalloproteinase subtypes and bacterial gingipain. These enzymes can break down proteins (e.g., collagen) and are involved in processes such as pocket formation. At the 12-hour analysis, enough stannous fluoride was retained to inhibit about 40% of most enzymes measured.

These studies demonstrate the sustained antibacterial and anti-inflammatory effects of this SFSH dentifrice, supporting its antiplaque and antigingivitis efficacy.

Antiplaque and Antigingivitis Efficacy

Many studies have investigated the effects of stannous fluoride on gingivitis and plaque. These evaluations have involved a wide range of trial durations, subject populations and modes of application (Table 1).[23-34] The majority of these trials report significant reductions in plaque and gingivitis, supporting the agent's ability to improve gingival health when used twice daily.

In addition, long-term research has been conducted to evaluate stannous fluoride among special populations.[35] A 2-year study investigated the periodontitis prevention efficacy of a dual-phase stabilized 0.454% SFSH dentifrice compared to a positive control (sodium fluoride/triclosan dentifrice) in a population of

Table 1. Long-term clinical trials examining the effect of stabilized stannous fluoride on reduction of plaque, gingivitis and gingival bleeding.

Reference	No. of Subjects	% SnF_2	Mode of Delivery	Treatment Frequency	Length of Trial	Plaque Reduction	% Reduction Gingivitis : Bleeding
Archila et al[31]	186 adults	0.45	Dentifrice	Twice daily	6 months	ND	25.8%** : 27.4%**
Archila et al[32]	38 adults resistant to NaF treatment	0.45	Dentifrice	Twice daily	12 weeks	ND	54%** : 55%**
Boyd et al[28]	23 adolescent orthodontic	0.4	Brush-on gel	Twice daily	18 months	50% **	55%** : 50%**
Beiswanger et al[9]	140 adults	0.45	Dentifrice	Twice daily	6 months	3% ns	19%* : 31% ns
Ciancio et al[27]	28 adults	0.1	Mouth rinse	Twice daily	3 weeks	28% **	ND
Chitke et al[26]	26 handicapped children	0.2	Spray	Twice daily	3 weeks	48% *	52%* : ND
Mallatt et al[30]	128 adults	0.45	Dentifrice	Twice daily	6 months	8%**	17%** : 41%**
Mankodi et al[23]	104 adults	0.45	Dentifrice	Twice daily	6 months	20%**	21%** : ND
Mankodi et al[24]	130 adults	0.45	Dentifrice	Twice daily	6 months	7% **	22%** : 57%**
Perlich et al[29]	154 adults	0.45	Dentifrice	Twice daily	6 months	3% ns	21%* : 33%*
Tinanoff et al[25]	31 adults, partial denture	0.4	Brush-on	Twice daily	6 months	55% *[1]	48%* : 69%*
Williams et al[10]	112 adults	0.45	Dentifrice	Twice daily	6 months	23% **	22%** : ND

All reductions are versus control except for Archila[32] and Chitke[26] which were relative to baseline values.
[1]Significant difference for abutment teeth.
* $p \leq 0.05$ ** $p \leq 0.01$ ND-no data ns-non significant

over 330 subjects with medication-induced xerostomia. The study also evaluated the product's ability to remineralize root caries lesions. Results showed that twice daily use of stannous fluoride/sodium hexametaphosphate dentifrice demonstrated comparable benefits to the positive control, which was a sodium fluoride/triclosan dentifrice, in reducing periodontal pocket depth, attachment loss and bleeding on probing as well as remineralizing root caries.[35]

Recent studies have evaluated the antigingivitis efficacy of SFSH dentifrice.[24,30-32] One such six-month trial found statistically significant reductions of 22% in gingivitis, 57% less bleeding and 7% less plaque relative to a negative control.[24] In a second 6-month trial with 128 subjects, Mallatt et al found a 17% reduction in gingivitis ($p \leq 0.001$), a 41% reduction in gingival bleeding ($p \leq 0.001$) and an 8% reduction in plaque ($p \leq 0.001$) with the SFSH dentifrice versus a negative control dentifrice.[30] The SFSH dentifrice also demonstrated significant reductions in gingivitis (26%) and gingival bleeding (27%) relative to a triclosan/copolymer control.[31] In a follow-up to this study, Archila et al chose subjects who had used the triclosan/copolymer dentifrice twice a day but who had proved unresponsive to it, and still had high bleeding scores at the end of the six-month study period.[32] After three months' use of the stannous fluoride/sodium hexametaphosphate dentifrice both gingivitis and bleeding had decreased significantly, by 54% and 55% respectively. These results showed that, even for those who have persistent problems with gingival disease, the SFSH dentifrice can offer significant health benefits when compared to other dentifrices.

In a three-phase study involving use of digital plaque imaging analysis (Figure 3), White et al investigated the longer-term efficacy of the SFSH formula in the control of plaque.[36] In Phase 1, subjects brushed twice daily using a standard sodium fluoride dentifrice; in Phase 2, brushing frequency was reduced to once a day using the same dentifrice; in Phase 3, the daily brushing regimen was continued using the antimicrobial stannous fluoride/sodium hexametaphosphate dentifrice. Morning plaque coverage was 13% during Phase 1, increased to 18% in Phase 2, but decreased significantly in Phase 3, showing a 17% reduction as compared with the sodium fluoride dentifrice control. This supports the sustained antibacterial effects reported by Ramji et al.[21]

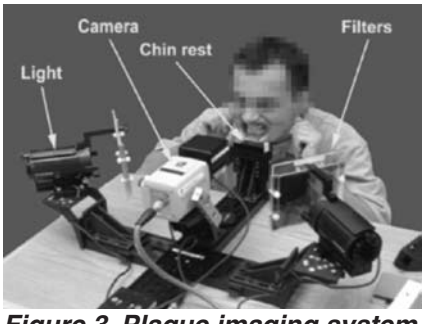


Figure 3. Plaque imaging system

Results of multiple independent clinical trials using the SFSH dentifrice mirror those investigating earlier stannous fluoride dentifrices; the recent formulation also shows benefits in the control of gingival disease where it is significantly more efficacious than sodium fluoride based dentifrices.

Dentinal Hypersensitivity

Reports indicate that dentinal hypersensitivity affects more than 40 million people in the U.S. annually,[37] or up to 30% of adults at some time during their lifetime.[38] Hypersensitivity is characterized by a short, sharp pain arising from exposed dentin in response to a stimulus that cannot be ascribed to any other form of dental defect or pathology;[39] it arises from exposure of the dentinal tubuli to the stimulus. Unlike potassium nitrate, which alleviates sensitivity by acting on the nerve synapse, stannous fluoride reacts with enamel or dentin surfaces to produce solid complexes or insoluble precipitates that wholly or partially occlude the tubuli, as has been shown by means of scanning electron microscopy (Figure 4).[40]

This action is thought to produce the clinical efficacy of stannous fluoride in the prevention and control of dentinal hypersensitivity.[41-44] Schiff and his collaborators carried out two studies to assess the efficacy of the SFSH formula in reducing hypersensitivity on a sample population of 77.[45,46] The first used an eight-week randomized trial to compare the effects on dentinal sensitivity of twice-daily brushing with the stannous fluoride/sodium hexametaphosphate dentifrice and with a sodium fluoride-based, negative control dentifrice.[45] Outcomes were assessed at 4 and 8 weeks with tests of tactile sensitivity (Yeaple Probe Index) and thermal sensitivity (Schiff Air Index). On all assessments, the SFSH dentifrice produced a significant decrease in sensitivity ($p \leq 0.0001$) as compared

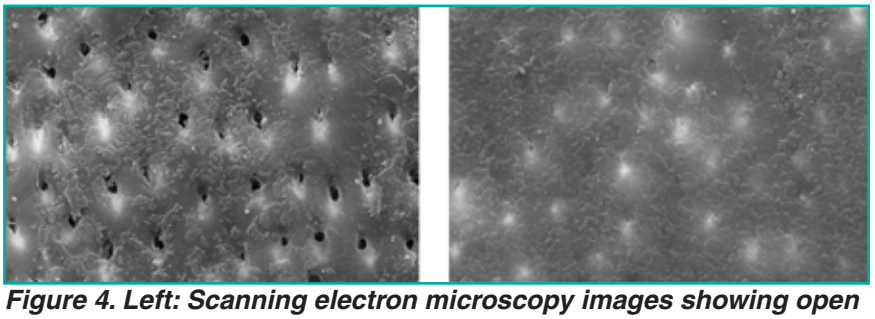


Figure 4. Left: Scanning electron microscopy images showing open tubuli after treatment with a sodium fluoride toothpaste (left) and closed tubuli after treatment with a SFSH dentifrice (right). From Baig and He.[5]

to the control dentifrice. In the second study, which used essentially the same procedures, results were similar, with the stannous fluoride/sodium hexametaphosphate group (n=45) producing significant reduction in sensitivity compared to the control (n=45) (Figure 5).[46] At 8 weeks, the SFSH showed improvements of 71% and 44% versus the negative control for tactile and thermal measurements, respectively.

These studies support that the SFSH dentifrice shares the antisensitivity characteristics of previous stannous fluoride formulations.

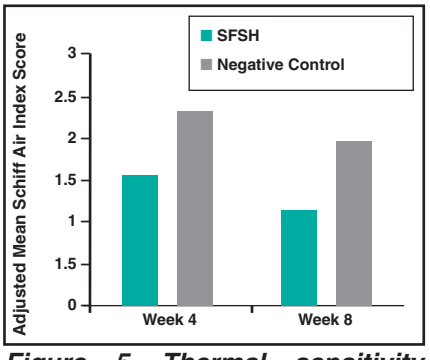


Figure 5. Thermal sensitivity scores for the SFSH dentifrice and negative control (lower scores indicate less sensitivity)[46]

Anticaries Effects

The anticaries effects of stannous fluoride have been recognized for over 50 years, and in the 1960s, the stannous fluoride-containing dentifrice, Crest® with Fluoristan™, received a Seal of Acceptance by the ADA's Council on Dental Therapeutics. Fluoride, in various forms, is well recognized for its ability to foster remineralization of partially demineralized tooth enamel using the calcium and phosphate present in saliva. In addition to these remineralization effects, stannous fluoride has been shown to react with enamel to form a tin fluorophosphate complex that coats and protects the surface of the enamel.[48,49] The antibacterial activity of stannous fluoride, which was discussed above, provides further protection by suppression of bacteria, particularly *Streptococcus mutans*, which is one of the primary pathogens associated with dental caries.[50,51] The anticaries benefits of stannous fluoride are therefore due to both physical chemistry and its bacteriological effects.

Before the introduction of this SFSH dentifrice, a large number of clinical trials had been carried out that demonstrated the efficacy of stannous fluoride in the control of dental caries.[52] More recently, Stookey et al carried out a large-scale clinical trial with 955 subjects comparing the anticaries efficacy of a dual-phase early prototype SFSH dentifrice with a positive control standard sodium fluoride dentifrice, and also a high-dose (2800 ppm F) and a low-dose (500 ppm F) sodium fluoride formulation.[53] Visual-tactile examination was supplemented with a radiographic examination at baseline, after 12 months, and at the end of the trial at 24 months. Both examiners found that there was significantly less caries in the SFSH (17% and 25%) and high-dose (2800 ppm) sodium fluoride groups (13% and 23%) than in the positive control group treated with 1100 ppm fluoride. In an in situ study of mineralization-demineralization, Wefel et al reported that a dual-phase stannous fluoride/sodium hexametaphosphate dentifrice produced anticaries activity that was as good as that of positive controls and concluded that the addition of sodium hexametaphosphate does not interfere with the normal activity of stannous fluoride.[54]

A series of in vitro studies evaluating the anticaries potential of the SFSH formulation have been reported in one publication by Pfarrer and colleagues.[55] In a study of fluoride uptake into demineralized enamel, it exhibited uptake comparable to a clinically proven stannous fluoride and silica dentifrice.[55] In a second lesion progression pH-cycling experiment, the stannous fluoride/sodium hexametaphosphate dentifrice provided almost complete protection against lesion initiation and progression; it was comparable to conventional clinically proven dentifrices.[55]

These studies indicate that this SFSH dentifrice is as effective as clinically proven fluoride dentifrices both in its mode of action and in its clinical effects.

Anticalculus Effects

Dental calculus results from the mineralization of bacterial plaque formed on the surfaces of teeth. Agents that inhibit crystal growth, particularly condensed phosphates, have been found to be very useful in the prevention of calculus development. In this class of phosphates, sodium hexametaphosphate has been shown to be particularly effective. In vitro studies by White et al have shown significant reductions in hydroxyapatite crystal growth and mineralization of plaque in the presence of sodium hexametaphosphate either in aqueous solution or in a dentifrice.[56] The effects were significantly greater than for a conventional anti-tartar dentifrice containing pyrophosphate. This finding has been supported by four 6-month clinical trials in which sodium hexametaphosphate produced significant reductions in calculus formation – when combined with sodium fluoride or stannous fluoride – as compared to a regular sodium fluoride dentifrice or a triclosan/copolymer dentifrice.[57-60] A total of 866 subjects participated in the four 6-month clinical trials. Efficacy was assessed using a standard clinical method (Volpe-Manhold Index) that measures supragingival calculus coverage on the lingual surfaces of the 6 anterior teeth. In the 2 studies evaluating SFSH formulations, calculus reductions of 55% and 56% were seen versus the respective controls at 6 months.[59,60]

Whitening Effects

There is an increasing demand for tooth whitening products and also for oral care products that sustain whitening effects. Peroxide is a successful bleaching agent when delivered via whitening strips or in tray-based systems, but it is not particularly effective in dentifrices because of the brief contact time with the tooth surface.[61] Pyrophosphates, on the other hand, help maintain whitening and control staining because they have a strong affinity for the minerals in teeth. Sodium hexametaphosphate has been shown to have important effects on the chemical mechanisms of chromogen adsorption and desorption.[62-63] It appears that the polymer chains interact with pellicle films to lift stain material out of the pellicle and to prevent the adsorption of new chromogens. Gerlach et al reported a 29% reduction in composite stain relative to a negative control following 6 weeks' use of a sodium fluoride dentifrice containing 7% sodium hexametaphosphate.[64] Clinical studies providing evidence for the efficacy of sodium hexametaphosphate in the control of extrinsic staining have been reviewed by Baig et al.[65]

A number of recent clinical trials have assessed the extrinsic stain removal efficacy of the SFSH dentifrice. In their 6-month study of anticalculus effects, Schiff et al[59] also assessed extrinsic stain, using the Lobene Stain Index on the facial surfaces of the 12 anterior teeth; at neither 3 nor 6 months did subjects in the SFSH group show signs of developing any such stain. Four recent clinical trials, which were summarized in 2 publications, have used similar methodologies to compare the extrinsic stain removal efficacy of the SFSH dentifrice with that of a positive control whitening dentifrice.[66,67] All 4 were randomized, double-blind studies in which efficacy was measured using a modified Lobene Stain Index. Two studies assessed whitening at baseline and 2 weeks;[67] the other 2 studies measured stain at baseline, 3 and 6 weeks.[66] In all cases, there was highly significant stain removal in the experimental groups and also in the positive control groups. There were no significant differences in the effects of the SFSH and positive control dentifrices.

In reviewing these data, it appears that combining sodium hexametaphosphate with stannous fluoride in the SFSH formulation removes and inhibits extrinsic stain formation and that the SFSH dentifrice is as effective as positive control whitening dentifrices.

Practice-Based Evaluation

The efficacy and safety of dentifrice with stannous fluoride or a combination of stannous fluoride and sodium hexametaphosphate is supported by an extensive body of evidence. However, its success ultimately depends on its acceptability to users as part of their personal home oral hygiene routine. In order to assess the acceptability of the SFSH dentifrice, a practice-based assessment was undertaken involving dental professionals and their patients.[68] Dentists and hygienists across the USA participated in the study, and samples of the SFSH formulation were offered to participating professionals to provide a supply to a small group of their patients for 3-4 months use, until their next visit. Patients' oral health was assessed at the beginning and end of the trial by the dental professional using a questionnaire (not clinical indices). Conditions assessed included gingivitis, gingival bleeding, inflammation, calculus, extrinsic staining, and sensitivity. Professionals submitted a survey report, and patients completed a questionnaire at the end of the study.

In total, 1267 completed surveys were returned by dentists and dental hygienists. Approximately 75% of the evaluations were based on 3-4 months' use and the remainder of subjects had used the product for up to 6 months. Responses analyzed were those in which dentists or hygienists provided both pretrial and post-trial oral health assessments and gave answers to questions. Sixty-eight percent of all these responses reported improvement in their patients' oral health, including improvements in gingival bleeding and inflammation and reduction in calculus formation. Reductions in sensitivity were reported by 61% of professionals and in staining by 57%. Eighty percent reported they would recommend the SFSH dentifrice; this rose to 91% among those professionals who observed improvements.

A total of 1078 questionnaires were returned by patients. Of these, 88% reported positive assessments of the SFSH dentifrice (Excellent/Very Good/Good) and two thirds of all patients stated that they intended to continue to use the product; this percentage rose to 77% when patients reported noticeable improvements in their oral health. In terms of rating specific effects, roughly 9 out of 10 patients rated the product positively for "keeping mouth healthy," "cleaning teeth thoroughly," being a "comprehensive toothpaste," "making gums healthier," and "freshening breath" (Figure 6). Eighty-three percent rated it positively for reducing surface stains and 77% for reducing gingival bleeding.[68]

It is important to differentiate practice-based evaluations from randomized, controlled clinical studies. For example, clinical trials typically involve calibrated examiners who use standardized indices to assess the status of a specific disease or condition. Often the examiner and subject are blind to treatment. In this practice-based assessment, practicing professionals and their patients assessed oral conditions using a questionnaire. Calibration was not done across offices, and the product identity was known. This type of evaluation is

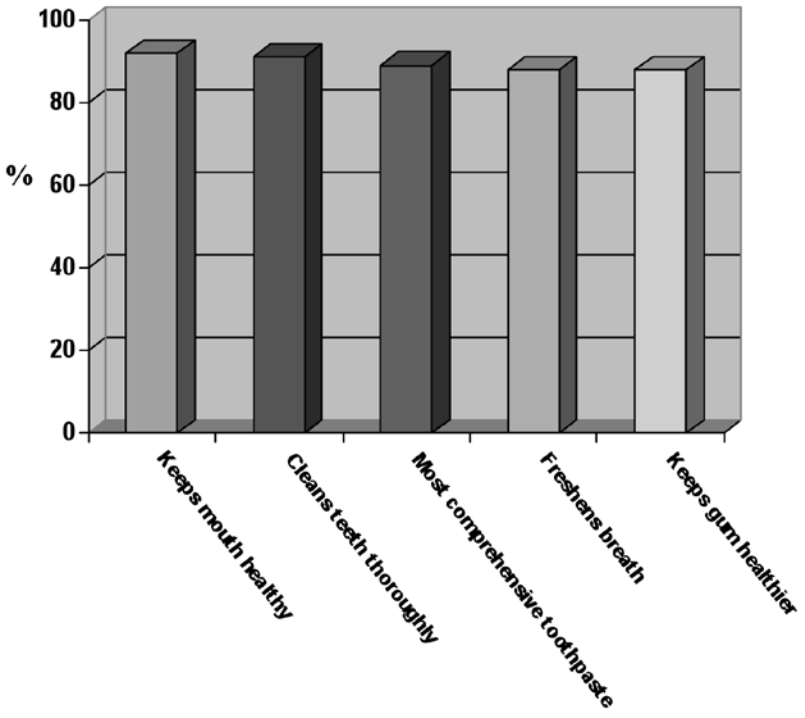


Figure 6. Results from patient surveys; Percent of patients rating SFSH product "Excellent/Very Good/Good".

similar to the assessments practicing professionals do on a routine basis. They recommend a home care product and then use their experience and clinical judgment to determine the effect it has on the patient's oral health. This large, practice-based assessment with the SFSH dentifrice complements findings of the controlled clinical trials. The major outcome is that it provides evidence of excellent professional acceptance and an equal level of acceptance among patients, expressed as an intention to continue using the SFSH dentifrice.

Conclusions

Extensive laboratory and clinical research add to the body of research supporting the value of stannous fluoride as a multi-benefit dentifrice ingredient. Stannous fluoride reduces bacterial growth, bacterial activity, and inflammatory markers as well as protects against plaque, gingivitis and gingival bleeding, hypersensitivity, and caries. Research also suggests the effectiveness of sodium hexametaphosphate in the control of calculus and extrinsic staining. Seventeen published clinical and laboratory papers demonstrate the efficacy of these dentifrice ingredients when they are combined in a dentifrice formulation, which is therefore able to deliver a wide combination of health and cosmetic benefits.[21, 24, 30-32, 35, 36, 45- 47, 53-55, 59, 60, 66, 67] Results from a large practice-based assessment involving over 1,200 dental professionals and over 1,000 patients further support the product is widely acceptable and beneficial for improving oral health.[68]

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Research Issues Related to Education

Ann Eshenaur Spolarich, RDH, PhD; Cynthia Gadbury-Amyot, BSDH, EdD; and Jane L. Forrest, RDH, EdD

Dental hygiene educational programs play a critical role in socializing dental hygienists to the research process. All dental hygienists must be taught in a manner that reinforces the importance of research so that an appreciation and basic understanding of the process becomes an inherent part of the value system of each individual. While the majority of dental hygienists do not aspire to the level of conducting research, all dental hygienists must possess basic skills gleaned from learning research that are applied in all aspects of our professional activities. This basic skill set includes problem-solving, critical-thinking and decision-making skills that are necessary to make good decisions during the process of care. Our educators assume a large responsibility for this socialization, yet are faced with multiple obstacles and limited resources that challenge their attempts to adequately prepare students in their research skill development. These issues are further explored below under Faculty, Student, and Curriculum Issues.

Faculty Issues

Faculty who are teaching in university-based programs have primarily been responsible for the dental hygiene research conducted to date, although there are exceptions to this rule. This is not surprising, as the quality most valued by universities is "intellectual achievement" and most specifically, research, which "represents the ultimate expression of a scholar's powers."[1] Faculty who teach in universities are required to conduct research as an aspect of scholarship that brings merit to the university and benefit to the society it serves, beyond the merit that is brought to the individual faculty member and to the profession of dental hygiene. The discovery of new knowledge is consistent with the mission of universities. Research is considered a key measure of scholarship that is used to determine rank and eligibility for promotion and tenure.

Dental hygiene is facing a shortage of faculty members: a shortage that is expected to grow.[2] In 2006, the Center for Health Workforce Studies at the School of Public Health, University of Albany, conducted a survey of dental hygiene program directors on behalf of the American Dental Hygienists' Association (ADHA). Two thirds of the program directors described recruitment of faculty as either very difficult (22%) or somewhat difficult (44%); 32% of the program directors identified recruitment of qualified faculty as a primary concern "in the near future."[3]

Closure of baccalaureate level programs has had, and will continue to have, a significant impact on both the number and the development of our future faculty and scholars, upon whom the growth of our body of knowledge is dependent. Research as a career path for dental hygienists requires a minimum of a master's degree, and our existing dental hygiene graduate programs will soon face a shortage of eligible candidates for enrollment. It is a legitimate concern that those individuals who do pursue a master's degree in dental hygiene will be encouraged to seek teaching positions to fill the vacancies in community college settings, where research is not typically a required element for employment. If this prediction holds true, it is feared that our dental hygienists with higher levels of education may not pursue research as part of their own faculty profile or professional development.

Further, the alarming trend in program closures in universities, and specifically in dental schools, eliminates employment opportunities for dental hygienists who desire to both teach and conduct research in this type of setting. Dental hygienists who are currently employed in these settings often face difficulties in meeting promotion and tenure criteria, as most possess only a master's degree and have limited grant funding and publications. Yet, these faculty are held to the same standards as their colleagues in other departments, most of whom possess doctoral degrees. Fortunately, there are a growing number of dental hygienists who possess doctoral degrees. Issues pertaining to grantsmanship, the quality and merit of our research, and the reputation of our journal publications have a profound impact upon dental hygiene faculty who are attempting to move upward in rank and stature within the university. These challenges may indirectly impact the decision to close existing university-based baccalaureate programs because our faculty often cannot meet the rigors of the scholarship demands imposed by the university.

The basic mission of dental hygiene programs in university settings, and thus their value, is defined

by education, research, and service to the community. However, the primary mission of dental hygiene programs has been the education of practitioners. While technical training encompasses a large portion of the dental hygiene curriculum, the practice of dental hygiene is grounded in scientific knowledge, which constantly changes and evolves over time. Good technical skills and the possession of basic knowledge are simply no longer enough to teach dental hygiene students, given the growing body of scientific knowledge and the required skills needed for evaluating the literature. Faculty themselves must be educated in the scientific method, and must be competent in searching and evaluating the literature to be able to adopt an evidence-based approach to teaching. A recent study found that the biggest barrier to implementing an evidence-based approach to care in dental hygiene programs was lack of skills among faculty.[4]

Dental hygiene educators must be challenged to incorporate Evidence-Based Decision Making (EBDM) methodology in their own curricula.[5] Faculty development programs can help teachers learn the evidence-based decision-making process and skills to help students become adept in critical thinking. As more faculty integrate EBDM methodology into their courses, it is more likely that students will develop the skills necessary to become self-directed lifelong learners who "have learned how to learn. They know how to learn because they know how knowledge is organized, how to find information, and how to use information in such a way that others can learn from them. They are people prepared for lifelong learning, because they can always find the information needed for any task or decision at hand."[6]

It has been stated that experience is the greatest teacher; however, experience alone does not guarantee the quality of the teacher. Faculty development programs are essential to continually improve the quality of our educators. Typically, faculty development programs are offered within each institution; however, there are dental hygiene programs that either do not create or do not have access to these training opportunities. A recent addition to faculty development is the American Dental Education Association/Academy for Academic Leadership (ADEA/AAL) Institute for Allied Health Educators (IAHE). The IAHE is a professional development program designed to prepare faculty in allied dental education and other allied health professions for successful academic careers.[7] ADEA and ADHA can also play important roles in facilitating faculty development by sponsoring training workshops on a variety of topics, including the use of technology, information resources, library skills, and teaching methodologies based on the evidence-based process.

Dental hygiene faculty need opportunities to share effective strategies for teaching and *mentoring research*. The level of experience and the degree of confidence in teaching this material varies greatly among educators, and will affect the level of preparation of our future researchers and educators. It would be interesting to know how many dental hygiene educators who teach research courses have actually conducted research. It also is important to assess how we are preparing our educators to socialize students to research and the scientific process, because dental hygiene students who are not taught to value research as the norm for practice will not have this foundation to evolve into teachers who value research and serve as role models.

Student Issues

Clearly, we have outgrown our current model of associate degree education as the entry-level degree for the profession; however, there appears to be little motivation to change this situation. The issues related to this problem are beyond the scope of this paper. It may be harder to encourage students to pursue a baccalaureate degree in dental hygiene, given the opportunities for employment stability and financial success with an associate's degree. Articulation agreements must be created to encourage dental hygiene students to complete their baccalaureate degrees and to facilitate their entrance into graduate school.

It seems logical to utilize our graduate dental hygiene programs as a resource to assist in efforts to accomplish the objectives set forth by the ADHA National Dental Hygiene Research Agenda (NDHRA).[8] It will be critical for graduate dental hygiene faculty to help graduate students identify topics and frame research questions for investigation that support ongoing research needed by the profession.

Graduate faculty may need to redefine how graduate students are utilized within their own departments and universities, so that maximum gain can be achieved on both the part of the department and the student. Typically, the research that graduate students conduct is descriptive in nature, which limits its utility. Many graduate program faculty realize that the purpose of the research study is merely to introduce the student to the research process, and to give the student firsthand experience in "walking" through the steps of the process. However, this trend has resulted in numerous studies that bring little to our knowledge base, and a collection of studies that amounts to little more than pilot data. Rarely are these studies ever published, replicated or expanded to a larger scale. Graduate faculty could accomplish a great deal more by using graduate students to study small aspects of an existing project, the outcome of which would be a greater depth of understanding of a given topic versus a superficial expansion of new knowledge.

Working alongside a graduate student is more of a traditional model of research mentoring found in the biomedical sciences and teaches the student to value collaboration. Sadly, in dental hygiene, we tend to mentor graduate students by convenience versus by our levels of shared interest and expertise in a given area of study. Often, it is the graduate school that dictates who can mentor a graduate student thesis project and the number of departmental representatives that must sit on the graduate student's thesis committee. These rules hold true, even if there is no one in the department with expertise in the student's topic of interest. How does a student find a mentor to direct and guide a research study if no one in the department holds a similar interest? Conversely, for those students who have difficulty in identifying a topic, it seems more practical to encourage graduate students to participate in an ongoing project.

Graduate dental hygiene programs also could be used as "centers" for investigation, similar to those established in dental schools, with concentrated research efforts focused on a particular field of study. Using the NDHRA as a guide, these schools could serve as regional sites for multicenter research studies to conduct large-scale investigations that add to our body of knowledge. Graduate students from across the country could work on the same project, investigating regional differences in a given problem. This would encourage graduate students to work in a collaborative model and teach them to network and communicate with their future research colleagues. Graduate students also are the logical choice for developing and testing the reliability and validity of new/existing measures and for validating existing bodies of work. These are all examples of projects that could be funded through the ADHA Institute for Oral Health. Whether research is the chosen career path or not, we must ensure that our graduate students possess the skills needed for employment in universities and other health care settings where decision making based on scientific evidence is an inherent part of their responsibilities.

Curriculum Issues

Given the disparities in experience, expertise, and comfort level among dental hygiene faculty, it would be of great benefit to the profession to utilize standard curriculum guidelines for teaching research methods and evidence-based decision making for use in all dental hygiene programs. There are several documents that can be used for this purpose. The American Dental Association (ADA) Commission on Dental Accreditation dental hygiene accreditation standards include research competencies that focus on being a good consumer of the scientific literature.[9] ADEA has developed research competencies that support decision making for evidence-based practice.[10] Several online and print resources are now available, including multipart articles that serve as a primer on evidence-based decision making that can be used by faculty and students alike.[5,11-19] Faculty are encouraged to utilize these documents for guidance in developing their research curriculum. There is an ongoing need for workshops at professional meetings to encourage educators to review the research competencies, and for sharing available resources and strategies for integrating these competencies into curricula.

Today, dental hygiene students are computer-literate and use computers as an integral part of their lives. Most, if not all, students own their own computers. Their existing computer skills may challenge faculty who do not share their same level of experience, expertise, and abilities. The need for computer training, use of technology, and use of scientific search engines and databases will continue for both faculty and students.

More schools are integrating computer use on the clinic floor, which enables students to quickly access information for use during patient care. Also, access to computers in the clinic creates greater opportunities to conduct clinical research by creating large databases of clinical measurements gathered during patient assessment and evaluation. Academic institutions should provide students, whenever possible, access to the latest technology that they will later encounter in practice.

Faculty should work closely with the librarians on campus to ensure that resources are current and available to support evidence-based practice. Access to MEDLINE (and PubMed), the EBM databases to access the Cochrane Database of Systematic Reviews, and CINAHL should be available for students and faculty. Librarians are excellent resources to support faculty development programs as well.

Support for Skill Development

Although an increasing number of dental hygienists are earning their master's and doctoral degrees, a critical core of researchers is still needed. Research skills take time and practice to be developed. For those who have not had formal training in research, there are a few avenues that can be pursued to gain the requisite skills. The University of Washington conducts a summer institute, Clinical Dental Research Methods, to offer training in research methods to oral health professionals who desire additional skill development beyond the basic information that was presented during their clinical education.[20] Companies such as The Grantsmanship Center offer training courses across the country.[21] Previously, the Na-

tional Center for Dental Hygiene Research (NCDHR), through HRSA-BHP funding, provided a 5-day intensive program during which teams of dental hygiene faculty and clinicians headed by a research mentor came together and developed pilot studies specifically related to the NDHRA. This proved to be a successful model in that 80% of the teams were successful in getting ADHA Institute or intramural funding; 3 theoretical models for dental hygiene practice were developed or refined; and 6 journal articles were published, adding to our body of knowledge. Given the success of this model, the NCDHR continues to seek collaborative relationships to obtain funding and to assist teams in moving their research forward. Individuals may also opt to take formal courses at a university. This presumes that the individual will take the initiative to pursue these options and that there is program or institutional support.

ADHA posts information about training and research opportunities on the ADHA Research Resource web page.[22] ADHA also offers a Research Mentoring Forum each year at the ADHA Center for Lifelong Learning (CLL) for novice researchers and for those who are new to the research process. We recommend that a 'hands-on' grant-writing workshop be held on a regular basis in conjunction with the ADHA CLL and that skill development sessions be offered at all future dental hygiene research conferences.

Dental hygiene researchers need the opportunity to come together to share ideas and to discuss strategies for advancing the profession through research. Those who have been successful in grant writing and developing a funded research area should be an integral part of the conference planning and workshop sessions. The upcoming North American Dental Hygiene Research Conference (June 15-17, 2009) is one such opportunity where the dental hygiene research community will come together with representatives from government and industry to exchange shared research interests and explore opportunities for advancing dental hygiene research.[23] In addition, recipients of funding through the ADHA Institute for Oral Health should be required to present their research at ADHA CLL, and abstracts and papers need to be published in the *Journal of Dental Hygiene* so that others have access to the information through MEDLINE and CINAHL.

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Current Perceptions of the Role of Dental Hygienists in Interdisciplinary Collaboration

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Introduction

In today's health care environment, medical professionals increasingly utilize interdisciplinary collaboration to reach optimal decisions regarding patient care. Collaborative health care teams are part of patient care in most medical settings.[1] A work environment supportive of collaboration better ensures positive outcomes for patient care.[2-4] Recent scientific studies show strong correlations between oral and systemic disease,[5-8] indicating a need for increased collaboration between the medical and dental professions. Interdisciplinary collaboration between medical and dental professionals is emerging as a critical component to effective patient care.[3]

Consider a case when the dental hygienist finds a suspicious lesion on the soft palate of a patient. The patient is referred to an oral surgeon by his general dentist and subsequently diagnosed with oral cancer. The collaborative team may consist of the medical oncologist, radiologist, oral surgeon, social worker, dentist, and dental hygienist. All of these professionals will work together collaboratively to make the best decisions regarding treatment for the patient.

In recent years, diabetes,[5,6] cardiovascular disease,[9,6] preterm, low-birth-weight ba-

Abstract

Purpose: Recent scientific studies show strong correlations between oral and systemic disease, creating a crucial need for increased communication between the medical and dental professions. Interdisciplinary collaboration between medical and dental providers is emerging as a critical component to effective patient care. Dental hygienists have been underutilized in interdisciplinary collaboration, and what utilization does take place has not been well studied. The objectives of this research are to assess dental hygienists' perceptions of (1) their role in interdisciplinary collaboration, (2) the barriers to effective collaboration, and, (3) communication skills needed to better participate in interdisciplinary collaboration.

Methods: Data were gathered using an original, 45-question, quantitative survey instrument, consisting of Likert scale, ranking, and demographic questions. After approval from Oregon State University's Internal Review Board, the survey was pilot tested with 8 dental hygienists licensed in Oregon with diverse educational and practice backgrounds. The survey was revised based on feedback from the pilot test. Variables measured included experience, confidence, importance, leadership, knowledge utilization, and the future of interdisciplinary collaboration. Survey participants consisted of a convenience sample of Oregon dental hygienists (N=103), recruited from 2 large dental hygiene meetings. The overall response rate was 60% (N=103). Descriptive statistics and histograms were generated for all responses. To better understand the nature of relationships between variables, and to make comparisons among groups, statistical analyses included correlation analysis and t-tests.

Results: Results show that dental hygienists perceive their role in interdisciplinary collaboration as valuable, both now and in the future. However, current experience in collaboration is limited. Barriers to collaboration include insufficient time and knowledge of medical diseases. Speaking, listening, and leadership skills are necessary to effectively participate in interdisciplinary collaboration.

Conclusions: Analyses of these findings support a call for greater education in communication skills. Increased knowledge of medical diseases is also needed to increase further confidence in interdisciplinary collaboration. Interdisciplinary education needs to become the expected standard in dental and medical education. Organizational and individual barriers to collaboration require further study.

Keywords: Interdisciplinary collaboration, communication skills, professional roles, barriers to practice, dental hygienist

bies,[7,8,10,11] and certain respiratory diseases[12] have been linked to the inflammation caused by periodontal disease.[13] These correlations place the dental hygienist in a unique position within the interdisciplinary team, as it is often his/her role to initiate communication within the dental team and with the medical office concerning the care of the patient. Of all the dental team members, dental hygienists regularly spend the most time with patients, updating the medical history and listening to patients' descriptions of their medical conditions.

The dental hygienist's assessment is an important piece of patient care as well as potential interdisciplinary collaboration. While the role of the dental hygienist in interdisciplinary health care collaborations deserves inquiry, it has not been studied.

Before defining the role of dental hygienists in interdisciplinary collaboration, it is important to investigate their current practice regarding interdisciplinary collaboration. This small exploratory study will provide a starting point for elucidating the role of the dental hygienist in interdisciplinary collaboration, discovering barriers to collaborative efforts and communication skills perceived as necessary for effective collaboration.

Review of the Literature

What Is Collaboration?

Collaboration is defined as both a process of interaction and an outcome of decision making.[14,15] Collaborative process includes open communication between parties, allowing for constructive exploration of differences in search of workable solutions.[14,16] A collaborative project ultimately brings members from multiple disciplines or fields of knowledge to collectively engage in critical thinking for the purpose of meeting a goal. Through collaborative interaction, individuals with different competencies and skill sets can combine knowledge and experience to create outcomes and answers that no one individual could accomplish alone.[17] Collaborative process centrally involves attributes of a democratically oriented flow of communication transactions; this process involves a sharing of information that is beneficial to the outcome goals of the group.[18] As an outcome, collaboration is defined as how decisions are made within a group. Collaborative decision-making can be measured by shared power, collective responsibility and meaningful opportunities for input by group members.[15] An exchange of information occurs, leading to completion or closure of the collaborative problem.[19] Optimally, the opinions of all are respected, and individual biases are secondary to the goals of the group.[20] For the purpose of this study, interdisciplinary is defined as 2 or more academic or professional disciplines, coming together to engage in the process and outcomes of collaboration. Interdisciplinary can also be referred to as interprofessional, multidisciplinary or cross-disciplinary and cross-professional.[21,22] These various synonyms are used interchangeably within the literature.

Competence, Roles and Goals within Collaboration

Individual members of an effective collaborative team need to be competent in their fields of knowledge and display critical-thinking skills.[23,24] The collaborative team needs members with skill, knowledge and the expertise from their disciplines coupled with a willingness and ability to share.[17] Clear roles and responsibilities are also important to effective collaboration. Team members need to understand clearly their designated responsibilities and roles. Often, individuals within groups will self-organize according to their own specialties and interests.[23,24] Leadership and facilitation are roles that can contribute to the success or failure of the collaboration.[3,25] Standard professional roles are learned through education and the setting in which professional training is accomplished.[21,22,26] For example, dental hygienists trained in a dental school setting often have the opportunity to collaborate with dental students regarding patient care. Collaborative efforts then become part of the learning process. Collaborative team members must have constructive conversations about each other's roles within the group in order to understand their role within the team. A shared understood goal is an essential component of successful collaboration and is the first step in a collaborative process.[14] There must be a common definition of the problem, and a commitment to collaborate for a desired outcome. Cooperative goals mutually benefit the group and the individuals within the group.[24] In dental/medical interactions, the common shared goal is optimal patient care. Strategic collaborative members are individuals respected by their peers who understand their roles and responsibilities and are committed to the shared understood goals of the group. Willingness to participate, positive attitudes towards communication, effective communication skills, and hard work are individual contributions important to realizing collaborative goals.[3,27]

Collaborative Practice Model

The collaborative practice model is taught as one of the foundations of dental hygiene practice. This model teaches that dentists and dental hygienists work together, each offering professional expertise to reach the goal of optimal patient care.[28,29] The relationship should be one of co-therapists,[30] each with unique and differing roles. In the collaborative practice model, the dental hygienist is viewed as the

expert in oral health interventions, dental hygiene treatment planning, and evaluation.[30] Today, many state practice acts allow dental hygienists to work collaboratively with dentists in nontraditional facilities and in under-accessed populations. Collaborative models today include, but are not limited to, collaborative practice agreements (MN, NM), public health endorsements (NV, ME), limited access permits (OR) and alternative practice hygienists (CA).[31]

Increasingly, dental team members need to communicate with medical professionals concerning shared patients.[32,33] Thus, the collaborative model that is taught in the dental hygiene curriculum, and often is at work between the dentist and dental hygienist, needs to be expanded to include communication with other medical specialists. The growing need for interdisciplinary collaboration is driven by the current science connecting oral and systemic diseases, providing new concerns for the whole health of the patient.

Interdisciplinary Education

Increasing shared learning experiences between professions in health care education is a way to advance interdisciplinary collaboration.[1] Curran et al reported on a study of interdisciplinary teams working together in education. Health care students from medicine, nursing and pharmacology concluded that continuous exposure to other professions leads to improved attitudes towards teamwork and a better understanding of what differing professions offer to the collaboration.[2] At Georgetown University, students and faculty in medicine and nursing have developed an interdisciplinary curriculum in clinical ethics. The goal is to bring students together collaboratively in order to prepare future clinicians for the realities of practice. Clinical decision making and patient care are increasingly collaborative endeavors dependent on multiple disciplines working together.[34] Rafter et al[35] reviewed current literature on interprofessional education and conducted a preliminary survey of 7 academic health centers. They concluded that topics such as ethics, communication skills, and evidenced-based practice could effectively be taught in an interprofessional setting.

Currently, some academic health centers are attempting to develop interprofessional education programs. At Oregon Health Sciences University, an Interprofessional Ethics Education Team is being co-chaired by the associate dean of the dental school and an MD at the university hospital. The goal of this team is to educate multiple specialties on professionalism and ethics of care. Collaboration is emphasized in this setting.[36] In other studies, dental and medical students report a positive attitude towards interprofessional education, yet they have little concept of collaborative teamwork between the two disciplines nor the roles of each other to achieve it.[36,37] In a 2007 national study of dental hygiene program directors, 99% agreed that dental hygienists will play an increasing role in collaborative endeavors concerning patients with periodontal and systemic disease connections, yet only 4% report teaching periodontal disease curriculum content with other allied health professionals.[39] Clearly, there is much work to be done in this area.

Interdisciplinary education can help promote mutual respect and trust in the competence of others and decrease barriers such as status posturing and self-preservation.[40] Students in medicine, nursing, pharmacy and dentistry need to learn to work together as a team in order to provide efficient, high-quality patient care. The changing face of medicine with increased patient expectations, the growing complexity of medical care, and the developing science of discovery require the collaborative expertise of many disciplines working together,[3,41] including dentistry, dental hygiene, and medicine.

The purpose of this study was to determine 1) how dental hygienists view their role in interdisciplinary collaboration within their professional setting; 2) what barriers dental hygienists face in becoming an active participant in interdisciplinary collaboration; and, 3) communication skills dental hygienists perceive as being important to interdisciplinary communication.

Methods

A 45-item, quantitative survey instrument was designed and utilized for this study. The survey consisted of 5 sections: foundation questions, roles, barriers, communication skills and demographics. Section 1 included 14 Likert scale questions that address current interdisciplinary practices. For example, "I have experienced interdisciplinary collaboration in patient care." And, "I am more confident collaborating with dental professionals than with medical professionals."

The second section was divided into 2 parts. Part 1 consisted of 10 Likert scale questions focusing specifically on issues of leadership, value and respect when collaborating. For example, "I initiate communication between my workplace and other dental specialists, regarding patient care." Part 2 asked respondents to rank roles fulfilled in patient care, such as clinician and patient educator.

The third and fourth sections focused on perceived barriers to becoming an active voice, and communication skills needed to better participate in interdisciplinary collaboration. Both the barriers and communication sections asked participants to check all items that applied to them. Barrier choices included items such as insufficient

time, being taken seriously, and insufficient knowledge of medical diseases/conditions. Communication skills important for interdisciplinary participation included listening, leadership, and speaking skills. The communication section also asked participants if they had previous communication training and if so, where the training took place. The final section consisted of demographic questions.

After approval from Oregon State University's Internal Review Board (IRB), the survey was pilot tested with 8 Oregon dental hygienists with diverse educational and practice backgrounds. Comments and suggestions for changes were incorporated into the final survey instrument. No additional review was required.

The survey sample was cross-sectional, voluntary, and non-random. It consisted of dental hygienists registered to practice within the state of Oregon. One hundred seventy-two surveys were distributed, at 2 separate dental hygiene meetings, 1 statewide and 1 local. After data were collected, surveys were numbered and results were manually entered into a spreadsheet. All statistical analyses were performed using the data analysis tools in Microsoft Excel version 11.2.[42] Statistical analyses included generating descriptive statistics and histograms for all responses. Data were analyzed using nonparametric correlation analysis: specifically, Spearman's rank correlation analysis was used to investigate correlations between appropriate variables, determining positive or negative relationships and the relative strength of those relationships.

Results

A total of 103 surveys were completed and returned for a response rate of 60%.

Demographics

Survey respondents generally work in urban and suburban areas. The majority of respondents (68%) live in the northwest corner of Oregon. The surveys were distributed at 2 meetings, both in northwest urban settings. This would account for the lower number of respondents from rural practice areas and from differing parts of the state. Respondents overwhelmingly answered clinician (77%) when asked about their primary work responsibility. Private practice was the primary type of work setting reported (67%), followed by dental HMO, education and independent practice, each with 10%. Respondents reported a fairly equitable distribution of years in practice, 0-10 years (38%), 10-25 years (35%), and 25+ years (27%). Almost one half of study participants hold bachelor's degrees (48%). Over one third has associates degrees and almost 1 in 8 has earned a master's degree. Finally, over two thirds of respondents are members of the American Dental Hygienists' Association (ADHA).

The Dental Hygienist's Role in Interdisciplinary Collaboration

Respondents were asked multiple questions addressing their perceptions of their role in interdisciplinary collaboration. Aspects of role include experience, importance, leadership, knowledge utilization, and future (Table 1). Three items generated mean scores above 4, or reasonably strong agreement. Hygienists noted the importance of interdisciplinary collaboration, the future of interdisciplinary collaboration and knowledge utilized as key factors. Respondents agreed that the role of the dental hygienist is important in interdisciplinary collaboration even though they only occasionally have experienced it in daily practice. They concur that their knowledge is utilized when they engage in interdisciplinary collaboration and that the dental hygienist will have a greater role in collaboration in the future. The lowest ranked variable is experience in interdisciplinary collaboration, although the collective response indicates a modest degree of agreement.

Table 1. Perceptions of the Dental Hygienist's Role in Interdisciplinary Collaboration (IC) (n=103)

Role Factors	X Mean	S.D. Standard Deviation
I have experience in IC	3.27	0.98
My knowledge is utilized in IC	4.2	0.73
The role of the dental hygienist is important in IC	4.58	0.55
The dental hygienist will have a greater role in IC in the future	4.42	0.70
I take a leadership role in IC within my work setting	3.82	0.98

Primary Role Perceptions in the Workplace

Respondents were asked to rank the role of the dental hygienist, in order of importance to them, in their working practice. The role choices were patient advocate, patient educator, clinician, treatment coordinator, and communication facilitator. This role ranking was undertaken both in light of their current practice and what they foresee for the future (Table 2). More than half of survey participants identified clinician as the

Table 2. Reported Roles of the Individual Dental Hygienist, Now, and in the Future (n=83)

Roles: Individual	Present		Future	
	Frequency	%	Frequency	%
Clinician	45	54%	32	39%
Patient Educator	22	27%	26	31%
Patient Advocate	6	7%	14	17%
Communication Facilitator	5	6%	6	7%
Treatment Coordinator	5	6%	5	6%

most important role (54%). The role ranked as least important was treatment coordinator (6%). The role identified as increasing the most in the future was patient advocate, from 7% to 17%. However, clinician still ranks as most important in the future (39%) and communication facilitator (7%) and treatment coordinator (6%) rank last.

Barriers

Respondents were asked, "What barriers or obstacles does the dental hygienist face in becoming an active voice in interdisciplinary collaboration regarding patient care?" They were asked to check all that applied to them. The top 4 barriers reported were insufficient time (72%), willingness of other professionals to collaborate (67%), need more professional freedom (51%), and insufficient knowledge of medical diseases (50%) (Table 3).

Communication Skills

Respondents were asked, "What communication skills are important to learn to better participate in interdisciplinary collaboration?" They were asked to check all that applied. Survey respondents marked speaking skills, listening skills, leadership skills, working effectively with teams, dealing with difficult people, power and influence strategies and motivation and persuasion strategies at 58% and above. Negotiation (43%) was the only communication variable marked in less than half the surveys (Table 4). The majority of respondents (62%) have had some communication skills training. Forty-one percent report that communication training happens at the college (23%) and university level (18%), as part of the dental hygiene general education curriculum, while only 6% report receiving communication training from a professional organization.

Table 3. Barriers to Interdisciplinary Collaboration (n=103)

Barrier	Yes % (#)	No % (#)
Insufficient time	72% (74)	28% (29)
Willingness of other professionals to collaborate	67% (69)	33% (34)
Need more professional freedom	51% (53)	49% (50)
Insufficient knowledge of medical diseases	50% (51)	50% (52)
I won't be taken seriously	42% (43)	58% (60)
Unsupportive work environment	41% (42)	59% (61)
Lack of confidence in using professional language	39% (40)	61% (63)
Insufficient education	29% (30)	71% (73)
Unable to identify correct contact person	18% (19)	82% (84)
It is not my job	14% (14)	86% (89)
Insufficient knowledge of dental diseases	13% (13)	87% (90)
Other	12% (12)	88% (91)

Table 4. Communication Skills Necessary for Interdisciplinary Collaboration (n =103)

Communication Skill	Yes	No % (#)
Speaking skills	79% (81)	21% (22)
Listening skills	72% (74)	28% (29)
Leadership skills	66% (68)	34% (35)
Effectively working in teams	64% (66)	36% (37)
Dealing w/difficult people	61% (63)	39% (40)
Power/Influence strategies	60% (62)	40% (41)
Motivation/Persuasion	58% (60)	42% (43)
Negotiation	43% (44)	57% (59)

Correlations

Correlation analysis was performed on a number of variables. Having experience in interdisciplinary collaboration relates positively to the importance of the dental hygienist's role ($r=0.345$, $p<0.000$), and to taking a leadership role in collaboration ($r=0.429$, $p<0.000$). Perceiving collaboration as important is also positively

correlated to taking a leadership role in interdisciplinary collaboration ($r=0.306$, $p<0.002$).

Correlation analysis was performed on collaboration factors between medical and dental professionals. One hypothesis examined was that the number of years a hygienist has practiced would correlate positively with experience and confidence in interdisciplinary collaboration. The findings of this study do not support that hypothesis. In this study, years in practice did not predict levels of experience, feeling respected, or having confidence in collaboration with medical or dental professionals. Another hypothesis was that the level of education would positively compare with self-confidence and experience in collaboration. This hypothesis was also not substantiated.

Discussion

This exploratory study revealed perceptions dental hygienists hold concerning their role in interdisciplinary collaboration. The 2 highest scoring factors are the importance of the dental hygienist's role in interdisciplinary collaboration and having a greater role in the future with interdisciplinary collaboration. Those who believe their role is important are more likely to initiate or engage in the experience of collaborating with other health care professionals and are more likely to take a leadership role in collaboration. Results of the study show that experience in interdisciplinary collaboration is the best predictor for positive responses to collaboration. However, experience was the lowest ranked variable. Dental hygienists need to use their clinical knowledge of oral disease to communicate with their patients' medical providers when necessary. Literature states that collaborative team members need to recognize the unique contribution each profession offers to the process.[1,21] Therefore, dental hygienists need to perceive their role as important in order to be valuable in the collaborative process. Respondents overwhelmingly view their role as that of clinician both now and in the future. Discovering how to better facilitate interdisciplinary collaboration within the clinical role is important to the dental hygienist's increasing role in it.

Findings indicate there are 2 primary reasons dental hygienists are not more proactive in initiating and leading collaborative efforts. First, they lack sufficient time during dental hygiene appointments, and second, interdisciplinary collaboration is not a conventional role. Regarding conventional roles, the profession of dental hygiene emerged from the historical model of a traditional, dominant patriarchal male dentist and a subservient female hygienist in a helper or auxiliary role.[43] Even today, hygienists are referred to as auxiliary to the dentists. While the dental workplace culture is beginning to develop more gender equality, a strong patriarchal attitude still exists in many dental practice settings.

Respondents report higher levels of confidence, experience, and feeling respected when collaborating with dental professionals as compared to medical professionals. This may reflect the fact that the dental hygienist works in dental settings and is more comfortable and understands better how the profession of dentistry functions. Dental hygienists collaborate with dental professionals during their clinical education; however, they do not often have opportunity to collaborate with medical professionals during training. Dental hygienists would benefit from receiving education and clinical training in interdisciplinary academic and health care facilities with opportunities to collaborate with medical professionals on individual patients. Respondents reported a high level of competency in knowledge of dental diseases (87%); however, half of all respondents feel they have insufficient knowledge of medical diseases. Feeling comfortable with medical diseases and the appropriate language or cultural protocol in medicine will greatly enhance dental hygienists' experience in collaboration with medical professionals.

Insufficient time, unwillingness of other professionals to collaborate, and need for more professional freedom are the top 3 barriers reported. These barriers are not in direct control of the individual dental hygienist, but rather involve workplace expectations and behaviors of others. Having insufficient time may limit the willingness of the dental hygienist to attempt collaboration with other providers. Willingness of others to collaborate is a variable controlled by all individual dental and medical team members. If other medical and dental personnel do not see value in working together with dental hygienists, collaboration will not occur. Interdisciplinary education seeks to address this barrier by training medical and dental professionals about the benefits of collaborating with other disciplines.[35] Finally, needing more professional freedom is an issue that ADHA is addressing through education and legislation.

Barriers the individual dental hygienist controls include insufficient knowledge of medical diseases and lack of confidence using professional language. The dental hygienist can attend continuing education courses and read peer-reviewed journals to gain familiarity with medical terms and to increase their vocabulary skills in the correct language to use and the proper questions to ask.

Respondents identify training in nearly every communication skill as highly important, with percentages from 58% (motivation and persuasion strategies), to 79% (speaking skills). This high response rate speaks to an enormous need for education in communication skills. Oral and written communication

education is part of the general education required for dental hygienists by the Commission on Dental Accreditation; however, most dental hygiene programs require only 3 credit hours in these subjects.[44] The need for education in speaking (79%) and listening (72%) proficiencies are the top 2 communication skills identified by respondents. Because their daily practice involves much more than technical skills, dental hygienists see a great need for communication education. A competent dental hygienist can motivate, educate, and build relationships with patients. She/he can present a case for referral to other dental specialists and often is expected to take a leadership role in office activities. All of these responsibilities are enhanced by excellent communication skills.

Limitations of this research project include sample size, demographic questions and the researcher's association with participants. The generalizability of this study is limited because of the small sample size and the demographic characteristics of the sample population. Due to time and access limitations, a random, stratified sample was difficult to obtain. The cross-sectional convenience sample of participants numbered 172 with a response rate of 60%, N=103. The total number of registered dental hygienists in Oregon is 2,593 (Oregon Board of Dentistry, 2007, personal telephone conversation). Therefore less than 5% of the dental hygienists in Oregon answered the survey. In the demographic section, educator and independent practice categories were omitted from the choices for area of primary practice. This oversight was recognized when 6 respondents wrote in educator and 5 wrote in independent practice. Finally, a limitation may exist regarding the researcher's association with respondents. At both events where the survey was presented and participants were solicited, many dental hygienists knew the researcher on a personal and professional level. While this may have been a limitation, actions were clearly taken to receive unbiased, voluntary and honest results from respondents. First, the researcher was physically present at both meetings, available to answer any question or concerns about the study. Second, all responses were voluntary and anonymous. A clear explanation was given of the research goals, and there was no direct benefit given to those who chose to respond. Nevertheless, the limitations of this study make it difficult to generalize to larger populations of dental hygienists. The intent is to initiate a discussion of the dental hygienist's role in interdisciplinary collaboration.

Further research is needed to determine how interdisciplinary collaboration fits with the role of clinician. If no change is expected in the primary role of clinician, where will the increased collaboration be evidenced? Studies focusing on the expected roles of different medical and dental professionals within collaborative efforts will be useful in expanding participation of dental hygienists. Continued research into the patient care benefits derived from dental and medical clinicians who have been educated in an interdisciplinary model of care will be beneficial to advance further interdisciplinary education efforts.

Conclusion

In light of the findings of this exploratory study, the following conclusions are made. Interdisciplinary education needs to become the expected standard in dental and medical education. Learning to collaborate in the educational environment will translate to the practice setting, allowing the hygienist more opportunity and experience in collaboration. Increased communication education in accredited dental hygiene programs should be promoted concurrently with continuing education courses in multiple areas of communication. Continued education in medical conditions that have a strong correlation to dental disease such as diabetes, cardiovascular disease, and pregnancy may increase dental hygienists' knowledge and consequently increase their confidence in collaboration. If the dental hygienist is to be a key player in interdisciplinary collaboration, changes in expectations and time management strategies of the individual hygienist and her or his employer entities will be essential.

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The Advanced Dental Hygiene Practitioner at the Master's-Degree Level: Is It Necessary?

Michele Leonardi Darby, RDH, MS

Introduction

Achieving oral health for all, especially for those with the highest disease levels, is one of the greatest challenges facing our nation.[1,2] Almost a decade ago, the U.S. Surgeon General[1] and Oral Health America,[3,4] a national advocacy group, released a national report card on our nation's oral health. Unfortunately, reports reveal that we are underachievers in access to care, cultural diversification, oral disease prevention, the policies that we promote, and the infrastructure that we have created.[1] These conditions have placed additional demands on the practice of dentistry and dental hygiene. The mediocre rating (a "C" grade) in oral health care can be improved if we build on the successes and potential of the dental hygienist as proposed by the American Dental Hygienists' Association in the Advanced Dental Hygiene Practitioner (ADHP).[5] An ADHP is "a dental hygienist who has graduated from an accredited dental hygiene program and has completed an advanced educational curriculum, approved by the American Dental Hygienists' Association, which prepares the dental hygienist to provide diagnostic, preventive, restorative and therapeutic services directly to the public."[5] Establishing the ADHP curriculum at the master's degree level requires transformational change in dental hygiene education and practice.

The need for the master's degree has challenged the thinking and opinions of many in our professional community. Therefore, the purpose of this paper is to focus discourse on why the ADHP should be prepared at the master's degree level—the terminal academic preparation for dental hygiene practice. This discourse is built on the following tenets:

- Graduate education in dental hygiene should evolve within the context of social need and is a logical mechanism to expand workload capacity.
- Advanced practice based on graduate education has become a reality in other health professions due to:[6]
  - Expansion of knowledge, technology, and generation of new scientific evidence to guide practice
  - The need to expand workforce capacity to meet the primary dental care needs of the underserved and unserved
  - The desire to avoid curricula that exceed the usual credit and time limits for a baccalaureate degree
  - The desire to award the appropriate degree for the demanding academic preparation and for the responsibility/complexity of practice that will follow upon graduation.
- If ADHPs have a master's degree as the entry-level credential, they will:
  - Improve access to primary oral health care
  - Increase quality of care, professional accountability, societal trust, and acceptance by the public
  - Be accepted as collaborators with dentists and other health professionals
  - Expand career opportunities
- An effective ADHP model is based on the advanced nurse practitioner model in which nurses with specialized graduate degrees successfully improve access to primary care in a variety of settings using evidence-based protocols in collaboration with physicians and other health professionals.[6]

Justification for the ADHP Curriculum at the Master's-Degree Level

Demographics and Complexity of Practice

ADHPs will treat dentally underserved populations, including but not limited to racial and ethnic minorities, children living in poverty, the elderly on fixed incomes, and persons with disabilities.[5] These target populations experience barriers to dental care—so their treatment needs are more complex and expensive than those of persons who receive regular preventive and therapeutic care.[1] By 2020, 16% of the population will be 65 years of age or older; by 2050, the figure rises to 20%.[7] Care planning and initial treatment most likely will be more complicated due to these individuals' chronic medical and dental conditions.[8] The ADHP at the master's degree level can safely and cost-effectively meet the unique demands of these populations and then provide referrals to dentists or dental specialists when warranted.[5]

As conceived, the ADHP model includes an expanded scope of dental hygiene practice, e.g., some prescriptive authority, basic restorative procedures, simple extractions, direct access to care, and reimbursement from federal, state, and private payers.[5] It is unlikely that the education underlying these components of practice can be incorporated into the associate or baccalaureate degree programs.[9-11] Moreover, for associate degree and baccalaureate degree dental hygienists, their important roles continue. Being a dental hygienist first will remain the prerequisite pathway for those whose goal is to become an ADHP. For example, given finite resources for health care, responsibility on the part of all citizens to stay healthy is essential, and dental hygienists work with clients toward this goal. A significant component of a person's health status is behaviorally based, (i.e., tobacco and alcohol use, diet, exercise, oral self-care practices, seeking regular professional oral health care, etc.). People who learn and practice oral-health-promoting behaviors can expect a lifetime of oral health and an economic savings that comes with disease prevention.[12] Dental hygienists will continue to provide preventive, educational, and therapeutic care within their scope of practice to people in private practices, schools, public health centers, extended care facilities, and adult daycare centers. In this way, dental hygienists and ADHPs complement each others' roles to ensure oral health care to all populations. Similar complementary relationships exist among nurses (LPNs, RNs, BSNs, MSNs, NPs, DNPs) who all fill important roles in the health care system.

Curriculum Creep

Educators and administrators have been guilty of squeezing too much information into entry-level dental hygiene curricula.[9-11] Everything there is to learn in the dental hygiene discipline cannot be accomplished solely by adding it to the associate or baccalaureate level programs or gleaned from continuing education.[13-14] Other health care disciplines (nursing, physical therapy, occupational therapy, pharmacy) have delineated role expectations for entry level, the master's degree, and the doctoral degree. These health care disciplines evolved into advanced practitioner roles via specialized graduate degree programs. The dental hygiene profession must follow this path, not for prestige, but for fulfilling its service role within a society of varied populations and settings. The ADHP can help fill some of the vacant niches in our oral health care system.

Society recognizes the advanced nurse practitioner as having an advanced degree with competencies that extend beyond the RN or BSN levels. As dental hygienists earn specialized clinical degrees at the graduate level, the more familiar and confident Americans will become with ADHPs providing primary dental care. Consider the alternatives—building the ADHP into already overflowing associate and baccalaureate degree curricula, or offering this training to practicing dental hygienists as a continuing education program leading to a certificate. These approaches constitute unsound educational practices and would greatly shortchange the dental hygienist who might be interested in becoming an ADHP.[14]

Level of Responsibility Commensurate with Education

Through institutions of higher education, society awards degrees when a substantial body of information is mastered. With each defined increment of substantial information and mastery, a higher- level degree is awarded. Substantial coursework and clinical education are needed to develop the competencies of an ADHP, above what is possible to accomplish in the accredited entry-level dental hygiene curriculum. Society also rewards persons with graduate degrees because they typically assume greater responsibilities in the workforce. It would be "educational malpractice" to require persons to complete extra coursework and master additional competencies and not provide them the opportunity of earning an advanced degree as evidence of their achievement. As professionals, we owe more to ourselves and our colleagues than to expect dental hygienists to assume added responsibilities in complex environments without the recognition of a formal graduate degree. Moreover, it is unfair to the student (or practitioner) who would enroll in the ADHP program, develop additional competencies, take on additional legal liabilities, be expected to make more complicated clinical decisions and not be duly recognized for this advanced preparation by holding a commensurate degree.

That is not to suggest that our associate degree programs and their graduates are incapable or less competent at what they are prepared to do. Most have earned college credit beyond the associate degree level… and some even hold the number of credits beyond the defined minimum for a bachelor's degree.[14-15] Dental hygienists who are not ADHPs will continue to be valued oral health care professionals and in demand by dentists and society.

Collaborative Practice

This proposed practice model includes ADHPs working in health professional shortage areas where they are collaborating with dentists and physicians via phone, computer, or satellite communication.[5,16] When a dental diagnosis or medical directive is necessary and a decision is beyond the ADHP's scope of practice, a dentist or physician can be contacted to step in and pro-

vide the needed care at a later appointment, or direct the ADHP in client treatment. Tele-health care is already practiced in hospital-based intensive care and critical care units where there is a shortage of specialist physicians known as intensivists.[2] Using two-way communication, nurses in hospitals can care for critical-care patients under an intensivist's direction using established protocols. Even emergency medical technicians manage life-threatening situations while in telecommunications contact with the emergency room physician.[16]

Supervisory Restrictions

Specialized graduate-level education will enable the ADHP to go into dental health professional shortage areas where needy populations are predicted to increase, given the state of the global economy.[5,17] The majority of dental hygienists and dentists work in private practice settings. History shows that merely increasing the number of dental hygienists or dentists graduating from our schools does not translate into greater access to care for vulnerable populations who are found outside of the traditional practice setting. Most dental hygienists work supervised in the traditional dental private practice setting, where about 60% of the U.S. population receives dental care annually. Restrictive supervision requirements undermine the ability of dental hygienists to provide care according to established protocols and limit members of the dental team from serving diverse populations in need. Governmental reports consistently document the shortage of dentists in rural and inner city communities and in marginalized populations that do not receive regular dental care.[17] If ADHPs work within these communities and populations, access to primary oral care can be expanded. For instance, in some states, dental hygienists cannot provide patient care unless the patient has a recently documented visit to a dentist—a catch-22 for those who desperately need dental care, but who have not seen a dentist for years.[18] In a collaborative model, the dental hygienist would be the conduit to the dentist for patient treatment that requires a higher level of expertise.[16] These aforementioned access to care challenges support the need for the ADHP who would provide care in dentally underserved communities.[16]

There is no easy solution to the access to care challenges, but "healthy" dental and dental hygiene practice laws, if implemented, can enable dental hygienists, ADHPs, and dentists to prevent and treat most oral diseases and promote health for the entire nation.[2]

Reimbursement for Services

The economic downturn of the market, downsizing of operating budgets, high cost of drugs and technology, advances in technology, unemployment and underemployment, and the top-heavy demographics of the aging American population present challenges to the economic viability of ADHPs. For ADHPs to understand economic trends and develop the business acumen necessary to be direct access primary care providers, education beyond entry level is necessary. Patient outcomes, fees, overhead and salary data will need to be tracked to validate the value and cost-effectiveness of the ADHP to the health care of populations and the nation. Such data are important for influencing legislation and health care policy, and for attracting third-party payers who see that there is added value in reimbursing the services of both dental hygienists and ADHPs. As part of their business plans, ADHPs must measure their quality of care, safety, productivity, process, clinical outcomes, and patient satisfaction; and these qualitative and quantitative research skills require advanced knowledge that is obtained at the graduate level. Earning a graduate degree provides the ADHP with a comprehensive education for becoming a qualified primary care provider, which is a necessary step for attracting patients and obtaining reimbursement for services provided.

ADHPs at the Policy Table

Who sits on the major industry, institutional, and government policy boards that make decisions about health care delivery, how it is financed, and who receives care? The answer is CEOs of companies; government policy makers; insurance executives; and physicians, dentists, pharmacists, and nurses with graduate degrees who together plan, organize, finance, and deliver health care. Collaboration implies equality among collaborators. When collaboration occurs, it is predicated on competence and interprofessional respect with comparable levels of education as a common core.

ADHPs will need to proactively collaborate as members of insurance boards, governmental task forces, and health planning councils where health care and public health policy decisions are shaped. Level of education is one criterion used when inviting professionals to join in the decision-making process. For ADHPs to become recognized in the health care system as valued colleagues who contribute directly to the health of the nation, then ADHPs must be educated beyond the current entry-level credential of the associate or baccalaureate degree.

Conclusions

Oral health care professionals fail when the health of the entire population is not served. "The advanced practice model, with its emphasis on dentist and advanced dental hygiene practitioner collaboration, has the potential to serve populations characterized as low-income, underserved

and unserved."[5] Dental hygienists and ADHPs can work together with other health care professionals to contribute to the advancement of quality health care to the most vulnerable populations who have been disenfranchised from the traditional dental care delivery system, i.e., private practice. People separated from the health care system because of costs, geography, language, or culture should be proactively reached, assessed, treated within the dental hygiene and ADHP scopes of practice, and then referred to dentists for complex dental care.

Adopting "healthy" practice acts that recognize and support the complementary roles of dental hygienists, ADHPs, and dentists would result in greater distribution of preventive, educational, basic restorative, simple extractions, and nonsurgical periodontal services to those outside of the private practice system. ADHPs would be able to provide primary care, direct individuals to seek the advanced care of dentists, and then as case managers monitor oral health status so that individuals are not lost in the system.

Preparation at the master's degree level is a legitimate pathway to the expanded scope of practice, and the complexity of the diverse patients and settings that ADHPs will encounter. As transformational changes occur in dental hygiene and health care delivery, we should keep in mind that there may be a time when the terminal academic preparation for advanced dental hygiene practice will be at a doctoral level.[19-21]

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Errata

The printed version of the Winter 2009 issue of the *Journal of Dental Hygiene* was erroneously labeled Volume 84, Number 1. The correct citation is Volume 83, Number 1. Please note for future referencing. We apologize for any inconvenience that may result from the oversight.

Also in the print version of the Winter 2009 issue, an incomplete reference list was published on page 44 in

Nash DA. Expanding dental hygiene to include dental therapy: improving access to care for children ("Critical Issues in Dental Hygiene" column). J Dent Hyg. 2009; 83(1): 36-44.

The complete list of references appears below and in the online version of the *Journal of Dental Hygiene,* available to American Dental Hygienists' Association members and online subscribers at http://adha.publisher.ingentaconnect.com/content/adha/jdh/2009/00000083/00000001/art00008.

The editorial staff of the *Journal of Dental Hygiene* regret this error.

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