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Admission criteria for Canadian dental hygiene programs

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EDITORIAL

Vaccine hesitancy: Root causes and possible solutions

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The *Canadian Journal of Dental Hygiene* is the official peer-reviewed publication of the Canadian Dental Hygienists Association (CDHA). Published in February, June, and October, the journal invites submissions of original research, literature reviews, case studies, and short communications of scientific and professional interest to dental hygienists and other oral health professionals. Bilingual *Guidelines for Authors* are available at www.cjdh.ca.

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†Study conducted using a 0.454% w/w stannous fluoride toothpaste; measuring Schiff score and DHEQ questionnaire.
‡Percentage improvement in Bleeding Index after 24 weeks, test 0.454% w/w stannous fluoride toothpaste vs. control sodium monofluorophosphate toothpaste. Study also showed 19% improvement in modified Gingival Index with the test toothpaste vs. control at Week 24. Both these measures are indicative of improvements in gum health.

1. Parkinson CR, *et al. Am J Dent*. 2015;28(4):190-196. **2.** GSK data on file. Study number 204930. 2017. **3.** GSK data on file. Study RH01515 topline summary. 2014.

PM-CA-SENO-20-00042

Vaccine hesitancy: Root causes and possible solutions

Salme E Lavigne*, PhD, RDH


Salme E Lavigne

I cannot believe that one year ago, I wrote my first editorial about the COVID-19 pandemic.[1] Never in my wildest imagination did I think that we would still be discussing it now, let alone dealing with a third wave. However, here we are.

If you recall, in my February 2021 editorial I discussed the federal government's appeal to dental hygienists, as health professionals, to step up and assist with educating our clients about both the safety and importance of receiving the COVID-19 vaccine in order to establish "herd immunity."[2] At that time, the mRNA vaccines (Pfizer-BioNTech and Moderna) were the only ones approved by Health Canada. Since then, two viral vector-based vaccines have been added to that list: AstraZeneca/COVISHIELD and Janssen (Johnson & Johnson).[3] In order to educate our clients and encourage them to take one of these vaccines, we not only need to understand how the new vaccine additions work, but we must also address the topic of vaccine hesitancy and attempt to understand the underlying issues that prevent so many Canadians from getting vaccinated.

Viral vector-based vaccines use a harmless virus (typically a type of adenovirus similar to those that can cause the common cold) as a delivery system. This "vector" virus is **not** the virus that causes COVID-19. These adenoviruses have been used in many vaccines developed in the past and have been shown to be very safe. Once injected into the body, the vector virus produces the spike protein that is found on the surface of the SARS-CoV-2 virus. This subsequently stimulates the body to launch a strong immune response against this spike protein, ultimately producing sufficient antibodies to provide the necessary protection against SARS-CoV-2. Once antibodies have been produced, the spike protein itself goes away. Table 1 compares the 2 approved viral vector vaccines in Canada; a comparison of the mRNA vaccines was published as part of my February 2021 editorial.[2]

Dental hygienists should check Health Canada's website on a regular basis as vaccine distribution plans continue to change. A prime example is that the Pfizer-BioNTech vaccine has now been approved for adolescents between the ages of 12 and 17 as well as for pregnant women. In addition, several provinces have recently halted the distribution of the first dose of the AstraZeneca vaccine due to the rising number of cases of vaccine-induced thrombosis with thrombocytopenia (VITT). It appears that sufficient vaccine is being saved for those wishing the second dose, although some provinces are now giving individuals the choice of an mRNA vaccine for dose 2.

VACCINE HESITANCY

In April 2021, the Canadian Dental Hygienists Association (CDHA) conducted its second member poll on vaccines.[4] I was pleased to see that 75% of the 4,378 dental hygienists who responded had already received 1 dose of the vaccine and an additional 6% had received 2 doses—an improvement over the results of the first poll back in January! I was, however, disappointed to see that 5% of respondents were not sure if they wished to receive the vaccine and 4% were absolute "Nos." Although the number of individuals who completed the survey represents only 22% of CDHA's 20,000 members and 15% of the 30,000 registered dental hygienists in Canada, if this is a representative sample, then at least 1,200 dental hygienists may not be inclined to promote vaccination and an additional 1,500 are unsure. Given the invitation we received from Health Canada to help educate our client population and encourage them to have the vaccine, I cannot help but wonder what these dental hygienists are recommending to their clients? As regulated health professionals, dental hygienists have an obligation to support and promote the health of Canadians by assisting our national public health agency in encouraging everyone to eradicate this pandemic by achieving herd immunity. I would hope that no matter what a dental hygienist's personal beliefs are about vaccines, they would not project those beliefs onto their clients and discourage them from being vaccinated.

The question then arises as to why so many people are hesitant to receive a vaccine?

Vaccine hesitancy is not a new phenomenon. Since the introduction of vaccines in 1798, vaccine hesitancy has been recorded, particularly in parents who have chosen not to

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Table 1. Comparison of currently approved viral vector-based COVID-19 vaccines in Canada

	AstraZeneca/COVISHIELD	Janssen (Johnson & Johnson)
Health Canada approval	February 26, 2021	March 5, 2021
Population	Ages 18+	Ages 18+
Dose	2 injections of 0.5 mL each	1 injection only of 0.5 mL
Schedule	4 to 12 weeks after 1st dose	N/A
Route of administration	IM (deltoid)	IM (deltoid)
Storage temperature	Regular refrigeration	Regular refrigeration
Efficacy	62% 2 weeks after 1st dose	66% after 2 weeks
Number of participants in Phase 3 trial	11,636 Total	43,000 Total
Common side effects	Pain at injection site; body chills; fever; fatigue	Pain at injection site; body chills; fever; fatigue
Rare side effects	Blood clots with low platelets; VITT	Blood clots with low platelets; VITT
Contraindications	Allergic reactions to ingredients. Unknown efficacy for those 65+ or pregnant women (not included in trials)	Allergic reactions to ingredients. Unknown safety for pregnant women (not included in trials)

Sources: AstraZeneca/COVISHIELD COVID-19 Vaccine: What You Should Know (https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/drugs-vaccines-treatments/vaccines/astrazeneca.html); Janssen (Johnson & Johnson) COVID-19 Vaccine: What You Should Know (https://www.canada.ca/en/health-canada/services/drugs-health-products/covid19-industry/drugs-vaccines-treatments/vaccines/janssen.html)

vaccinate their children against some of the common childhood diseases. Fortunately, through herd immunity, the majority of the world's major public health threats have been eradicated, such as smallpox, polio, tetanus, typhoid, measles, mumps, rubella, and pertussis. However, we have seen a resurgence of several of these diseases recently, such as measles, varicella, and pertussis, because of the refusal of a growing number of the world's population to be vaccinated.[5]

Over the years, scientists, sociologists, ethicists, and philosophers have attempted to understand what causes vaccine hesitancy in a certain proportion of the population. Often and perhaps incorrectly, many public health and medical personnel believe that vaccine non-supporters do not understand the science. However, Dr. Maya Goldberg, a University of Guelph philosophy professor, claims it is not a lack of knowledge or a misunderstanding of science, but rather a low level of trust in the health care system and in scientists that shapes their beliefs.[6] She also claims that this distrust is often driven by concerns about the credibility of industry-funded research.[6] Interestingly, a group of Canadian researchers just published their study investigating COVID-19 vaccine hesitancy based on an analysis of 605 "tweets" from Canadian Twitter profiles.[7] They identified 5 themes in these tweets: concerns over safety; suspicion about political or economical forces driving the pandemic or vaccine development; a lack of knowledge about the vaccine; antivaccine or confusing messages from authority figures; and a lack of legal liability from vaccine companies. These themes were then categorized and analysed using the Theoretical Domains Framework.[7] Based on this study's findings, dental hygienists could consider the following interventions to increase vaccine acceptance: 1) as a profession, launch campaigns through social media to educate the public about the importance of vaccination for global public health; 2) emphasize that vaccines are rooted in science not politics; 3) mention celebrities, such as athletes, musicians, and other well-respected individuals, as examples of those who support the vaccine; 4) reiterate the safety of the vaccines (i.e., National Advisory Committee on Immunization [NACI] surveillance); 5) explain the rigorous vaccine development process; 6) ask clients about their specific concerns and respond accordingly. Most importantly, dental hygienists must refrain from expressing their personal beliefs about the vaccine if they are not supportive of it.

Returning to vaccine-hesitant dental hygienists, the CDHA April poll identified their top 5 concerns. Here they are along with my responses:

1. **Do not have enough confidence in the vaccine development process. (57%)**
   My October 2020 editorial[8] detailed how vaccines are created and the stringent rules that must be followed prior to approval. It also noted that the chief executive officers of 9 manufacturing companies had signed a pledge to "uphold the integrity of the scientific process" in the race to develop effective COVID-19 vaccines.[9] Additionally, my February 2021 editorial explained that the seemingly rapid development of the mRNA vaccines was made possible through global collaboration among researchers and the inherent efficiency of mRNA technology, rather than "cutting corners."[2]
2. **Do not think that pharmaceutical companies and governments are being transparent in the research they release to the public. (51%)**
   Each country has its own monitoring agency to review the clinical trials and validate the results for both safety and efficacy. In Canada, we

have an independent review panel comprising 12 members with expertise in pediatrics, infectious diseases, immunology, medical microbiology, internal medicine, and public health (NACI). The purpose of this external non-industry/non-governmental agency is to ensure, through unbiased review, that vaccine research is conducted to a high standard prior to recommending approval of a vaccine. One can rest assured that all rules have been followed.

3. **Worried about the long-term efficacy of the vaccine. (51%)**
   These vaccines have been approved for emergency use to eradicate a pandemic. Thus, it is true that long-term efficacy is unknown at this time. However, data on all vaccines continue to be gathered and, thus far, at the 6-month mark, the efficacy has been reported to be strong. Historically, some vaccines have required boosters while some do not. As time evolves and research continues, the experts will be able to determine if boosters are necessary.
4. **Worried about the possible long-term side effects associated with the vaccine. (81%)**
   Once again, although the vaccines appear to be safe and effective at this time, the possibility of long-term effects exists. Currently, there is no evidence of any long-term effects, but there are many stories circulating that are not science-based that we as health professionals should be dismissing. We must have confidence in the current science in order to eradicate this life-threatening pandemic so that we can all return to a normal life.
5. **Concerned about the risk of blood clots with the AstraZeneca vaccine. (42%)**
   This is an understandable concern since there have now been several documented cases in Canada, increasing the risk estimate to 1 occurrence in every 55,000 vaccines administered. The world statistics on this risk range from 1 in 26,500 to 1 in 127,300 according to the Ontario COVID-19 Science Advisory Table.[10] However, we must remember that well over 2,000,000 doses of this vaccine have already been safely administered. At the time of writing, a temporary hold has been placed on the administration of first doses of this viral vector-based vaccine in 9 provinces. Second doses are being offered to those who had already received the first dose, with the assurance that the risk of blood clots is even lower with the second dose.

Dental hygiene is a science-based discipline, and although some of the concerns identified by poll respondents are valid, the emergency in which we find ourselves nationally and internationally requires us to weigh the benefits against the risks and above all follow the science, trust our experts, and dispel the rumours, conspiracy theories, and false information that are circulating, particularly through social media. Never in our lifetimes have we experienced a pandemic; research is evolving and we are continuously learning.

What is most important for us to understand as health professionals is that we are facing an enormous global challenge with the COVID-19 pandemic. Our only hope of ending this threat is to reach herd immunity through global vaccination. The constantly mutating SARS-CoV-2 strains will continue to produce new variants until the world population reaches herd immunity. Only then can we return to any semblance of normality.

Alone, we can do so little; together, we can do so much —Helen Keller

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ISSUE AT A GLANCE

We are pleased to feature 3 original research articles in this issue. **Avraham Zini, Sigal Mazor, Hans Timm, Matthew L Barker, Julie M Grender, Robert W Gerlach,** and **Aaron R Biesbrock** evaluate the effects of an oral hygiene regimen involving an oscillating–rotating electric toothbrush, bioavailable stannous fluoride dentifrice, cetylpyridinium chloride mouthrinse, and dental floss on the periodontal health of adults with established gingivitis and early periodontitis over 24 months (pp. 85–94). **Mahnoor Shahab, Sharon M Compton,** and **Ava K Chow** explore the variation in admission criteria for Canadian dental hygiene programs and how these criteria correlate with a program's success rate on the National Dental Hygiene Certification Exam (pp. 95–100). **Padmini Hari, Sulagna Dutta, Nur Sulwana Binti Mohamad Hanapi, Tara Bai Taiyeb Ali, Betsy Thomas, Thean-Hock Tang,** and **Ashfaq Akram** study the clinical efficacy and safety profile of a novel-designed isosceles-configured toothbrush in comparison to a standard reference toothbrush with end-rounded bristles (pp. 101–109).

In addition, this issue includes a literature review by **Kelsey Henneberry, Shannon Hilland,** and **S Kimberly Haslam** on dental hygienists' risk for noise-induced hearing loss and current hearing protection options (110–119). You will also find a short communication by **Maria G Kallal, Sharon M Compton, Arlynn R Brodie, Breanne L Moran, and Minn N Yoon** on the strengths and weaknesses of a free-service inner city dental clinic, as perceived by health brokers working with low-income and homeless individuals (pp. 120–123).

PLAIN LANGUAGE ABSTRACTS

Zini A, Mazor S, Timm H, Barker ML, Grender JM, Gerlach RW, Biesbrock AR. Effects of an oral hygiene regimen on progression of gingivitis/early periodontitis: a randomized controlled trial. *Can J Dent Hyg.* **2021;55(2):85–94.**

This 2-year study examined the effectiveness of a combination of at-home oral care therapies in preventing gingivitis and increased probing pocket depth (PPD) in generally healthy adults. Ninety participants with established gingivitis and isolated sites with PPD >4 mm were assigned either to the regimen group (an oscillating-rotating electric toothbrush, dental floss, stannous fluoride toothpaste, and cetylpyridinium chloride mouthrinse) or to a usual care group (sodium fluoride dentifrice and manual toothbrush). Participants were examined at baseline and every 6 months for 24 months. Over 2 years, the oral health regimen was significantly and consistently more effective in reducing the number of bleeding sites and inflammation compared to usual care. It may offer long-term periodontal health benefits.

Shahab M, Compton SM, Chow AK. Admission criteria for Canadian dental hygiene programs. *Can J Dent Hyg.* **2021;55(2):95–100.**

Canadian dental hygiene programs use a variety of admission criteria to evaluate prospective students. Given how resource intensive this selection process is, programs should know if they are identifying and selecting the most appropriate applicants. This study reviewed admission criteria from all 30 English-language dental hygiene programs in Canada to determine if they correlate with a program's success rate on the National Dental Hygiene Certification Exam (NDHCE). While all programs use grades as an admission criterion, those that require more post-secondary credits prior to admission tend to perform better on the NDHCE. Some programs also conduct interviews, but it is unclear which attributes are being evaluated. Because dental hygienists interact closely with the public, an assessment of a potential student's "soft skills" during interviews may be useful.

Hari P, Dutta S, Hanapi NSBM, Ali TBT, Thomas B, Tang TH, Akram A. Evaluation of isosceles-configured SUN Teeth™ toothbrush in dental plaque removal and gingival health. *Can J Dent Hyg.* **2021;55(2):101–109.**

Toothbrush design has a significant impact on brushing efficacy, particularly in the areas that are difficult to clean. This study evaluated the clinical efficacy and safety of a toothbrush with bristles angled at 45° in comparison to a standard reference toothbrush. Researchers recruited 104 participants for this 4-week study, who were randomized into either the test or control group. Gingivitis and plaque scores were recorded on days 1, 14, and 28. Both scores were reduced at all time intervals in both groups, showing that the isosceles-configured (45°-angled) toothbrush is equivalent in plaque removal to the conventional, flat-bristled reference brush. The 45° angle of the test brush bristles may make it easier for clients to adopt the modified Bass brushing technique.

Henneberry K, Hilland S, Haslam SK. Are dental hygienists at risk for noise-induced hearing loss? A literature review. *Can J Dent Hyg.* **2021;55(2):110–119.**

This article reviews 26 studies of noise-induced hearing loss among oral health professionals and describes current hearing protection options. Research shows that dental hygienists may be at risk of temporary and permanent hearing loss from noise in the dental setting. However, more research is necessary to determine the long-term effects of exposure to high-frequency noise from ultrasonic scalers. To prevent hearing loss, dental hygienists should schedule regular hearing exams with an audiologist and use active (electronic) sound control devices, as they block high-level sounds while still enabling 2-way communication with clients.

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COLTENE

Effects of an oral hygiene regimen on progression of gingivitis/early periodontitis: A randomized controlled trial

Avraham Zini[*], DMD, MPH, PhD; **Sigal Mazor**[*], MPH, DMD; **Hans Timm**[§], PhD; **Matthew L Barker**[ǂ], PhD; **Julie M Grender**[ǂ], PhD; **Robert W Gerlach**[ǂ], DDS, MPH; **Aaron R Biesbrock**[ǂ], DMD, PhD, MS

PRACTICAL IMPLICATIONS OF THIS RESEARCH

- An oral hygiene home care regimen including an electric toothbrush, stannous fluoride dentifrice, CPC rinse, and dental floss improved gingival health and slowed the rate of disease progression compared to a regimen involving a manual toothbrush and sodium fluoride dentifrice only.
- At-home use of the regimen can provide long-term periodontal health benefits.

ABSTRACT

Background: Periodontal disease continues to be prevalent globally, but little clinical research has been undertaken to evaluate the long-term benefits of a daily oral hygiene regimen on progression of gingivitis/early periodontitis. The objective of this study was to evaluate the effects of an oral hygiene regimen (OHR) on the periodontal health of adults in good general health with established gingivitis and early periodontitis over 24 months. **Methods**: A randomized controlled trial was conducted in adults with established gingivitis, with isolated sites of probing pocket depth >4 mm. Study participants were randomized to the OHR (bioavailable stannous fluoride dentifrice, oscillating-rotating electric toothbrush, cetylpyridinium chloride rinse, and floss; P&G) or usual care products (sodium fluoride dentifrice and manual toothbrush; P&G) groups. At baseline and every 6 months, gingivitis and periodontal measures were assessed and a prophylaxis was conducted. The primary outcome was Gingival Bleeding Index–Bleeding Sites (GBI–BS). Analyses used ANCOVA at 5% significance levels. **Results**: A total of 107 individuals were enrolled; 87 completed the study. Mean GBI–BS, Modified Gingival Index, and Probing Pocket Depth (PPD) scores were significantly lower at each visit for the OHR versus usual care group by 28% to 39%, 12% to 18%, and 6% to 13%, respectively ($p \leq 0.0009$). The magnitude of reduction in median number of ≥2 mm PPD loss events for OHR versus the usual care group at 24 months was 74%. **Conclusion**: Long-term use of the OHR produced significant periodontal health improvements versus the usual care products.

RÉSUMÉ

Contexte : La maladie parodontale continue d'être prévalente sur le plan mondial, mais peu de recherches cliniques ont été effectuées pour évaluer les avantages à long terme d'un régime d'hygiène buccodentaire sur la progression de la gingivite ou de la parodontite précoce. L'objectif de cette étude était d'évaluer les effets d'un régime d'hygiène buccodentaire (RHB) sur la santé parodontale des adultes en bonne santé générale qui présentent une gingivite établie et une parodontite précoce au cours de 24 mois. **Méthodologie :** Un essai contrôlé randomisé a été effectué chez des adultes présentant une gingivite établie et des sites isolés de profondeurs de poches au sondage >4 mm. Les participants de l'étude ont été confiés à un groupe de RHB aléatoire (pâte dentifrice au fluorure stanneux biodisponible, une brosse à dents électrique rotative et oscillante, un rince-bouche au chlorure de cétylpyridinium et la soie dentaire; P & G) ou à un groupe de produits de soins habituels (dentifrice au fluorure de sodium et une brosse à dents manuelle; P & G). La gingivite et les mesures parodontales ont été évaluées au début de l'intervention et tous les 6 mois et une prophylaxie avait été effectuée. Le résultat primaire était l'Indice de saignement gingival–les sites de saignements (ISG–SS). L'analyse de covariance a été utilisée à des seuils de signification de 5 %. **Résultats :** Un total de 107 personnes ont été inscrites : 87 ont terminé l'étude. Les cotes moyennes de l'ISG–SS, de l'indice gingival modifié et des cotes de profondeurs des poches au sondage (PPS) étaient significativement plus faibles à chaque visite du groupe de RHB par rapport au groupe de soins habituels, de 28 % à 39 %, 12 % à 18 % et 6 % à 13 %, respectivement ($p \leq 0{,}0009$). L'ampleur de la réduction en nombre médian d'événements de perte de PPS ≥2 mm du groupe de RHB par rapport au groupe de soins habituels était de 74 % à 24 mois. **Conclusion :** L'utilisation à long terme du RHB a produit des améliorations significatives de la santé parodontale par rapport aux produits de soins habituels.

Keywords: cetylpyridinium chloride; dental floss; gingivitis; oral hygiene; periodontal diseases; stannous fluoride
CDHA Research Agenda category: risk assessment and management

INTRODUCTION

Surveys find the earliest form of periodontal disease, gingivitis, in the majority of populations worldwide.[1-3] The more severe form of periodontal disease, periodontitis, affects approximately 10% of surveyed populations.[2,3] Gingivitis and periodontitis result from an inflammatory response in the periodontal tissues due to localized toxic effects of dental plaque microbial biofilms.[4-6] Host response competence also plays an important role in the progression from gingivitis to

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periodontitis.[7] The cost and effort to repair (or compensate for) damaged periodontium (e.g., periodontal therapy, dental implants, prosthodontics) support the importance of disease prevention, principally consistent, effective oral hygiene directed towards thorough dental plaque removal. While professional dental scaling and root planing provide this benefit on an infrequent basis, daily thorough personal oral hygiene is considered to be the most effective approach to maintaining a healthy periodontium.[4,8-12] Though most populations carry out some form of daily oral hygiene, the underlying epidemiological statistics and specific studies show most individuals find it challenging to maintain periodontal health through their own efforts.[13-15]

Numerous clinically proven products have been developed to assist clients in improving gingival health, including manual toothbrushes with angled bristles,[16] oscillating–rotating electric toothbrushes,[17,18] irrigators,[19] polytetrafluoroethylene dental floss,[20] and a number of antimicrobial dentifrices and mouthrinses.[21] Several studies have begun to evaluate the effect of these oral hygiene measures on more advanced periodontal disease progression.[22-25] Recent studies have been initiated to explore the benefits of combination oral hygiene for controlling plaque and gingivitis at home.[26-28]

The purpose of this study was to examine the clinical benefits of combined mechanical (oscillating–rotating electric toothbrush + polytetrafluoroethylene dental floss) and chemotherapeutic (bioavailable stannous fluoride toothpaste and cetylpyridinium chloride mouthrinse) technologies on the prevention of gingivitis and progression of probing pocket depth (PPD) over a 2-year period in generally healthy adults with established gingivitis and isolated sites with PPD >4 mm.

METHODS

Study design and population

This was a randomized, controlled, examiner-blind, 2-treatment parallel group study approved by an Institutional Review Board (Ref# 0482-13-HMO, Hadassah Medical Organization Helsinki Committee, Jerusalem, Israel) and registered in the ISRCTN database (ISRCTN66780304). The study was conducted over a 24-month period at the Kibbutz Na'an in Israel. One hundred and ten physically healthy adult volunteers with established gingivitis and isolated sites of PPD >4 mm but no PPD >6 mm were qualified to be enrolled in the study. All participants provided written, informed consent. The target population consisted of individuals between 18 and 65 years of age with at least 16 natural teeth, a minimum of 20 bleeding sites, and 9 sites for possible plaque sampling, including 3 healthy sites (PPD ≤3 mm, no bleeding), 3 gingivitis sites (PPD ≤3 mm, bleeding), and 3 periodontal sites (PPD 4 mm to 6 mm, bleeding). Individuals with moderate to severe periodontal disease, undergoing active treatment for periodontitis, and/or any diseases or conditions that could be expected to interfere with safe completion of the study were excluded. Plaque sampling was conducted for purposes of future research. Participants were stratified and randomly assigned equally to either a regimen group (antimicrobial paste, rinse, floss, and electric toothbrush) or a usual care group (standard anti-cavity toothpaste and regular manual toothbrush). Participants were requested to carry out home oral hygiene with the assigned products twice daily for the duration of the study according to the written and verbal usage instructions given to them during product distribution. At the same time points, participants received oral soft tissue exams and had gingival inflammation, bleeding, and periodontal evaluations. Both groups received supragingival dental prophylaxes every 6 months at study visits, consistent with local norms and standards. Products were resupplied approximately every 6 months post-baseline. Study participants were contacted periodically to check compliance with product use.

Investigational product(s) and instructions

The regimen group was provided an oscillating–rotating electric toothbrush with brush head comprising angled bristles (Oral-B Professional Care 5000 with Smart Guide and CrossAction [EB50] brush head); dentifrice with 1100 ppm F bioavailable stannous fluoride and 350 ppm F sodium fluoride (Oral-B Pro-Expert All Around Protection toothpaste); 0.07% cetylpyridinium chloride rinse (Crest Pro-Health Multi-Protection rinse); and floss (Oral-B Essential). Participants were instructed to brush with the assigned electric toothbrush and the marketed dentifrice for 2 minutes twice daily (morning and evening) following the manufacturer's usage instructions and to floss the whole mouth once daily for the duration of the study. They were instructed to glide the floss between teeth to the gumline and to curve the floss to contact as much of the tooth as possible and to rinse with 20 mL of the mouth rinse for 30 seconds after each brushing. Participants used only the assigned products in place of normal oral hygiene products for the duration of the study.

The usual care group was provided a dentifrice with 1450 ppm F sodium fluoride (Oral-B 123) and a soft regular manual toothbrush (Oral-B Indicator 35). They were instructed to brush with the assigned products twice daily (morning and evening) in their customary manner, using only the assigned products in place of normal oral hygiene products during the study (continued use of floss was allowed if that was part of their usual care). All products in both groups were manufactured by The Procter and Gamble Co., Cincinnati, Ohio, USA.

Study visits

Study participants refrained from performing any oral hygiene procedures the morning prior to scheduled evaluation visits and from using medicated lozenges, breath mints, eating, drinking (except for water), smoking, and chewing gum for 4 hours prior to the visit. A comprehensive oral examination was conducted, and demographic information and study inclusion and exclusion criteria were obtained. Participants then received Modified Gingival Index (MGI), Gingival Bleeding Index (GBI), CAL, and PPD assessments in that order by the

same experienced examiner (AZ). They were instructed to continue using regular home oral hygiene products until the baseline visit, approximately 2 weeks after screening.

At baseline, continuance criteria were verified and a comprehensive oral examination was conducted. Participants were randomized to either the regimen or usual care group by site staff using a computer-generated sequence produced by the study sponsor based on screening mean PPD, mean GBI, age, gender, and tobacco use. They received assigned products from site staff to use twice daily in an area separated from the examination area to ensure blinding of the examiner to the identity of the test products. Participants in both groups also received supervised oral hygiene and product usage instructions (verbal and written) and used the assigned products in front of a mirror supervised by site staff, which was considered one of the participant's 2 daily brushings. Approximately 1 week later, and periodically throughout the study, site staff not blinded to the products reconnected with all individuals via phone to ensure proper product usage and compliance. Within 1 month from baseline visit, all participants received a dental prophylaxis.

At months 6, 12, 18, and 24 participants returned to the site and continuance criteria were verified. Participants returned used brush heads (regimen group), manual brushes (usual care group), paste, rinse, and floss. Site staff monitored compliance based on the product returns, and if low product consumption was suspected study participants were reinstructed on product usage (at months 6, 12, and 18). At each visit, participants used their assigned treatment products in front of a mirror supervised by site staff. A comprehensive oral examination was then conducted followed by an MGI assessment by the experienced examiner. Participants then received GBI, CAL/GR, and PPD examinations in that order by the experienced examiner.

Following that, participants received a supplemental kit box containing resupply of assigned products in an area separated from the examination area to ensure blinding of the examiner to the identity of the test products. Within 1 month from month 6, 12, 18, and 24 visits, participants received a dental prophylaxis.

The same experienced examiner conducted clinical assessments for each participant: MGI,[29] GBI,[30] CAL/GR, and PPD. The examiner was blinded to the treatment group assigned to each subject. Clinical information was recorded for all scorable teeth present, excluding 3rd molars, teeth with crowns or large restorations (i.e., covering 50% or more of the tooth surface), bridges, orthodontic appliances or implants. At screening, direct measurements of MGI, GBI, PPD, and CAL were made and GR was calculated as follows GR = CAL – PPD. After completion of screening measurements, it was decided, based on practical considerations, to replace direct measurements of CAL at subsequent visits with direct measurements of GR and to calculate CAL as follows: CAL = GR + PPD (where CEJ/recession = positive values and overgrowth = negative values). The impact of this change in measurement methodology for CAL and GR between baseline and ensuing visits resulted in confounding of CAL and GR measurements with respect to magnitude and ≥2 mm loss events. Oral soft tissue assessment was conducted by a licensed dental professional. Abnormal findings were recorded and categorized by location; hard tissue findings were categorized as "other." An adverse event was recorded if a new abnormal finding was noted after product distribution or if any previously noted abnormal finding increased in severity during the treatment period. All self-reported adverse events were recorded. Whole body adverse events were collected only if potentially related to product use.

Statistical methods

Statistical power calculations were conducted and a sample size of 94 individuals (47 per group) would yield at least 85% power to detect a statistically significant difference between treatment groups estimating a mean difference of 9.0 bleeding sites with a standard deviation of 14.4. In addition, there would be at least 85% power to estimate a mean difference of 0.125 for MGI with a standard deviation of 0.200. These power calculations utilized a 2-sided 5% significance level. Up to 110 participants (55 per group) were enrolled in the study to account for the possibility of up to 15% subject dropout.

Participants were stratified based on screening mean GBI (equal to/above or below 0.49), mean PPD (equal to/above or below 2.23 mm), mean age (equal to/above or below 45 years of age), gender (male or female), and tobacco use (yes or no). Within strata, participants were randomized to 1 of the 2 study groups using a balance and assignment procedure on site. Participants from the same household were assigned to the same study group.

The primary variable was number of bleeding sites (GBI-BS) as measured from GBI. Summary statistics (e.g., means, standard deviations, frequencies) of the demographic characteristics as well as each efficacy endpoint were calculated for each study group and visit. For each efficacy variable and visit, the means for the study groups were compared using the analysis of covariance method with the screening values of the respective endpoint as the covariate. For each efficacy variable and visit, mean comparisons to screening for each study group were investigated using paired difference t-tests. Additionally, the average number of persistent bleeding sites (e.g., sites bleeding at consecutive visits) were summarized by visit for each study group. The location of the persistent bleeding sites at each visit was estimated by determining highest site frequency within each group. The average number of sites with pocket depth progression of 2 mm or greater from the screening visit was also summarized by visit and study group. The location of the sites with pocket depth incidence 2 mm or greater at each visit were estimated by determining the highest site frequency within each study group. To analyse the number of ≥2 mm PPD loss events, a nonparametric ANOVA was carried out at each visit to determine between groups differences.

Statistical tests were 2-sided using a 5% significance level. *P* value adjustments were not carried out for multiple testing, and missing data were not imputed since only 2% of post-baseline data was missing.

RESULTS

One hundred and ten (110) individuals were screened; 107 signed informed consents for study participation and were enrolled. Seventeen subjects were dropped at baseline because they were inappropriately placed in the regimen group in conflict with their randomization assignment to the control group, leaving 90 who were assigned to treatment and received products. Three enrollees did not complete the study—2 were lost to follow-up and 1 dropped out due to pregnancy—leaving 87 participants completing the 24-month clinical evaluations (Figure 1). Table 1 shows baseline demographics and clinical measures. Individuals who entered into the study ranged in age from 28 years to 64 years, with an average of 46.7 years. Fifty percent (50%) of participants were female and 14% were tobacco users.

Self-reported oral hygiene practices at baseline indicated that 98% of all study participants had regular dental cleanings or checkups; 84% reported having biannual visits. More than 80% reported using a manual toothbrush and toothpaste at least twice daily. The majority (≥69%) reported using mouthwash, dental floss, and an electric rechargeable toothbrush no more than once a week.

At baseline, the mean number of gingival bleeding sites (GBI-BS) was 55–56 (screening), with a mean MGI score of 1.68–1.69 (Table 1). Table 2 highlights gingivitis measures (GBI-BS, MGI) at months 6, 12, 18 and 24. The usual care group showed little change in either GBI-BS or MGI throughout the 24-month study period. The regimen group in contrast showed statistically significant ($p < 0.001$) and consistent reductions in number of GBI-BS and MGI throughout the study at months 6, 12, 18, and 24. With respect to GBI-BS, the regimen group was associated with statistically significant ($p < 0.001$) reductions of 33%, 28%, 38%, and 39% at 6, 12, 18, and 24 months versus the usual care group. With respect to MGI, the regimen group was associated with statistically significant ($p < 0.001$) reductions of 14%, 12%, 17%, and 18% at 6, 12, 18, and 24 months versus the usual care group. Importantly, the difference between regimen and usual care groups in the management of gingival bleeding increased over time (Figure 2).

The GBI-BS data were analysed with respect to which sites manifested bleeding most frequently by both timepoint and treatment group. These frequency data were plotted on whole mouth tooth diagrams to visualize where bleeding sites most frequently occurred through rank ordering (Figure 3). These data support that bleeding sites occur with the highest frequency in the posterior and interproximal dentition. Similar analysis examining persistent GBI-BS, defined as those sites that bled at baseline and each ensuing visit, was performed. These frequency data for persistent GBI-BS were plotted on whole mouth tooth diagrams to visualize where persistent bleeding sites most frequently occurred through rank ordering (Figure 4). With respect to persistent GBI-BS, the regimen group was associated with statistically significant ($p < 0.001$) reductions of 33%, 43%, 53%, and 64% at 6, 12, 18, and 24 months versus the usual care group.

Table 3 shows results for PPD. PPD loss events over the 2-year treatment period were statistically significantly ($p < 0.001$) lower in individuals in the regimen group compared

Table 1. Baseline demographics summary and clinical parameters

Demographic/statistic or category	Control (n = 53)	Regimen (n = 54)	Overall (N = 107)	*p* value
Age (years)				
Mean (SD)	47.6 (10.29)	45.9 (10.79)	46.7 (10.53)	0.4075[a]
Min–Max	28–64	29–63	28–64	
Sex				
Female[b], n (%)	26 (49)	27 (50)	53 (50)	1.0000[c]
Male[b], n (%)	27 (51)	27 (50)	54 (50)	
Tobacco				
No[b], n (%)	46 (87)	46 (85)	92 (86)	1.0000[c]
Yes[b], n (%)	7 (13)	8 (15)	15 (14)	
Mean GBI-BS	56.11 (14.921)	55.36 (13.723)	55.73 (14.266)	0.784
Mean MGI score (SD)	1.69 (0.154)	1.68 (0.129)	1.68 (0.141)	0.723
Mean PPD mm (SD)	2.25 (0.186)	2.25 (0.206)	2.25 (0.195)	0.980
Mean CAL mm (SD)	2.62 (0.228)	2.60 (0.241)	2.61 (0.234)	0.783
Mean GR mm (SD)	0.36 (0.174)	0.35 (0.139)	0.36 (0.157)	0.741

[a]2-sided ANOVA *p* value for the treatment comparison
[b]The number (percent) of participants in each category
[c]2-sided Fisher's exact test *p* value for the treatment comparison

Figure 1. Study flow diagram

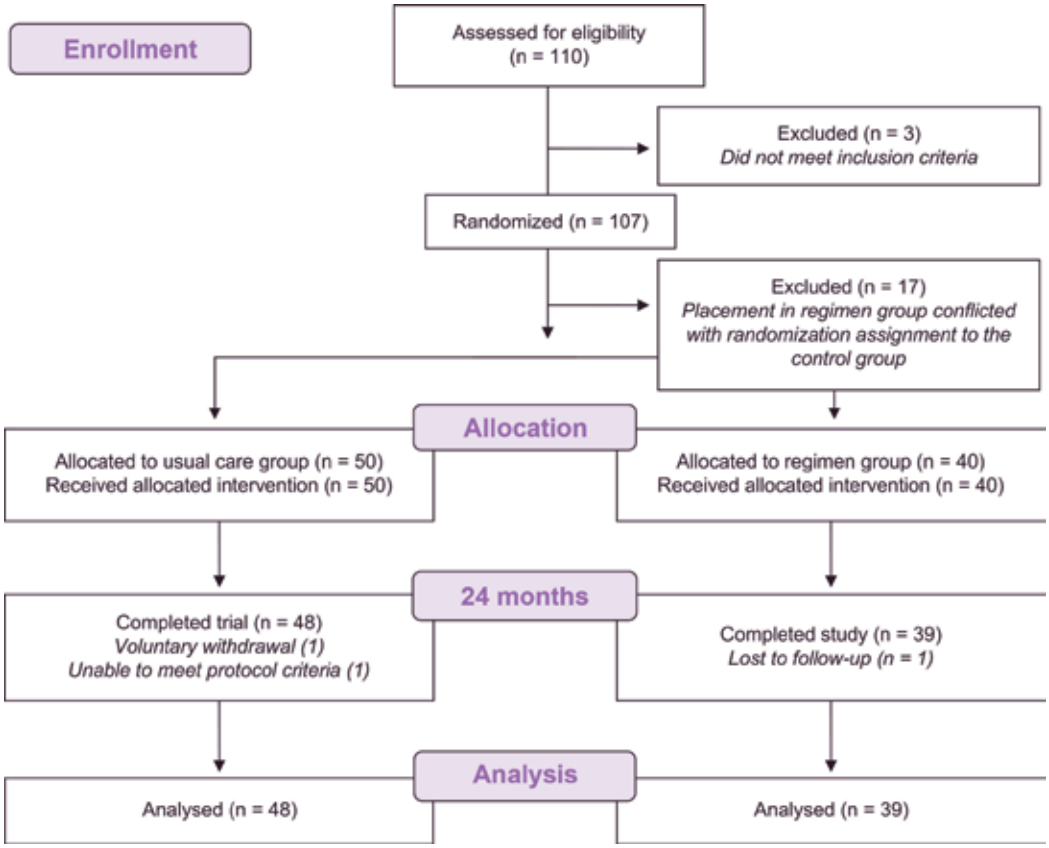


Table 2. Gingivitis clinical results (GBI-BS, MGI) per visit

Treatment	n	Adjusted mean GBI-BS (SE)	% change versus control	2-sided *p* value[a]	Adjusted mean MGI Score (SE)	% change versus control	2-sided *p* value[a]
Month 6							
Control	50	60.11 (2.564)			1.80 (0.021)		
Regimen	40	40.36 (1.887)	32.9	<0.0001	1.54 (0.025)	14.1	<0.0001
Month 12							
Control	49	58.37 (2.689)			1.55 (0.024)		
Regimen	39	42.18 (2.127)	27.7	<0.0001	1.37 (0.025)	11.8	<0.0001
Month 18							
Control	48	60.63 (2.593)			1.57 (0.022)		
Regimen	39	37.48 (2.144)	38.2	<0.0001	1.31 (0.020)	16.9	<0.0001
Month 24							
Control	48	60.01 (2.144)			1.65 (0.019)		
Regimen	39	36.63 (2.064)	39.0	<0.0001	1.35 (0.018)	18.4	<0.0001

[a]ANCOVA with respective screening value as the covariate

Figure 2. Mean GBI-BS per visit

*Means are adjusted for months 6, 12, 18, and 24
**$p < 0.001$ for change from control and change from baseline

Figure 3. Location of most frequent bleeding sites by visit

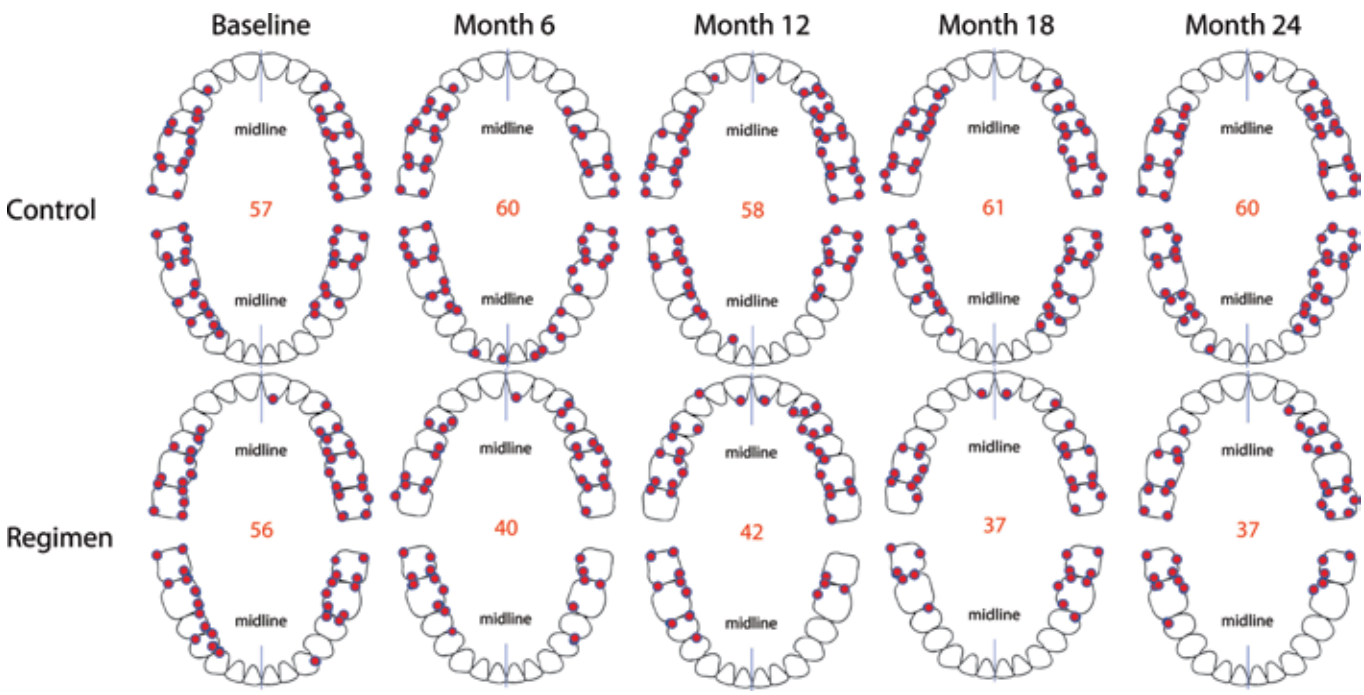
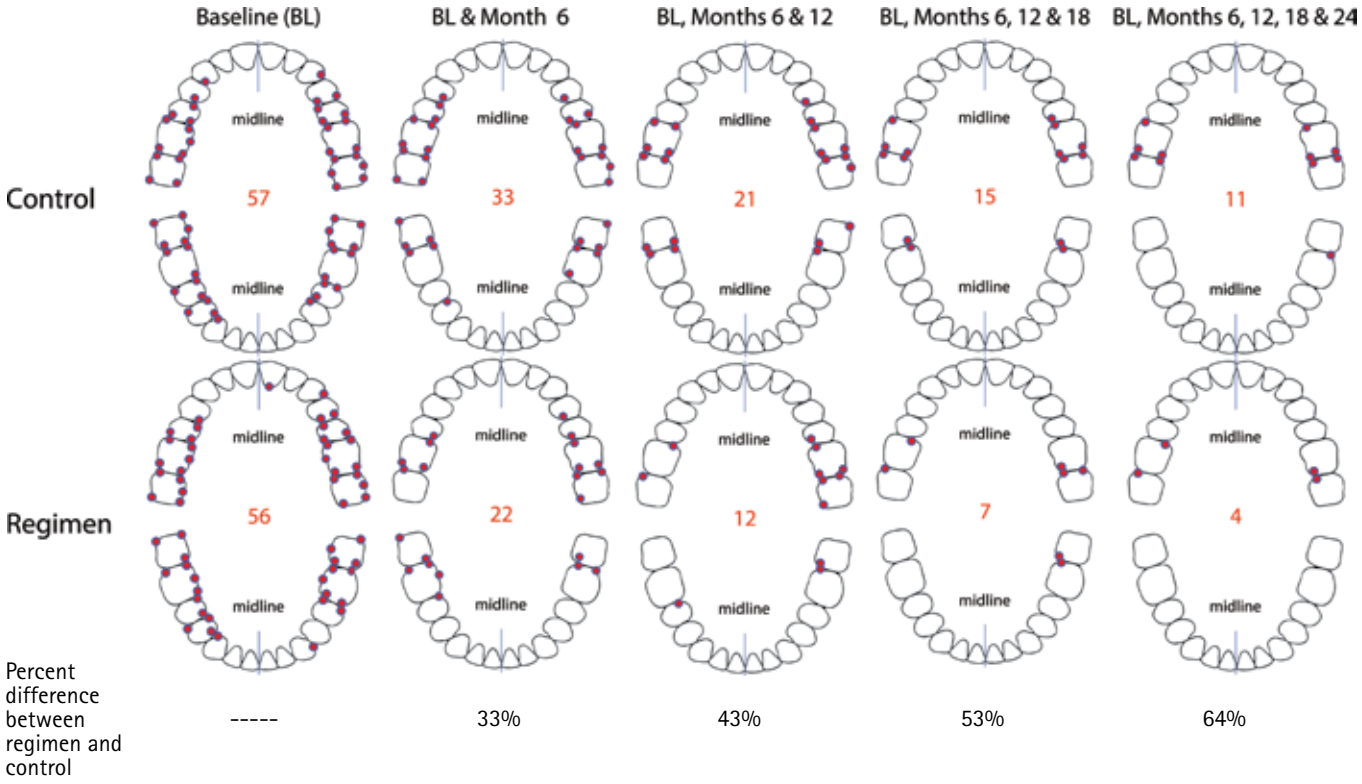


Figure 4. Location of most frequent persistent bleeding sites by visit



to those in the usual care group. The PPD adjusted means for the regimen group were lower by 12%, 6%, 11%, and 13% at 6, 12, 18, and 24 months, respectively.

Figure 5 shows median number of sites with ≥2 mm PPD loss events from baseline per subject analyses. PPD loss events during the study period were lower in participants in the regimen group than in those in the usual care group. For median number of ≥2 mm PPD loss events, results were statistically significantly ($p \leq 0.005$) lower for the regimen group with fewer median number of events by 73%, 56%, 77%, and 74% at 6, 12, 18, and 24 months, respectively, versus the usual care group. Figure 6 shows the location of the most frequent ≥2 mm PPD loss events by tooth and site over the course of the study.

There was 1 non-serious adverse event (mild burning mouth) reported in the regimen group at month 6 which resolved. All components of the test regimen as well as the usual care products were well tolerated.

DISCUSSION

Clinical data support efficacy for the individual therapeutic interventions of oscillating–rotating electric toothbrushes, bioavailable stannous fluoride dentifrice, cetylpyridinium chloride mouthrinse, and dental floss for reducing plaque and gingivitis.[16,17,20,21] However, a limited number of studies have examined these individual therapies for periodontal disease progression extending up to 2 years.[23] Likewise, combinations of these therapies have been examined in shorter-term studies showing high levels of efficacy.[26-28]

This study combined 4 clinically proven technologies for their gingivitis effects and progression of periodontal indices over a longer period (2 years) in adults with established gingivitis and isolated sites of incipient periodontitis. Results demonstrated significant and consistent efficacy of the regimen in reducing number of GBI-BS and gingival inflammation (MGI) over 2 years. The periodontal measure of PPD progressed consistently throughout the study. In the regimen group, PPD increased over the 24 months. However, the increase in this periodontal parameter was statistically significantly lower versus the usual care group. The magnitude of reduction in GBI-BS for the regimen versus usual care group was 39% at 24 months. The magnitude of reduction in median PPD for the regimen versus usual care group at 24 months was 13%. The magnitude of reduction in ≥ 2 mm PPD loss events for the regimen versus usual care group at 24 months was 74%. These represent clinically important reductions in gingival inflammation and periodontal measures.

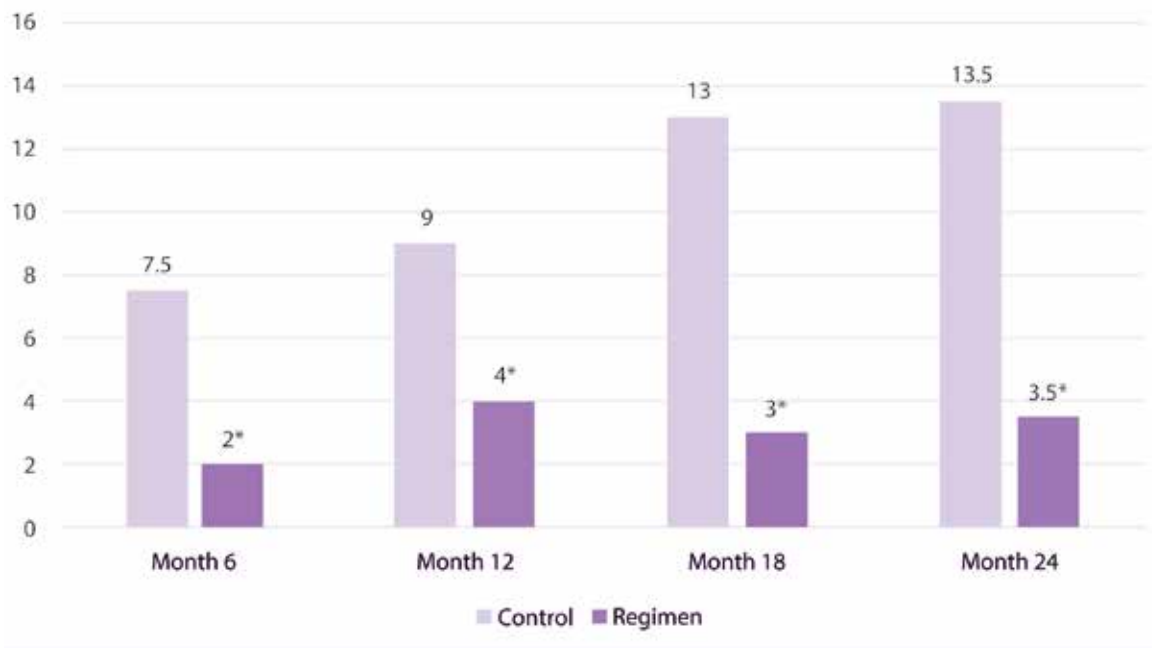
Clearly, the regimen slowed the rate of periodontal disease progression in the population. The decreased progression of PPD in the regimen group might be expected from the reductions in GBI-BS observed during the study for the regimen group versus the usual care regimen. Lang and others[31-34] have systematically studied the longitudinal progression of periodontal disease in populations and assessed the role of localized gingivitis on disease progression towards tooth loss. In these studies,

Table 3. Periodontal clinical results (PPD) per visit

Treatment	n	Adjusted mean PPD mm (SE)	% change versus control	2-sided *p* value[a]
Month 6				
Control	50	2.65 (0.047)		
Regimen	40	2.33 (0.041)	12.3	<0.0001
Month 12				
Control	49	2.75 (0.030)		
Regimen	39	2.57 (0.041)	6.3	0.0009
Month 18				
Control	48	2.86 (0.031)		
Regimen	39	2.54 (0.033)	11.4	<0.0001
Month 24				
Control	48	2.91 (0.035)		
Regimen	39	2.54 (0.026)	12.6	<0.0001

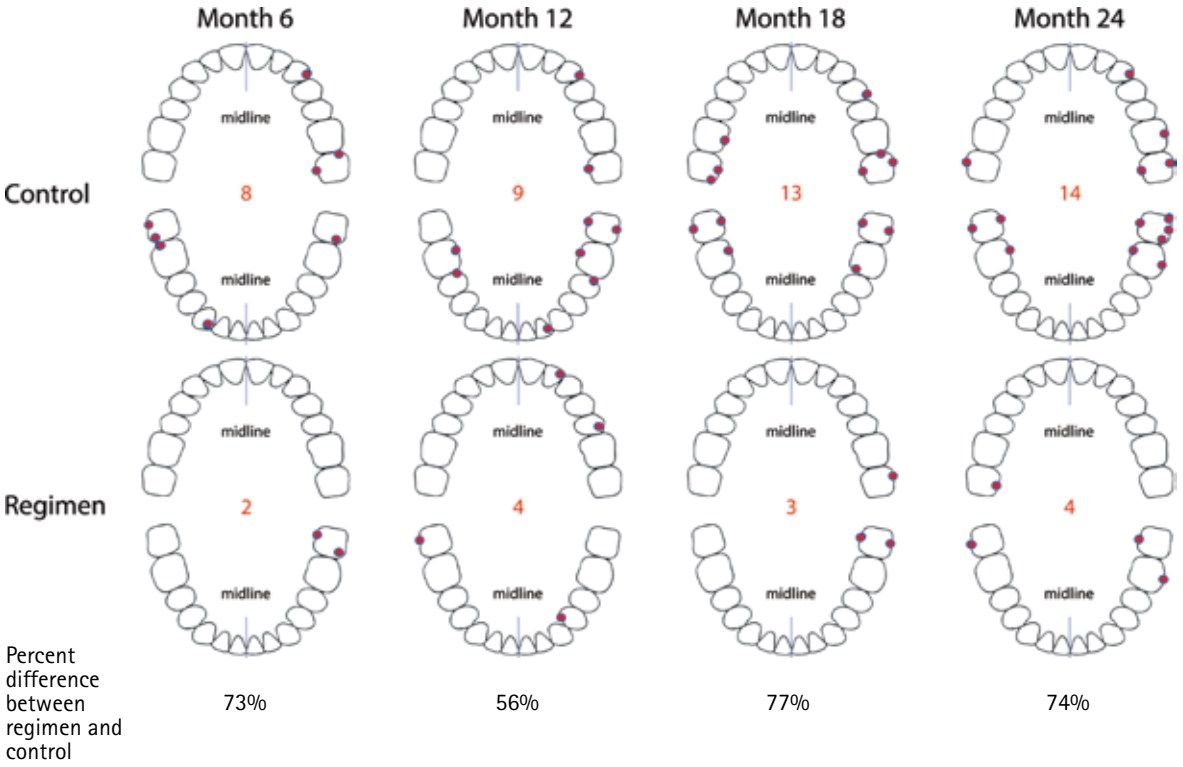
[a]ANCOVA with respective screening value as the covariate

Figure 5. Median number of ≥ 2 mm PPD loss events



*$p \leq 0.005$ versus control group, nonparametric ANOVA

Figure 6. Location of most frequent ≥ 2 mm PPD loss events from baseline by visits



sites with persistent gingival bleeding on probing exhibited significantly elevated rates of CAL as compared to sites with infrequent or no gingival bleeding. These studies went on to determine that approximately one-third of sites with consistent gingival bleeding during adulthood are at risk of future tooth loss due to periodontal disease. PPD and CAL are highly correlated, as CAL is calculated by adding PPD and GR. The results of this study support the benefits that reducing gingival bleeding has on reducing the rates of PPD progression.

With respect to study limitations, the change in measurement methodology for CAL (direct) and GR (imputed) at screening/baseline to CAL (imputed) and GR (direct) at 6, 12, 18, and 24 months introduces a potential confounding effect on change from baseline analyses in terms of absolute magnitude of change, as well as the ability to measure CAL events. Importantly, the GBI-BS, MGI, and PPD measures were not affected by this change in methodology. Due to the nature of the study in which the test variable was the regimen itself rather than the individual products within the regimen, another limitation is that it is impossible to determine the relative contribution of each product within the regimen with respect to the observed clinical benefits. Nevertheless, the study results provide compelling evidence of the importance of oral hygiene measures in improving the gingival health of clients with at-home care. Furthermore, these gingival health improvements have the long-term benefit of slowing the progression of periodontal disease (PPD).

CONCLUSIONS

In summary, a regimen of oral care hygiene aids including an oscillating–rotating electric toothbrush, bioavailable stannous fluoride dentifrice, cetylpyridinium chloride mouthrinse, and dental floss was found to be effective in reducing GBI-BS, MGI, and PPD compared to a usual care routine including a manual toothbrush and fluoride toothpaste over a period of 2 years. The regimen was well tolerated by study participants.

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Admission criteria for Canadian dental hygiene programs

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Canadian dental hygiene programs seek to select applicants who are not only most likely to be successful on the culminating board examination, but also who embody the values and attitudes desired of the profession.
- There is a moderate, positive correlation between a program's performance on the NDHCE and the number of postsecondary credits required for admission.
- Programs that have an increased credit requirement for application may have an applicant pool with higher academic performance than those programs that require fewer prerequisites.

ABSTRACT

Objective: The purpose of this project was to understand the variation in admission criteria to Canadian dental hygiene programs and determine whether the criteria are appropriate in predicting a program's success rate on the National Dental Hygiene Certification Exam (NDHCE). **Methods:** Admission criteria were gathered from the websites of English-language dental hygiene programs in Canada. Individual dental hygiene programs were also contacted directly by phone or email if their admission criteria were not outlined on the program website. NDHCE success rates for each program were collected from the National Dental Hygiene Certification Board website. The association between the admission criteria and NDHCE success rates was examined. Pearson's product moment correlations were performed for post-secondary credits required for admission and program length. **Results:** Admission criteria for 29 of 30 dental hygiene programs were examined. Twenty-two programs accepted applicants directly from high school. The average program length was 83.7 weeks. Four programs offered post-diploma baccalaureate degrees in dental hygiene; one program offered a direct entry-to-practice degree program. Twenty-two (22) of the 29 programs utilized academic grades (including overall and/or prerequisite GPA) as admission criteria. Twelve programs included interviews in the admission process. A moderate correlation was observed between the number of postsecondary credits required for admission and NDHCE success rates (r = 0.6723). A weak correlation was found between program length and NDHCE success rates (r = 0.1797). **Conclusion:** Academic performance as an admission criterion, including overall/prerequisite GPA, was the most common criterion used by dental hygiene programs. Graduates from programs that required more postsecondary credits tended to perform better on the NDHCE. The higher success rate may be attributed to the rigour of the prerequisite courses, which may prepare students for dental hygiene studies and ultimately success on the national examination. In addition, students with more postsecondary coursework may be better adjusted to studies at a postsecondary level and/or be more experienced at taking examinations.

RÉSUMÉ

Objectif : Le présent projet avait pour but de comprendre la variation des critères d'admission aux programmes d'hygiène dentaire canadiens et d'établir la pertinence des critères dans la prédiction des taux de succès d'un programme à l'examen de certification nationale en hygiène dentaire (ECNHD). **Méthodologie :** Les critères d'admission ont été obtenus à partir de sites Web de programmes d'hygiène dentaire anglophones au Canada. On a communiqué directement par téléphone et par courriel avec les programmes d'hygiène dentaire individuels si leurs critères d'admission n'étaient pas présentés sur le site Web du programme. Les taux de succès à l'ECNHD de chaque programme ont été recueillis du site Web du Bureau national de la certification en hygiène dentaire. Le lien entre les critères d'admission et les taux de succès à l'ECNHD ont été examinés. La méthode de corrélation de moment-produit de Pearson a été utilisée pour examiner les crédits postsecondaires requis pour l'admission et la longueur du programme. **Résultats :** Les critères d'admission de 29 des 30 programmes d'hygiène dentaire ont été examinés. Vingt-deux programmes ont admis des étudiants directement de l'école secondaire. La longueur moyenne des programmes était de 83,7 semaines. Quatre programmes offraient des programmes post-diplôme menant au baccalauréat en hygiène dentaire; un programme offrait un programme d'admission directe à la profession. Vingt-deux (22) des 29 programmes utilisaient les notes scolaires (y compris la moyenne pondérée cumulative globale ou de prérequis) comme processus d'admission. Douze programmes avaient un processus d'admission qui comprenait des entrevues. Une corrélation modérée a été observée entre le nombre de crédits postsecondaires requis pour l'admission et les taux de succès à l'ECNHD (r = 0,6723). Une faible corrélation a été trouvée entre la longueur du programme et les taux de succès à l'ECNHD (r = 0,1797). **Conclusion :** Les programmes d'hygiène dentaire utilisaient le plus fréquemment la performance scolaire comme critère d'admission, y compris la moyenne pondérée cumulative globale ou de prérequis. Les diplômés de programmes qui exigeaient un plus grand nombre de crédits postsecondaires avaient tendance à mieux réussir à l'ECNHD. Le taux de succès plus élevé peut être attribué à la rigueur des cours prérequis, ce qui pourrait préparer les étudiants aux études d'hygiène dentaire et en fin de compte, à la réussite de l'examen national. De plus, les étudiants ayant un plus grand nombre de cours postsecondaires pourraient être davantage prêts aux études de niveau postsecondaire ou être plus à l'aise à faire des examens.

Keywords: academic performance; academic success; Canada; dental hygiene certification; dental hygienists/education; educational measurement; humans; oral hygiene; school admission criteria; students

CDHA Research Agenda category: capacity building of the profession

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INTRODUCTION

The scope of dental hygiene practice in Canada varies greatly. Some dental hygienists practise independently, with local anesthetic, temporary restoration, and prescribing rights (e.g., Alberta), while others are required to work under the direct supervision of a dentist (e.g., Prince Edward Island).[1] Similarly, the criteria for admission to dental hygiene programs are equally diverse, partly because university-based dental hygiene programs offer pathways where students can graduate with a baccalaureate degree, while colleges and technical schools offer diplomas. The challenge for all dental hygiene programs is to identify and select applicants who not only are most likely to be successful in the program and on the culminating board examination, but also who embody the values and attitudes desired of the profession.

Much of the literature focuses on individual achievement of students admitted into the program. Dental hygiene programs throughout Canada typically consider student academics as a major admission criterion. The majority of programs use overall grade point average (GPA) and/or science GPA as part of their admission criteria. For example, a study found that individual students who have higher marks in prerequisite anatomy and physiology courses also have a higher success rate on board examinations.[2] Furthermore, entering GPA has been shown to be the strongest predictor of individual success in both dental hygiene programs[3,4] and the American National Board Dental Hygiene Examination (NBDHE).[3]

Other work has found that grades in specific courses as part of the dental hygiene programs, including oral pathology,[5] microbiology,[6] dental anatomy, head and neck anatomy,[5] and oral radiology, were found to be a predictor of success on the NBDHE.[7] A course in human nutrition was found to be correlated with cumulative dental hygiene GPA, which subsequently predicted success on the NBDHE.[2] The same study also found that prerequisite biology and chemistry courses were somewhat correlated with NBDHE success.[2] However, because these students had already been admitted into the dental hygiene programs, it is difficult to discern whether the programs' success was a result of appropriate selection of students or of the efficacy of the training program itself. In fact, Sanderson found that none of the 27 examined admission criteria were significantly correlated with NBDHE success rate,[8] suggesting that student success on the board exam is a product of the training programs, rather than selection for admission.

Some programs in Canada require that the applicants have prior postsecondary experience, while others admit students directly from secondary schools. At the University of Alberta (Edmonton), applicants are required to have at least one year of postsecondary education with specific mandatory prerequisite courses. Qualifying applicants are also required to participate in the multiple mini interview (MMI) to allow for evaluation of attributes that align with those of the program.[9] However, admission criteria for other programs in Canada vary widely, likely leading to the selection of applicants with very different characteristics.

While significant work has been done to correlate admission criteria and success on an individual level, there is little that examines a training program's success in selecting the most appropriate applicants. Given the resource-intensive nature of the selection process, an understanding of the variation in admission criteria across the country and how these criteria correlate with a program's success rate on the National Dental Hygiene Certification Exam (NDHCE) is important to ensure that admissions committees are selecting appropriate applicants to become future colleagues.

The purpose of this descriptive study is to examine the variation in admission criteria in Canadian dental hygiene programs. Using this discovery-driven approach will allow for the investigation of the full breadth of criteria used by various programs, while also capturing nuances that may otherwise be overlooked with a directed, hypothesis-driven approach.

MATERIALS AND METHODS

The work in this study was reviewed by and deemed outside the mandate of the University of Alberta Research Ethics Board (REB 2). Consequently, the requirement for ethics approval was waived.

Admission criteria were gathered from the websites of all 30 English-language dental hygiene programs in Canada. Twenty-nine (29) out of 30 programs were used in data analysis, as 1 program had incomplete admission criteria. Admission criteria included interview type, secondary and/or postsecondary prerequisite courses, personal profile, reference letter(s), and entrance GPA. Other information such as the length of program, whether the program is degree granting, class size, number of applicants, accreditation status, and direct entry from secondary schools was also recorded in a spreadsheet. Each program was contacted directly by phone or email to ascertain the specifics of the admission criteria if they were not outlined on the program website.

NDHCE pass rates for each program were collected from the National Dental Hygiene Certification Board (NDHCB) website for 2015–2017. Scores for programs with fewer than 5 candidates at a sitting were excluded from analysis.

The association between the admission criteria and NDHCE success rates was examined. Pearson's product moment correlations were calculated. Strength of the correlations were assigned according to the guidelines established by Evans[10]:

- 0.00 to 0.19: very weak
- 0.20 to 0.39: weak
- 0.40 to 0.59: moderate
- 0.60 to 79: strong
- 0.80 to 1.00: very strong

RESULTS

One program was excluded from analysis as the admission information was incomplete. Information from 29 accredited English language dental hygiene programs in Canada was collected. The majority were diploma programs; only 2 were degree programs, and another 2 offered a degree-completion option. Program lengths ranged from 64 weeks to 96 weeks, with a median of 90 weeks. NDHCE success rates ranged from 52% to 100% over the course of the 3 years (2015 to 2017, inclusive), with a median of 90%.

Eight schools required that students have postsecondary prerequisites (advanced entry). Eleven programs admitted students directly from high school and 10 schools allowed for both direct and advanced entry into the dental hygiene training programs. Biology, chemistry, and English were the most common prerequisites required, whether they were at the postsecondary or high school levels.

Twelve programs required that candidates participate in an interview process. Two of these schools used the MMI format, one used a candidate questionnaire, and one required interviews only for those students who were under special consideration. All other schools did not have an interview type specified. Eight programs required that candidates submit a personal profile or statement as part of their application package. Standardized tests in the form of the Health Occupation Aptitude Examination (HOAE), program-administered entrance exams or aptitude tests were administered by 12 programs. The most commonly used admission criteria were academically based. Nineteen schools used grade point averages (GPAs), prerequisite GPAs or minimum required grades as part of their admission process.

The NDHCE success rates were omitted in 8 instances where a program had fewer than 5 candidates at that particular examination session. Strong correlations were found in all 3 years that were investigated (2015, r = 0.6711; 2016, r = 0.6782; 2017, r = 0.6723; combined, r = 0.6982) between the number of postsecondary prerequisite credits and program success rates on the NDHCE (Figure 1). The correlations between program length and NDHCE success rate were weak or very weak (2015, r = 0.1666; 2016, r = 0.3093; 2017, r = 0.0546; combined, r = 0.1797) (Figure 2).

Figure 1. Moderate correlations between the number of postsecondary credits required for admission and NDHCE success rates (%) were observed

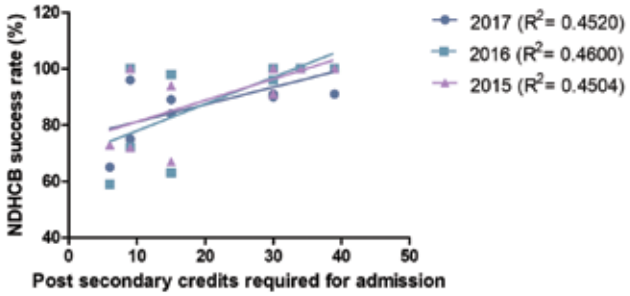
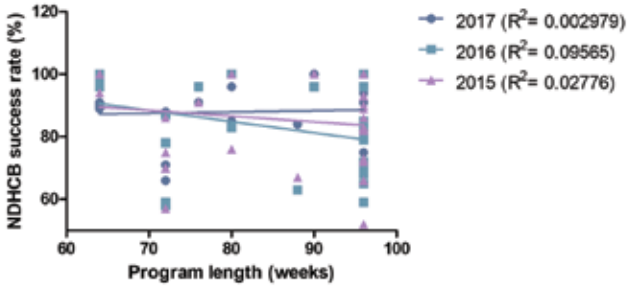


Figure 2. Weak correlations between program length (weeks) and NDHCE success rates (%) were observed



DISCUSSION

There is considerable variation in the student selection process for dental hygiene programs in Canada. Admission criteria generally fall into the following categories: academic criteria, non-cognitive requirements (personal statement, interview, work experience), and standardized testing.

Academic criteria

As expected, the use of grades, both in direct and advanced admission programs, is common among the Canadian dental hygiene programs, similar to results from the United States.[8] Examinations of dental hygiene programs reveal that grades are consistent predictors of success, not only within the matriculated dental hygiene program,[4] but also on the culminating board exams.[3] A comprehensive study in the United States, however, found that there were no statistically significant correlations between preadmission criteria and board exam success.[8]

Dental hygiene programs in Canada use academic information in a number of different ways. Some schools calculate GPA using only prerequisite courses, whereas others use the entirety of a student's educational history for this calculation. Additionally, schools weigh the importance of the GPA differently, with some using academic grades as the only admission criterion, and others simply using grades as a minimum standard that must be achieved prior to progressing through the admission process.

English, biology, and chemistry, either at the secondary or postsecondary levels, are the most frequently required prerequisites by Canadian dental hygiene programs. Prerequisite biology grades have been found to be a predictor of performance while matriculated in dental

hygiene programs,[2,11] but they cannot be used to predict NDHCE scores, given that the Canadian board exam is reported as pass/fail, rather than as an indication of level of performance. Additional studies have shown correlations with grades in courses taken while in the program and board exam success.[2,6] However, the students have already been selected and matriculated in the program making it difficult to draw conclusions about the efficacy of the admission criteria.

Though the calculation of GPAs varies widely among programs and the weighting and composition of the courses used in the GPA calculation differs from program to program, the focus of this work is on the type of criteria that is used, rather than how those criteria are established or evaluated for admissions purposes. Grades, whether in the form of cumulative GPA, science GPA or secondary GPA, are grouped together as "academic criteria." However, because of the variations in standards found between the prerequisite institutions, as well as how the admission criteria are calculated and/or weighted by the different dental hygiene programs, the use of these academic criteria can be a problematic measure in the admissions process, despite the fact that they are widely used by all programs.

Non-cognitive requirements

The purpose of interviews during the admission process is to examine personal characteristics of the applicant that may not otherwise be apparent from other application materials. Identifying candidates who have desirable attributes that are not easily teachable may ensure that the future health professional will embody the desired characteristics of the profession. However, the purpose of the interviews and how they are utilized in the admissions process was not made clear.

Several different interview formats are used during the admission processes of various health professional programs, with each type of interview capturing different attributes. Of the 12 dental hygiene programs that used some sort of interview processes, it was not clear which attributes each program was trying to evaluate. MMIs are often used to examine a candidate's soft skills, including professionalism, ethical judgment, interpersonal skills, and emotional intelligence. Studies examining other allied health professions have revealed that students with higher MMI scores tend to have higher clinical but not academic performance.[12] Dental students with higher MMI admission scores also demonstrated higher levels of professional behaviours.[13] Another study evaluating the outcomes of interviews as admission criteria in an undergraduate medical program found that a selection interview increases the likelihood of selecting candidates with the potential to develop good communication skills with their patients and peers, leading to successful careers.[14] These studies all support the notion that use of non-academic criteria can aid in the selection of successful health professional students.

Using MMI scores as an admission criterion, however, is not without drawbacks. Research has shown that personality characteristics like extroversion[15] are associated with higher MMI scores, which may present a subset of candidates in a more favourable light to interviewers. Another criticism of using MMI scores is that interviewer subjectivity[16] has been shown to affect reliability and validity of the MMI. Taken together, these factors can limit the diversity and inclusion of potential candidates to the profession who are needed to serve a heterogeneous population.

MMIs must be effectively designed according to the non-cognitive attributes desired by the program with attention to the number of stations and interviewer training.[17] Additionally, MMIs may predict success on practical postgraduate performance. Due to the small number of schools that use the MMI, and the diversity of other interview techniques, conclusions regarding the use of interview scores as a predictive factor on the NDHCE exam are limited.

Various non-cognitive measures have been used by a number of health professional training programs in an attempt to improve diversity,[18] with mixed results.[19,20,21] Because of the differing types of measures that are used by schools to measure non-cognitive variables, it is difficult to assess the value of these measures in determining a candidate's likelihood of success in the program as well as on the board exam. Non-cognitive measures need to be validated prior to being used as a criterion for admission into health care programs.[22]

Standardized testing

This study shows that the majority of dental hygiene programs in Canada place heavy emphasis on academic achievement as a criterion for admission. Because GPA can vary depending on the types of courses taken, rigour of the institution where courses were taken, and the time period during which the courses were taken, some institutions have elected to administer a standardized test as an equalizer.

Standardized tests are used as admission criteria in many other health professions programs, including nursing[23] and medicine[24], but research examining their effectiveness in determining the success of students has been primarily on an individual candidate basis, rather than on how impactful they are to the program.[25]

For both dentistry and medicine, a number of studies have found that the Dentistry Admission Test (DAT)[26,27] and the Medical College Admissions Test (MCAT)[28] are correlated with student performance in their programs, as well as their respective board exams.[29-31] Similarly, performance on the American College Test (ACT) is predictive of dental hygiene student performance on the NBDHE.[6,32] Unlike other health professions, however, dental hygiene does not have a common standardized admissions test. The present study found that the most commonly used standardized admission test is the HOAE. There do not seem to be any

studies evaluating the efficacy of this test in determining student success.

Academic experience

Perhaps most interestingly, this study found that there is a moderate, positive correlation between a program's performance on the NDHCE and the number of postsecondary credits required for admission, though the reason for this correlation is not clear and requires further study. The most obvious explanation is that the prerequisites selected by the programs better prepare the students for the rigours of the board examination. Other factors may also contribute to this finding.

It is also possible that students who have more postsecondary requirements may be older and/or have more experience with postsecondary education and test taking. However, the literature indicates that there is no difference in ages of those who performed well on the NBDHE,[6] and age is not predictive of performance on dental board exams.[26] In fact, at an undergraduate level, younger students fare better academically than their older peers.[33] Although evidence indicates that age is not a predictor of performance on board examinations, a study found that older students with bachelor's degrees had higher motivation to pursue a medical career than younger students who had recently graduated high school.[34]

Another possible explanation for why more postsecondary credits at admission is correlated with board examination success is that the applicant pool of programs that have more postsecondary credit requirements may be different. In other words, less academically inclined students may have been removed from the applicant pool based on their performance in the prerequisites. Consequently, programs that have an increased credit requirement for application may have an applicant pool with higher academic performance than those programs that require fewer prerequisites.

Limitations

There are a number of limitations that also must be considered when interpreting these results. The weighting of each admission criterion in the admission process was not always made clear by each program, and this can have an impact on the profile of the admitted students.

This study used the NDHCE as a single marker of program success, even though other markers, such as attrition, diversity, clinical competence, and/or social responsibility, are also indicative of program success. The use of the NDHCE is also a limitation because the Canadian exam is reported as pass/fail, while other board exams such as the National Board Dental Hygiene Examination administered by the Joint Commission on National Dental Examinations (NBDHE) in the United States report discrete percentages, allowing for more precise evaluation of program success.

Importantly, correlation between admission criteria and NDHCE scores may be obscured by the effects of the training programs themselves. That is, the success rate may not be entirely due to admission criteria but may also likely be due to the nature of the program itself.

Future directions

The information gleaned from this descriptive work allows for the future development of hypothesis-driven studies that can explore the differences between programs with and without preprofessional preparation. This information would be important to determine which factors are most predictive of ultimate success. Additionally, determining whether differences exist between the graduates from programs that do and do not use non-cognitive admissions criteria would be useful to determine the predictive value of using such measures in selecting successful candidates.

CONCLUSION

Varied admission criteria are used by Canadian dental hygiene programs, with each type capturing different attributes. Consequently, the ideal applicant may differ for each program. All programs utilize grades as a component of the admissions process while relatively few programs use criteria that can showcase an applicant's "soft skills," which is what is more obvious to the public that interacts with dental hygienists. This can be particularly challenging for the public opinion and knowledge of a relatively young profession like dental hygiene. The heterogeneity in provincial scopes of practice, coupled with the differences in selection and training of candidates, can further complicate public perception of dental hygienists and their roles.

CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

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Evaluation of the isosceles-configured SUN Teeth™ toothbrush in dental plaque removal and gingival health

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Toothbrushing is a major determinant of oral health, as it helps to remove biofilm from the gingival third of the teeth.
- The novel-designed isosceles-configured toothbrush, with 45°-angled bristles, can reduce the difficulty in switching to the modified Bass toothbrushing technique, which is widely recommended by oral health professionals, particularly for individuals with poor dexterity.

ABSTRACT

Objective: To evaluate the clinical efficacy and safety profile of a novel-designed isosceles-configured (SUN Teeth™) toothbrush in comparison to a standard reference toothbrush with end-rounded bristles (approved by the American Dental Association [ADA]). **Methods:** The sample size was determined using the G-Power-software, version 3.1.2 and, accordingly, 104 subjects (ages 19 years to 25 years) were recruited and randomized into either the test group (n = 54) or the control group (n = 50). Prior to study commencement, scaling was performed followed by abstinence from oral hygiene for 24 hours. Baseline pre-brushing gingivitis scores (Lobene) and plaque scores (Turesky modification of Quigley Hein) were recorded. Brushing was performed for 3 minutes and post-brushing scores were recorded on days 1, 14, and 28 without refraining from regular brushing. Data were analysed with Statistical Package for Social Sciences (IBM-SPSS, v.25.0). **Results:** Post-brushing plaque scores showed significant reduction in both groups at all time intervals. However, no significant differences between the test and control brush groups were achieved at any time points. **Conclusion:** The isosceles-configured SUN Teeth™ toothbrush is equivalent in plaque removal to the conventional flat-bristled ADA reference brush.

RÉSUMÉ

Objectif : Évaluer l'efficacité clinique et le profil de sécurité d'une brosse à dents à conception novatrice d'une configuration isocèle (SUN Teeth[MD]) en comparaison à une brosse à dents à référence standard dotée de soies aux pointes arrondies (approuvée par l'Association dentaire américaine [ADA]). **Méthodologie** : La taille de l'échantillon a été établie à l'aide du logiciel G-Power, version 3.1.2, et 104 sujets (âgés de 19 à 25 ans) ont été recrutés et randomisés dans un groupe d'essai (n = 54) ou un groupe témoin (n = 50). Avant le début de l'étude, un détartrage a été effectué, suivi par l'abstinence de l'hygiène buccodentaire pendant 24 heures. Des cotes de référence de gingivite prébrossage (Lobene) et des cotes de plaque (modification Turesky de Quigley Hein) ont été consignées. Le brossage était effectué pendant 3 minutes et les cotes après-brossage étaient consignées aux jours 1, 14 et 28 sans éviter le brossage régulier. Les données ont été analysées avec l'Ensemble des programmes statistiques relatif aux sciences sociales (IBM-SPSS, v.25.0). **Résultats :** Les cotes de plaque après-brossage ont été significativement réduites dans chaque groupe à tous les intervalles de temps. Cependant, aucune différence significative n'a été réalisée en aucun temps entre les groupes de brossage d'essai et témoin. **Conclusion :** La brosse à dents SUN Teeth[MD] à configuration isocèle est équivalente en matière d'enlèvement de la plaque à la brosse de référence conventionnelle à soies plates de l'ADA.

Keywords: angled bristles; dental hygiene; gingival index; isosceles-configured toothbrush; periodontal status; plaque
CDHA Research Agenda category: risk assessment and management

INTRODUCTION

Mechanical plaque removal by regular use of a toothbrush is essential to avoiding excessive biofilm accumulation.[1,2] Thus, the design of a toothbrush has a significant impact on brushing efficacy, particularly in the areas that are difficult to clean, including the lingual, interproximal, and posterior surfaces.[3] Toothbrush design modifications can include improvements in the orientation of the handle, brush head, and pattern of the bristles.[4] Manual toothbrush designs with flat-trimmed bristle patterns on rectangular heads have most commonly been used for regular teeth cleaning.[5] Over the years, brush heads have evolved and been modified into several different forms. Some are

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more tapered and some are oval or diamond-shaped, with bristle trim patterns evolving into bilevel, multilevel, and rippled trims, and some designs have criss-cross angulated bristle tufts.[6] Frandsen recommended that a manual toothbrush should have soft nylon end-rounded bristles with a diameter of approximately 0.2 mm and a length of 10 mm with a multi-tufted, straight-trimmed brush head design.[7] Brothwell et al. suggested that serrated tufts, raised toe bristles, and an angled head may offer better advantages.[6] Another popular brush head design is the Oral-B CrossAction brush that was developed with tufts of bristles angled at 16° in both directions.[8] This design was intended to support a brushing action that penetrates, lifts, and sweeps plaque away on both forward and backward strokes.[8] Single-use clinical studies comparing the CrossAction brush to traditional manual brushes and 2 powered toothbrushes reported the CrossAction brush to have better plaque removal efficacy after single use than the comparison brushes.[8] The unique angled arrangement of the bristles improved the potential for plaque removal on approximal surfaces and along the gumline by enhancing penetration of bristles into interproximal spaces.[8] These findings were further supported by a multicentre descriptive study, receiving favourable responses from clients as well as dentists in better plaque reduction following the use of the manual CrossAction toothbrush over 12 weeks.[9]

Toothbrushing technique is also a major determinant of oral hygiene, and the modified Bass technique is widely recommended by dental professionals because it facilitates plaque removal from the gingival third of the teeth.[10] This technique, however, requires the user to place the toothbrush bristles at a 45° angle at the gingival margin and move the brush back and forth gently followed by vertical sweeping strokes on all tooth surfaces.[11] Most commonly used toothbrushes usually have flat surfaces, and the users must bend some part of the bristles/brush head to an angulation of 45° to follow the Bass technique.[12] This placement has been shown to be challenging for many people and thus client compliance has been far less than ideal.[5] The high prevalence of plaque-induced oral diseases indicates that many users fail to achieve adequate removal of plaque via normal manual toothbrush usage. Further, in clients who lack manual dexterity, adapting to the modified Bass method could be even more challenging.[13] In contrast, it has been estimated that over 90% of adults employ a personal brushing method, which is typically a "scrub" method.[14] Although dental professionals continue to educate and emphasize the importance of changing the brushing techniques employed by their clients, this behaviour modification is still a big challenge. Therefore, the literature has repeatedly suggested that less demanding or easier means of cleansing are required to make a real impact on toothbrushing behaviours.

To address this issue, a novel isosceles-configured toothbrush, named SUN Teeth™, was recently introduced with prefabricated bristles cut at 45° and arranged in 5 rows that have 2 brushing surfaces with a wider space for toothpaste. Having different lengths of bristles makes it unique and directs the user to employ only an up-and-down motion rather than a back-and-forth motion, thereby potentially preventing the harmful and ineffective outcomes of the scrub-brush method.

A short survey investigating perceptions of the SUN Teeth™ toothbrush was conducted with 500 volunteers who reported that it was convenient to use.[15] Nevertheless, it is a prerequisite for every newly designed mechanical plaque removal device to undergo clinical trials before it can be marketed for mass usage. Hence, the present study aims to evaluate a) the clinical efficacy of this novel-designed isosceles-configured (SUN Teeth™) toothbrush in plaque removal as compared to a standard reference manual toothbrush with end-rounded bristles (approved by the American Dental Association, ADA); and b) the effect of the newly designed test toothbrush compared to the control brush on gingival inflammation over a study period of 4 weeks.

METHODS AND MATERIALS

This randomized controlled clinical trial was a single-centre, double-blind, parallel-arm, repeated measures study (Figure 1) and followed the study protocol outlined in Figure 2. The study was approved by the Institutional Ethics Committee, MAHSA University, Malaysia.

Study population

Participants were recruited from the student population at MAHSA University (non-dentistry background or first-year dentistry students who had been in the program for less than 2 months). All volunteers were screened using the following inclusion criteria: a) a minimum of 18 years of age; b) systemically healthy with no intraoral diseases or lesions; c) healthy gingiva or localized mild gingivitis; d) presence of a minimum of 12 pairs of anterior and posterior teeth; and e) no experience with or training in the modified Bass technique. Exclusion criteria were as follows: a) individuals who are allergic to disclosing solution; b) presence of deep carious lesions, orthodontic appliances, dentin hypersensitivity, excessive crowding of teeth, established gingivitis or periodontitis, presence of mucogingival problems; c) habituated to the use of a mouthrinse, powered toothbrush or medications that affect the periodontal condition; d) individuals with visible physical or mental disabilities. The outline and purpose of the study were explained to the potential participants verbally and in writing prior to obtaining their signed informed consent form.

Sample size estimation

Sample size was calculated using G-Power software version 3.1.2. Two different calculation methods were applied based on 2 dependent samples and 2 independent

Figure 1. Study design–CONSORT flow chart

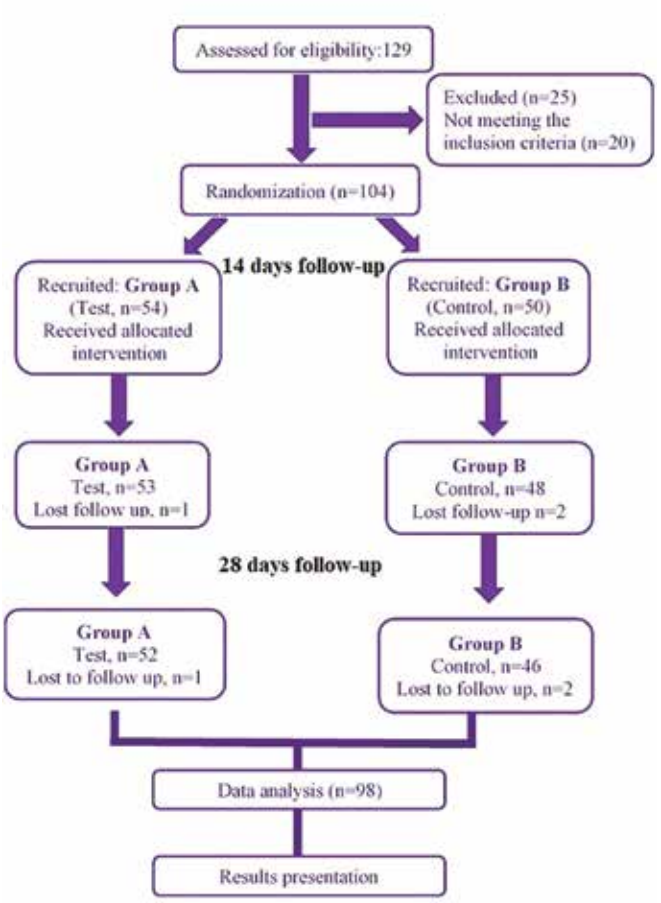
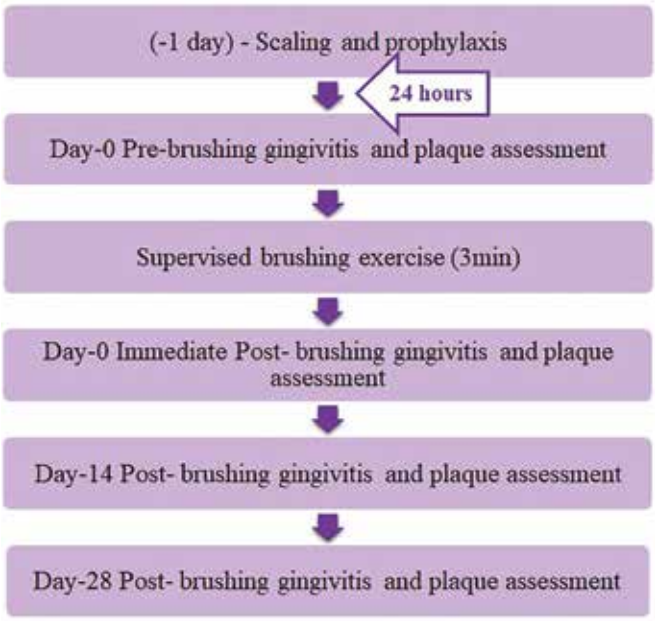


Figure 2. Protocol followed during the study.



samples. A similar study by Kulkarni et al.[16] reported the mean difference and standard deviation were 0.5 and 0.1, respectively. By considering 0.05 as the level of significance and 0.9 as the power of study, it was found that the minimum number of participants should be 44 or 38, respectively. Considering a 10% drop-out rate, a slightly higher sample size (n = 52 per group) was targeted. Thus, for the present study, 129 students were screened, of which 104 were included and were randomly divided into a test group (n = 54) and a control group (n = 50) using a block randomization method (Figure 1).

Familiarization phase

One week prior to the beginning of the study, all participants were instructed to discontinue using their regular toothbrushes and were given a standard dentifrice (Colgate, Colgate Palmolive™) and either the test or control brush for familiarisation. The test group received the toothbrushes with isosceles configuration (SUN Teeth™); the control group received the ADA standard reference brush with flat, end-rounded soft bristles arranged in 5 rows (Jordan™). Brushes were distributed in an opaque envelope to ensure the participants were unaware of the toothbrush given to others. The following brushing instructions were given to all participants.

1. Brush twice daily making sure to clean all tooth surfaces for 3 min.
2. Use their normal brushing technique.
3. Report any problems or brush wear.

Clinical procedure

At the end of the familiarisation period of one week, i.e., on day "0" of the study, scaling and prophylaxis were received by all participants. Following this, the participants were asked to abstain from all oral hygiene procedures (including brushing, mouthrinsing or flossing) for a period of 24 hours. At the end of 24 hours, on day 1 of the study, the participants reported to the dental clinic for baseline scoring. A pre-brushing gingivitis score using Lobene's Modified Gingival Index (MGI)[17] was recorded according to the following scoring criteria: 0 = normal (absence of inflammation); 1 = mild inflammation (slight change in colour, little change in texture) of any portion of the gingival unit; 2 = mild inflammation of the entire gingival unit; 3 = moderate inflammation (moderate glazing, redness, edema, and/or hypertrophy) of the gingival unit; 4 = severe inflammation (marked redness and edema/ hypertrophy, spontaneous bleeding or ulceration) of the gingival unit. Scoring was done on all the facial and lingual/palatal surfaces of all teeth, except third molars.

Once the MGI was recorded, a disclosing solution (2-tone dye) was applied with a cotton applicator on all surfaces to disclose the plaque and record pre-brushing plaque scores using the Turesky-Gillmore modification of the Quigley-Hein Plaque Index[18], where 0 = no plaque; 1 = isolated flecks of plaque at the gingival margin; 2 = a continuous band of plaque up to 1 mm at the gingival

margin; 3 = plaque greater than 1 mm in width and covering up to one-third of the tooth surface; 4 = plaque covering from one-third to two-thirds of the tooth surface; 5 = plaque covering more than two-thirds of the tooth surface. Individual plaque scores were calculated by summing up the total score on all surfaces divided by the number of surfaces examined. At all visits, the gingival index was recorded prior to disclosing the plaque to avoid the influence of disclosing dye.

Brushing exercise

After pre-brushing scores were recorded, the participants brushed according to the instructions given by the investigators with either the test or control brush based on their random assignment. Participants then spent 30 seconds brushing each of the following areas: facial/labial or palatal/lingual surfaces on anterior and posterior sextants of maxilla and mandible, which ensured brushing of all surfaces in a total brushing time of 3 minutes, as described in Table 1. Table 1 was pasted at the washing sink and re-emphasized by investigator (A) who also monitored the time using a mobile stopwatch with an alarm to indicate change of brushing surface every 15 seconds by the participants. This investigator also directed the participants to the next surface change. No specific instructions were given regarding angulation of bristles or bristle adaptation to the tooth surface. Because the plaque was disclosed prior to brushing, face mirrors were not provided during brushing to avoid specific focus on the stained areas by the participants.

After 3 minutes of brushing, post-brushing gingival index and plaque scores were recorded. The participants were then instructed to use the same brush and dentifrice, twice daily, for the next 4 weeks following the 3-minute brushing protocol. They were also asked to refrain from interdental cleansing and mouthrinsing or irrigation during the study period. Participants were given verbal instructions, and a mobile WhatsApp group was created to reinforce the brushing protocol twice daily and to report any adverse events. Text message reminders were sent to the participants through WhatsApp along with a brushing sequence table. Verbal reminders were given during the 2-week review visit.

Table 1. Brushing exercise

	Right posterior sextant	Anterior	Left posterior sextant
Maxilla (1.5 minutes)	1 15 sec facial + 15 sec palatal	2 15 sec labial + 15 sec palatal	3 15 sec facial + 15 sec palatal
Mandible (1.5 minutes)	4 15 sec facial + 15 sec palatal	5 15 sec labial + 15 sec lingual	6 15 sec facial + 15 sec lingual

MGI and plaque scores were recorded on day 14 and day 28 without refraining from regular brushing. Bristle fraying was also verified on day 14 and day 28; if the brush was found to be frayed it was replaced on day 14 by investigator (A). Three experienced periodontists (B, C, D) who recorded the plaque scores and MGI were completely blinded to the brush used by the participants. Prior to initiation of the study, the 3 examiners underwent a calibration exercise for standardization of scores. The interexaminer calibration showed good agreement, with Cronbach's alpha 0.88 for gingivitis scores and 0.86 for plaque scores. Moreover, care was taken to ensure that the same examiner recorded all the scores of an individual participant. For the safety portion of the study, the participants were asked to report any toothbrush trauma, ulcers or increased bleeding from the gums or any other discomfort in brushing if noticed. This was emphasized again during the review visits.

Randomization and blinding

Randomization was done using the block randomization method. A participant code and number were assigned to each individual in sequential order by the statistician (S), who also distributed the brushes and toothpaste in a sealed, opaque envelope according to each individual's group assignment. Investigator (A) monitored the brushing technique and reinforced the brushing instructions to the participants daily and verified the brushes that were frayed on day 14 and day 28. Replacement brushes were provided on day 14 as needed. Participants were instructed to keep the brush in the opaque envelope every time and not to discuss or reveal the brush to their examiners at any visit in order to maintain examiner blinding. The brushing and instructions area were also detached from the clinic where scores were recorded to maintain the blinding of the examiners (B, C, D).

Statistical analysis

Data obtained from this investigation were analysed using the Statistical Package for Social Sciences (IBM-SPSS, v.25.0) to make inferences and draw robust conclusions. In brief, a descriptive statistic of the sociodemographic characteristics was initially done to evaluate the distribution, normality, and homogeneity of the data. Frequency and percentages were reported for distribution of categorical variables while continuous variables were reported as means and standard deviations (SD). Based on the Kolmogorov-Smirnov test, the normality distribution assumption for all the variables was met ($p > 0.05$), thus parametric tests were used. Parametric analysis of variance for repeated measures (RM-ANOVA) was carried out in order to analyse the differences in plaque score and gingival index between the 2 groups across the 3 time points. Within-group comparisons were tested using the independent t-test. Differences were considered significant if p values were less than 0.05.

Table 2. Comparison of plaque score between groups based on time (N = 98)

	Pre-brushing	Post-brushing	Post at 14 days	Post at 28 days	*p* value
Test (n = 52)	2.11 ± 0.60	1.23 ± 0.48	1.56 ± 0.48	1.38 ± 0.39	0.553[a] F test = 0.35
Control (n = 46)	2.00 ± 0.59	1.27 ± 0.61	1.50 ± 0.47	1.32 ± 0.42	
	t-statistic = 0.91 p = 0.366[b]	t-statistic = –0.42 p = 0.673[b]	t-statistic = 0.77 p = 0.443[b]	t-statistic = 0.74 p = 0.464[b]	

Results are represented as mean ± SD
[a]Repeated measures ANOVA
[b]Independent t-test

RESULTS

Baseline plaque score and gingival index

Of the 104 initial participants, 98 completed the study at follow-up. There were 4 dropouts from the control group and 2 from the test group, leaving a final number of 52 in the test group and 46 in the control group, which still satisfied the estimated sample size requirement. All data were included for analysis for the remaining 98 participants. Of those who completed the study, 65 (66.3%) were male and 33 (33.7%) were female with a combined mean age of 20.2 ± 0.2 years. There was no statistically significant difference in the mean age (p = 0.770) and gender distribution between the groups (p = 0.978, Chi-square test).

At baseline, prebrushing full mouth plaque scores did not differ significantly between groups (p = 0.366), with a mean plaque score of 2.11 ± 0.60 in the test group and 2.00 ±0.59 in the control group (Table 2). Similarly, there was no difference in the baseline gingivitis scores (p = 0.394) between the two groups, with a mean of 0.45 ± 0.30 in the test group and 0.50 ± 0.34 in the control group (Table 3).

Efficacy in plaque removal and reduction in gingival index

The mean plaque and gingival indices for both groups along with their standard deviations are shown in Tables 2 and 3. Intragroup comparisons of plaque scores within each study group from baseline to 14 days, baseline to 28 days, and from 14 to 28 days were made using the paired t-test; the associated p values are shown in Table 4. Intergroup comparisons to determine the mean reduction from baseline to 14 days, baseline to 28 days, and from 14 to 28 days was analysed by RM-ANOVA; their associated p values are also shown in Table 4.

Pre-brushing versus post-brushing plaque scores at day 0

Mean post-brushing plaque scores at day 0 were 1.23 ± 0.48 in the test group and 1.27 ± 0.61 in the control group. There was a significant reduction in plaque scores at day 0 after brushing in both groups (p < 0.001). When the mean difference in pre- and post-brushing plaque scores was compared, plaque reduction was marginally higher with the test brush than the control brush (0.88 versus 0.72, Table 4 and Figure 3a). However, the difference was not statistically significant (p = 0.673) as shown in Table 2.

Pre-brushing plaque scores day 0 versus plaque scores on days 14 and 28

Following baseline, participants used the allocated brush and paste and reported on day 14 and day 28 for plaque and gingivitis assessment. A steep decrease in plaque scores

Figure 3. (A) Comparison of pre- and post-brushing percentage plaque reduction at day 0, day 14 and day 28; (B) Comparison of post-brushing percentage plaque reduction at day 0, day 14 and day 28

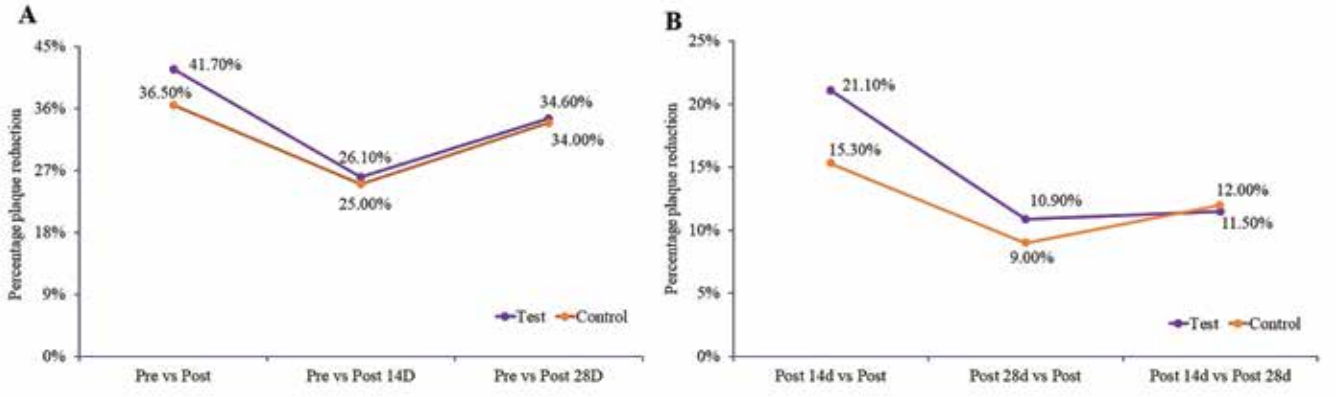


Table 3. Comparison of gingivitis index between groups based on time (N = 98)

	Baseline	Post at 14 days	Post at 28 days	*p* value
Test (n = 52)	0.45 ± 0.30	0.36 ± 0.19	0.37 ± 0.18	0.184[a] F test = 1.8
Control (n = 46)	0.50 ± 0.34	0.44 ± 0.34	0.42 ± 0.33	
	t-statistic = −0.8 $p = 0.394^b$	t-statistic = −1.4 $p = 0.172^b$	t-statistic = −0.8 $p = 0.418^b$	

Results are represented as mean ±SD
[a]Repeated measures ANOVA
[b]Independent t-test

was observed from pre-brushing to post-brushing at day 0, which increased on day 14 and dropped by day 28 (Figure 3a). Within both test and control groups, this reduction in plaque scores was highly significant ($p < 0.001$) on days 14 and 28 as compared to day 0 pre-brushing scores (Table 4).

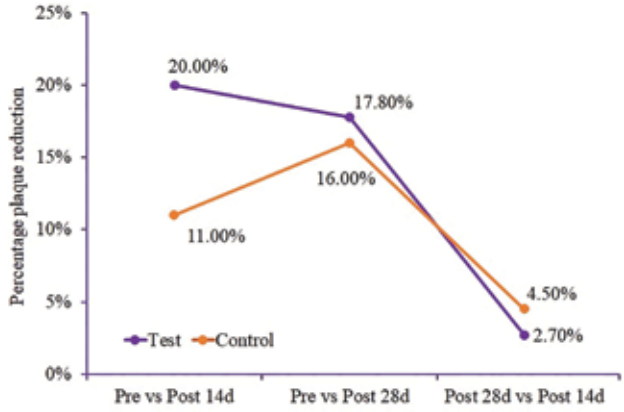
Comparison of post-brushing plaque scores

In both groups, plaque scores were lowest on day 0 immediately after brushing followed by day 28 and day 14, with the highest pre-brushing scores noted at baseline. (Plaque score: post-brushing day 0 < day 28 < day14) (Table 4). Further, the scores increased significantly on day 14 ($p < 0.05$) and again decreased by day 28. Reduction in the scores from 2 weeks to 4 weeks was significant in both the test group ($p < 0.001$) and the control group ($p < 0.007$). Plaque scores after 4 weeks were not significantly different from day 0 post-brushing ($p > 0.05$) (Figure 3b).

Intergroup comparison based on plaque reduction

When the mean percentage plaque score reductions in both groups were compared, the mean difference in plaque reduction achieved by the test brush was obvious in immediate post-brushing reduction at baseline, which thereafter was similar by day 14 and showed a marginally greater reduction than the control brush by day 28 (Figure 4). However, the observed differences between groups (intergroup difference) failed to achieve statistical significance at day 0, 14 or 28 (Table 2).

Figure 4. Percentage mean plaque reduction in test and control groups at all points of time



Gingival index

At baseline, the difference in gingival index in both groups was not significant, with a mean MGI of 0.45 ±0.30 in the test group and 0.50 ± 0.34 in the control group. These scores indicate that in both groups the gingiva was healthy and similar at baseline. Further, at 14 days and 28 days, there was a reduction in MGI compared to baseline but it was not statistically significant (Table 3). This observation is similar in both test and control groups and no significant differences in MGI were found between the 2 groups at all time points. (Table 5).

Safety observations

There were no adverse events reported or observed over the course of the clinical trial.

DISCUSSION

A randomised, double-blind, parallel-arm, repeated measures study was carried out to evaluate the efficacy of an isosceles-configuration (Sun Teeth™) toothbrush compared to a conventional flat-trim brush over a period of 4 weeks. The population included in this study primarily had a non-dental background, although there were a few newly enrolled first-year dentistry students, in order to avoid any bias of prior knowledge of oral hygiene

Table 4. Pairwise comparison of plaque score using the Bonferroni method

	Test MD (95% CI)	*p* value	Control MD (95% CI)	*p* value
Pre- versus post-brushing	0.88 (0.715, 1.044)	<0.001	0.72 (0.543, 0.905)	<0.001
Pre- versus 14-day post-brushing	0.54 (0.330, 0.754)	<0.001	0.51 (0.299, 0.715)	<0.001
Pre- versus 28-day post-brushing	0.72 (0.499, 0.952)	<0.001	0.68 (0.457, 0.896)	<0.001
Post- versus 14-day post-brushing	−0.34 (−0.513, −0.162)	<0.001	−0.22 (−0.428, 0.006)	0.041
Post- versus 28-day post-brushing	−0.15 (−0.346, 0.038)	0.191	−0.05 (−0.285, 0.191)	>0.999
14-day versus 28-day post-brushing	0.18 (0.050, 0.317)	<0.001	0.17 (0.034, 0.305)	0.007

MD = mean difference; CI = confidence interval

Table 5. Pairwise comparison of gingivitis index using the Bonferroni method

	Test MD (95% CI)	*p* value	Control MD (95% CI)	*p* value
Baseline versus post-brushing 14 days	0.09 (–0.028, 0.206)	0.199	0.07 (–0.066, 0.197)	0.658
Baseline versus post-brushing 28 days	0.08 (–0.038, 0.190)	0.313	0.09 (–0.039, 0.212)	0.278
Post-brushing 14 days versus post-brushing 28 days	-0.01 (–0.073, 0.048)	>0.999	0.02 (–0.097, 0.138)	>0.999

MD = mean difference; CI = confidence interval

maintenance and brushing techniques. To reduce the influence of variable brushing techniques, all participants were advised to use the toothbrush assigned to them in their normal, routine pattern of brushing for the specified time interval of 3 minutes, ensuring that brushing covered all facial and lingual surfaces. Earlier studies have reported that increased brushing time can facilitate more plaque removal and a 3-minute brushing time was considered ideal.[19-23] No specific instructions on angulation of the brushes (modified Bass) were given to the participants as the test brush bristles were angulated at 45°. As this clinical trial was designed specifically to assess the efficacy of the brushing alone in the absence of adjunctive aids, the participants were instructed not to use any kind of mouthrinse or interdental cleansing device during the study period that could influence the interproximal plaque control. The MGI was used to assess gingival inflammation, since it is noninvasive and based on visual examination, thus preventing the plaque formed at the gingival margin from being disturbed by probing.

One of the major strengths of this study is that randomization and coding were only known to the statistician (S) and investigator (A). Both the participants and examiners were blinded, and examiners (B, C, D) who evaluated the scores were different from those who monitored the brushing and the bristle flaring. The integrity of the blinding was maintained by concealing the assigned brushes in an opaque envelope.

In this study, it was observed that both the test and control brushes could reduce the pre-brushing plaque scores (after 24-hour accumulation) significantly with a single brushing procedure of 3 minutes that cleaned all dental surfaces irrespective of the technique used. Moreover, 2 weeks and 4 weeks after regular, twice daily usage of the respective brushes, mean plaque score levels were still maintained at significantly lower than pre-brushing scores for both groups (Figure 3).

When post-brushing plaque scores at baseline were compared to 2nd and 4th week scores, the initial increase in the plaque score observed at 2 weeks decreased by 4 weeks (Figure 3). This fluctuation in scores could be the result of supervised brushing at baseline (day 0) and immediate recording of plaque scores, followed by unsupervised brushing (at-home routine brushing) for 2 weeks and the recording of plaque scores 2 to 3 hours later on day 14 in the clinic. Although the scores were recorded with the same delay at 4 weeks (day 28) with unsupervised brushing, a decline in scores was observed. This decline could possibly be explained by a gradual adaptation of the participants to the instructed brushing regimen and reinforcement given by the investigators. However, the efficacy of the respective brushes cannot be ignored.

The MGI declined from baseline to 2 weeks and 4 weeks, but it was not statistically significant in either of the groups (Table 4). This finding could be due to the healthy or simple gingivitis status of the cases at baseline. The follow-up period of 2 to 4 weeks is adequate to clinically elicit any signs of gingival inflammation. Since plaque scores were reduced further in both groups, the MGI also showed improvement.

Comparison between the brushes showed that both could significantly reduce plaque scores from baseline to 4 weeks and could maintain gingival health. This study did not observe significant differences between the flat bristles and bristles with isosceles configuration in plaque reduction over 4 weeks. One potential explanation for these results may be that the brushing time routinely recommended in the literature is 1 to 2 minutes. In a study by Saxer et al.[24], it was reported that there was considerable difference between the brushing time the subjects claimed to have used and their actual independent brushing time. Brushing time is a crucial factor modulating the estimation of toothbrush efficacy as evident in various studies. One such study concluded that plaque removal after 1 minute of brushing with the test brush did not differ significantly from that after 2 minutes of brushing with the control brush. Moreover, when the brushing time was increased to 5 minutes, the efficacy also improved.[25] One systematic review on manual brushing efficacy concluded that, if the brushing time is increased, the efficacy appears to be higher.[26] In the present study, to ensure uniform plaque removal from all surfaces, a 3-minute brushing time was adopted, which perhaps allowed the brushes to clean well irrespective of bristle configuration. Another potential explanation for these results is the "Hawthorne effect," which occurs when the participants' behaviour is modified by being part of a research trial. They might have brushed overzealously and consciously regardless of their group,

potentially masking any differences there may have been between the groups. A third possible explanation may have been the constant reinforcement of regular brushing twice-daily through WhatsApp reminders that could have motivated the participants in both groups.

The results of the present study are similar to the observations of Sripriya and Ali,[27] who evaluated the efficacy of plaque removal of 4 different toothbrush bristle designs. The results of their clinical study indicated that all the toothbrushes reduced plaque scores significantly compared to baseline scores, but no single manual toothbrush design included in their study was found to be superior. Another single-blind crossover study comparing the performance of different toothbrush models for controlling plaque concluded that all the brushes were capable of efficiently removing plaque and the arrangement of the bristles had little effect on the removal of plaque.[28] Staudt et al.[29], in a single-blind crossover clinical study evaluating pre- and post-brushing plaque on the lingual surfaces of mandibular posterior teeth, observed that multilevel or flat-trimmed brush head designs were not significantly superior to the other brushes.[29] However, Terezhalmy et al.[25] reported efficient plaque removal with a CrossAction brush after 1 minute of brushing comparable to that achieved in brushing with the ADA reference brush for 2 minutes. When the brushing time increased to 5 minutes, greater whole mouth and gingival margin plaque removal scores were seen with the ADA brush.[25] Slot et al.[26], in their systematic review of the efficacy of manual toothbrushes following a brushing exercise, concluded that multilevel and angled brush head tuft configuration of manual brushes were more efficient than flat-trim toothbrushes. It was also mentioned that, if the brushing time is increased, the efficacy appears to be higher.[26] Similar results were reported in numerous other studies demonstrating superiority of the cross-action bristle design over the ADA reference brush heads.[8,30,31]

Conversely, electric toothbrushes have repeatedly been shown for many years to have superior efficacy to manual toothbrushes in both plaque removal and reduction in inflammation.[32-34] A 2014 Cochrane systematic review compared manual and power toothbrushes and concluded that rotation-oscillation powered brushes significantly reduce plaque and gingivitis in both the short and long term when compared with manual brushes.[34]

Few studies found significant differences in plaque removal efficacy between varied manual toothbrush designs.[34,36,37] While several studies comparing the efficacy of different designs of toothbrushes suggest there is no one superior design of manual toothbrush,[28,35,38-40] there is a significant amount of literature demonstrating superiority of the cross-action/criss-cross manual brush in plaque removal over the ADA standard control brushes.[41,42] Appropriate angulation of brushes may enhance the plaque removal efficacy as tested in this study.

Limitations

Potential weaknesses of this study are that participants may have been too healthy at baseline to demonstrate significant results. Additionally, this study only compared this novel brush design with the standard ADA flat-bristle brush and not with other bristle designs such as the cross-action bristle brush. Whether these results can be generalizable to the Malaysian or other populations is questionable as the sample comprised university students exclusively. In contrast, the decision to select participants from the university student population was made to avoid bias of age-related variability in brushing dexterity and to ensure a similar education level and level of oral hygiene motivation during the study period, as well as similar daily routines and timing of oral care so that the variability in brushing exercises could be minimized and greater compliance achieved. Future studies should include a larger representative sample from different sectors and different age groups to possibly provide more evidence. Additionally, future studies comparing the effectiveness of the 45° angled bristles with those of the cross-action brush design should be conducted.

CONCLUSION

Based on the results of this study, the novel-designed isosceles "SUN Teeth™" toothbrush is equivalent in efficacy to the conventional flat-bristle toothbrush in plaque removal and with no reported safety issues. The toothbrush could also prevent the onset or progression of gingivitis as shown over a 4-week period. However, the user is by far the most significant variable since good oral hygiene maintenance vastly relies upon the attributes of the users,[28] time of brushing, proper technique, and efforts to remove maximum plaque in all regions, rather than the design of the toothbrush itself. Nevertheless, the 45° angulation of the bristles of the test brush may facilitate the education of users on proper angulation and technique although not tested.

CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

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Are dental hygienists at risk for noise-induced hearing loss? A literature review

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Dental hygienists may be at risk for noise-induced hearing loss because of their repeated daily use of high- and low-frequency noise-emitting devices.
- Preventive measures can be taken to mitigate this risk in clinical practice.
- Active (electronic) sound control devices offer effective hearing protection without compromising comfort or communication with clients.

ABSTRACT

Objective: The aim of this review is to explore dental hygienists' risk for noise-induced hearing loss (NIHL) and to describe the current hearing protection options. **Methods:** A literature search was undertaken using the following databases: PubMed, CINAHL, Cochrane Libraries, and Google Scholar. The returns were screened using inclusion and exclusion criteria and the remaining studies were critically appraised. **Results and Discussion:** Seventeen articles assessed noise levels and NIHL risk in dental settings; and 11 articles examined hearing protection devices. The literature revealed that oral health practitioners were exposed to excessive noise limits (85 dBA) in an 8-hour workday, therefore increasing the risk of NIHL. Oral health professionals need to be aware of this risk and the preventive measures they can take to reduce the potential for hearing loss. Effective preventive measures may include hearing protective devices (HPDs), educational programs, insulated noise-absorbing materials, and regular monitoring of noise exposure. **Conclusion**: Dental hygienists may be at risk for permanent or temporary hearing loss in their work environment. Permanent hearing loss from the use of ultrasonic scalers appears to be minimal. To prevent hearing loss, active (electronic) HPDs are recommended as they allow practitioners to protect their hearing and communicate with clients.

RÉSUMÉ

Objectif : Le présent examen visait à explorer le risque couru par les hygiénistes dentaires en matière de la déficience auditive due au bruit (DADB) et à décrire les options de protection de l'ouïe actuelles. **Méthodes :** Une recherche documentaire a été effectuée au moyen des bases de données suivantes : PubMed, le CINAHL, la bibliothèque Cochrane et Google Scholar. Les trouvailles ont été triées au moyen de critères d'inclusion et d'exclusion et les études restantes ont été évaluées de façon critique. **Résultats et discussion :** Un total de 28 articles ont répondu aux critères d'inclusion. Dix-sept (17) articles ont évalué les niveaux sonores et le risque de DADB en milieux dentaires : 11 articles ont examiné les dispositifs de protection de l'ouïe. La documentation a révélé que les praticiens de santé buccodentaire étaient exposés à des valeurs de limites sonores excessives (85 dBA) au cours d'une journée de travail de 8 heures, augmentant ainsi le risque de DADB. Les professionnels de la santé buccodentaire doivent être sensibilisés à ce risque et aux mesures préventives qu'ils peuvent prendre pour réduire le potentiel de perte d'ouïe. Des mesures préventives efficaces peuvent comprendre des dispositifs de protection de l'ouïe (DPO), des programmes éducatifs, des matériaux insonorisants et la surveillance régulière de l'exposition au bruit. **Conclusion :** Les hygiénistes dentaires peuvent être à risque de perte d'ouïe permanente ou temporaire dans leur environnement de travail. La perte d'ouïe permanente en raison de l'utilisation de détartreurs ultrasoniques semble être minime. Pour prévenir la perte de l'ouïe, des DPO actifs (électroniques) sont recommandés, puisqu'ils permettent aux praticiens de protéger leur ouïe et de communiquer avec leurs clients.

Keywords: dental hygiene; hearing impairment; hearing loss; hearing protective devices; noise-induced hearing loss; occupational noise; suction; ultrasonic scalers

CDHA Research Agenda category: risk assessment and management

BACKGROUND

According to Statistics Canada, "an estimated 19% of adults (4.6 million) have at least mild hearing loss in the speech frequency range."[1] Hearing is important for daily living and vital to maintaining personal safety. A hearing impairment can result in the inability to hear warning signals, such as car horns, fire alarms, and other lifesaving sounds, which increases the risk for incidents and puts lives at stake.[2] There are many types of hearing loss in adults; the most common is sensorineural hearing loss.[3]

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Sensorineural hearing loss is defined as damage to the parts of the inner ear causing hearing loss.[3] The most common type of sensorineural hearing loss is age related (presbycusis) followed by noise-induced hearing loss (NIHL).[4] NIHL is described as the loss of hearing due to damage to the sensitive parts of the inner ear from overexposure to loud sounds.[3,5,6] It is the result of cumulative, long-term exposure to moderate and loud noises, which may affect one ear or both. The damage can be permanent and irreversible. However, damage can be limited if diagnosed at the early stages when preventive interventions can occur.[7,8] Unlike presbycusis, NIHL is not age related, and thus can happen at any time depending on the circumstances.[6]

The noises that cause NIHL can be either very loud for a short period of time, such as an explosion, or moderate to loud over an extended period, such as industrial machines or music,[6,8] which result in damage to the inner ear and subsequently cause permanent hearing loss.[3,6] Common symptoms of NIHL are muffled hearing, difficulty understanding or following conversations, as well as tinnitus.[8,9] Tinnitus is the perception of buzzing, whistling, ringing, roaring or other phantom sounds in the ear.[10,11] The causes of tinnitus are hearing loss, earwax blocking the ear canal, age, ear injury, medications, and other health problems.[10,11]

Excessive noise has many implications for daily life, as well as the potential to contribute to certain health conditions, such as increased risk for cardiovascular disease (including hypertension and ischemic heart disease), stress, sleep disruption, fatigue, anxiety, depression, difficulty concentrating, and mood disorders.[8,12-16] When the resulting NIHL occurs, people have difficulty communicating in groups, public settings or by telephone, which lead to social withdrawal.[2]

NIHL is related to work noise. Using data from two Canadian Health Measures Survey (CHMS) cycles (2012 to 2013 and 2014 to 2015), researchers determined that approximately 11 million Canadians (43%) worked in noisy environments.[12] Of these, over 6 million (56%) were classified as vulnerable to workplace noise.[12] The Canadian Centre for Occupational Health and Safety notes that the daily allowable time-weighted occupational noise exposure limit in most Canadian jurisdictions is 85 dBA over an 8-hour workday for 5 days a week, over 40 years.[17] Yet many workers in noisy environments are not required to wear hearing protection devices, which places them at risk for occupational NIHL.[12]

The daily allowable occupational noise exposure limit is important for oral health professionals to know, as the noise levels from dental devices have been suggested as a potential contributor to NIHL based on multiple studies.[13,18-21] These studies noted that high- and low-frequency noise-emitting devices are frequently used by the oral health team daily.[18,19] Oral health care professionals need to be aware of potential hearing loss risk if these noise levels are deemed dangerous for an average workday. They should also be familiar with the options to prevent such damage from occurring.

Objective

The aim of this review is to explore the risks for NIHL among dental hygienists and to describe the current hearing protection options available.

METHODOLOGY

A literature search was conducted in the electronic databases PubMed, CINAHL, Cochrane Libraries, and Google Scholar using the following keywords: hearing loss, hearing impairment, suction, ultrasonic scalers, noise-induced hearing loss, hearing protective devices, occupational noise, and dental hygiene. The inclusion criteria were 1) published in peer-reviewed sources; 2) written in English; 3) published within the past 20 years; 4) adult population studies. The following items were excluded: 1) letters to the editor; 2) studies of noise in dental laboratory settings.

The titles and abstracts retrieved were read by 2 of the team members (KH and SH) to determine their suitability for this review based on the inclusion/exclusion criteria. In addition, the reference lists were scanned for additional resources. Research methodologies included were randomized controlled trials, systematic reviews, descriptive studies, surveys or questionnaires, reviews, and pilot studies. Studies primarily assessing noise or hearing impairment in the oral health setting or with oral health personnel using ultrasonic scalers were highlighted.

RESULTS

There were 28 studies that met the inclusion criteria. Twenty-seven of the studies were from peer-reviewed journals; the remaining study was a dissertation from the Program in Audiology and Communication Sciences, Washington University School of Medicine.[15] Two articles were excluded as their primary focus was either not on clinical dental noise or did not include ultrasonic scalers as part of the study. The designs of the 26 included studies were as follows: 1 quantitative systematic review,[22] 2 quantitative randomized controlled clinical trials,[23,24] 1 quantitative case–control study,[19] 3 quantitative descriptive studies,[21,25,26] 15 quantitative cross-sectional studies,[13-15,18,20,27-35,39] 2 qualitative cross-sectional studies,[36,37] and 2 narrative reviews[38,42] (Table 1). Seventeen studies evaluated noise levels and the risk of NIHL when oral health professionals were using an ultrasonic scaler.[13,19-21,26,27,30-35,37-40,42] Eleven studies evaluated hearing protection devices and their current use in the oral health setting.[13-15, 22-25,27,29,36,38]

The importance of the daily occupational noise limit to oral health professionals was discussed in 8 studies.[13,18-21,25,34,35] Two articles identified the age of the practitioner and length of time in practice as other contributing factors to NIHL.[21,28] Seven articles attributed

Table 1. Summary of included studies

Author	Methodology	Study purpose	Sample size	Relevant findings
Ahmed HO, 2017[33]	Quantitative cross-sectional	To examine and determine the noise level in a dental college (noise annoyance, subjective hearing loss, and hearing related problems among students).	n = 114	Noise level were between 58 dB(A) and 79 dB(A). Peak levels ranged from 89 dB(A) to 93 dB(A). Students with prolonged exposure had more hearing issues.
Alabdulwahhab BM, 2016[31]	Quantitative cross-sectional	To determine whether the persistent high-frequency sounds produced by the dental equipment could cause hearing decrement among Saudi dental practitioners.	n = 38	A majority of dental professionals in this study were right-handed and the position of instruments (i.e., high-volume suction being to the left of most dentists) could play a role in level of hearing impairment. Evaluated noise levels from ultrasonic scalers.
Al-Omoush SA 2019[29]	Quantitative cross-sectional	To examine the hearing threshold in oral health personnel. To evaluate sound levels of the equipment used by these personnel.	n = 244	Self-reported risk for hearing loss in oral health professionals who were exposed to dental noise >4 hrs a day. Left ear threshold was poorer than right ear. Relationship between hearing loss and daily duration of noise and age of subject.
Al-Rawi NH 2019[30]	Quantitative cross-sectional	To determine whether the persistent high-frequency noise produced by dental equipment could cause hearing impairment among the dental professionals.	n = 90	Evaluated noise levels from ultrasonic scalers. Suggests time in practice can be related to increased hearing loss.
Arabaci T, 2007[42]	Review	To review the safety, efficacy, role, and deleterious side effects of sonic and ultrasonic scalers in mechanical periodontal therapy.	N/A	Ultrasonic scalers may cause tinnitus, temporary shifts in hearing thresholds. No permanent damage due to airborne noise from ultrasonics, no conclusive information of transmission through the bones of the inner ear.
Bono SS, 2006[15]	Dissertation Quantitative cross-sectional	To survey dentists' opinions of noise caused by handpieces. To quantify the noise output of dental handpieces including sonic/ultrasonic scalers.	Survey (n = 12) Handpieces (n = 6)	Dentists would wear HPD if instruments were deemed harmful to their hearing. Hearing loss is multifactorial. Oral health care providers should be 12 inches (30.48 cm) away from the noise source. The noise output for the titan and the Piezo was 80 dB(A). Frequency of use should be considered.
Burk A, 2016[13]	Quantitative cross-sectional and survey	To assess potential noise exposure among dentists, dental hygienists, and dental students. To assess the differences in exposure between the 3 oral health professional groups.	n = 46	Evaluated noise levels from ultrasonic scalers. Results suggest that oral health professionals and students may have some risk of developing NIHL particularly in pediatric clinical settings. HPD
Chopra A 2016[27]	Quantitative cross-sectional	To evaluate the negative auditory and non-auditory effects immediately after using ultrasonic scalers and their potential role in the development of permanent hearing loss.	n = 60	Noise-emitting devices such as ultrasonic scalers produce significant immediate auditory and non-auditory changes. It is important that oral health care providers recognize the initial signs of hearing damage and adopt appropriate measures while working to prevent the development of permanent hearing impairment in future.
Choosong T 2011[39]	Quantitative cross-sectional	To determine noise exposure among oral health professionals.	n = 113	Noise levels in the dental school were approximately 60 dB. This level may cause annoyance, conversation interference, and concentration difficulty but not NIHL. Evaluated noise levels from ultrasonic scalers.

Table 1. *continued*

Author	Methodology	Study purpose	Sample size	Relevant findings
Daud MK, 2011[32]	Quantitative comparative cross-sectional	To determine intensity and frequency of oral health instruments. Determine prevalence of NIHL in dental staff nurses.	n = 65	Dental staff nurses might be at risk for NIHL. Evaluated noise levels from ultrasonic scalers.
Kadanakuppe S 2011[25]	Quantitative descriptive	To measure, analyse, and compare noise levels of equipment under different working conditions and to measure and compare noise levels between used and brand-new handpieces under different working conditions.	N/A	Evaluated noise levels from ultrasonic scalers. The noise levels detected in this study were considered close to the limit of risk of hearing loss. HPD
Khaimook W 2014[21]	Quantitative descriptive	To determine the prevalence of hearing loss among dental personnel exposed to instrument noise during the workday. To identify noise levels in work areas. To identify risk factors of hearing loss.	n = 76	Risk factors are age and career length. No significant difference was found between dental personnel and control group.
Khan A 2006[37]	Qualitative cross-sectional	To determine if noise producing dental tools are a predetermining factor for NIHL.	n = 333	Hazardous auditory output is affected by intensity, duration, and frequency. Noises emitted from dental tools, including the ultrasonic scaler, are lower than the permissible limits, yet it is advisable that dentists using high-speed drills should have periodic hearing tests.
Lazar A 2015[34]	Quantitative cross-sectional	To assess prevalence of self-reported hearing difficulties among experienced dental hygienists who have been practising for a minimum of 20 years and explore the relationship between hearing difficulties and occupational noise exposure from ultrasonic scalers.	n = 372	Long-term noise exposure from dental equipment, such as ultrasonic scalers, may contribute to hearing difficulties among experienced dental hygienists.
Ma KW 2017[14]	Quantitative cross-sectional	To conduct noise exposure assessments on oral health professionals' daily working environment and to relate this as a health risk assessment.	n = 60	Noise in the oral health environment was within the recommended occupational limit. However, the increase in noise was related to dissatisfaction in the health risk assessment. HPD
Manchir M 2016[36]	Qualitative cross-sectional	To survey dentists regarding the type of HPD they prefer.	n = 15	Studied 4 different HPDs. The active noise devices (electronic) are preferred.
Messano GA 2012[20]	Quantitative cross-sectional	To investigate prevalence and factors associated with perceived hearing impairment among dentists.	n = 215	Self-reported incidence of hearing related problems due to dental equipment, including ultrasonic scalers.
Myers J 2016[18]	Quantitative cross-sectional	To evaluate noise levels in dental offices and to estimate the risk and prevalence of tinnitus and NIHL in practising dentists.	n = 144	Results from sound level measurements and questionnaire responses indicate that dentists are a population that could be placing their hearing health at risk in a typical daily work environment. Evaluated noise levels from ultrasonic scalers.
Paramashivaiah R 2013[38]	Review	Review of the literature on the various hazards associated with ultrasonic and sonic instrumentation.	N/A	Listed the factors associated with hearing loss among dentists. Conclusion was that using ultrasonic scalers was not associated with NIHL.
Salmani Nodoushan M 2014[23]	Quantitative RCT	To compare the effect of face-to-face training in effective use of earplugs with appropriate noise reduction rating (NRR) to overprotection of workers by using earplugs with higher than necessary NRR.	n = 150	Training in appropriate use of earplugs significantly affects the efficacy of earplugs—even more than using an earplug with higher NRR.

Table 1. *continued*

Author	Methodology	Study purpose	Sample size	Relevant findings
Sharma M 2019[28]	Quantitative cross-sectional	To determine the impact of hearing education on the attitudes towards and beliefs about noise and hearing protection among dental students.	n = 24	Hearing education was effective in changing the attitudes and beliefs of dental students on hearing protection and occupational noise exposure.
Sorainen E 2002[26]	Quantitative descriptive	To evaluate the noise levels of current dentistry equipment under very controlled conditions.	N/A	The average ultrasound level of the hand pieces was below 90 dB. The average ultrasound level of the ultrasonic scaler at the one-third octave band of 25,000 Hz was 107 dB.
Spomer J 2017[24]	Quantitative RCT	To evaluate hearing devices in dental clinics to better understand barriers and facilitate the use of these devices.	n = 15	Two suggested HPDs: The DI-15 High-Fidelity Electronic Earplugs HPD (ranked highest) and Music PRO Electronic Earplugs (second).
Verbeek JH 2014[22]	Quantitative systematic review	To assess the effectiveness of interventions in preventing occupational noise exposure or hearing loss compared to no intervention or alternative interventions.	n = 19 studies n= 82,794 participants	Low-quality evidence supports the use of hearing protection. Low-quality evidence that hearing loss programs reduce the risk of hearing loss.
Willershausen B 2014[35]	Quantitative cross-sectional	To assess the hearing abilities of dentists compared to other academic professionals to determine possibly significant differences in their hearing.	n = 115	Dentists and dental personnel are exposed to a noise level of different frequency ranges due to the use of high-speed handpieces, various instruments, and ultrasound devices. Maximum sound levels of 85.8 dB and 92.0 dB were found.
Wilson JD 2002[19]	Quantitative case–control study	To determine whether long-term ultrasonic noise exposure in the dental office environment is related to dental hygienists' hearing status.	n = 698	Right and left ears were not statistically different in the hearing threshold levels. Ultrasonic noise may in fact be affecting dental hygienists' hearing at 3000 Hz.

the risk of NIHL to the high- and low-frequency noise-emitting devices frequently used daily by the oral health team over an extended period.[18-20,25,35,37,39] These devices can reach hazardous outputs depending on the duration of use and intensity. Another study expressed concern over whether oral health students are at risk for NIHL given the accumulation of noise from such a high number of operatories.[13] In addition to studying the causes of NIHL in the oral health setting and hearing protection devices (HPDs), 1 article described the different methods used to reduce noise levels in dental clinics, such as using sound-absorbing materials in the walls.[33]

Many themes emerged from these studies, including that oral health professionals and students may be at risk for NIHL[18]; age and length in practice may have an effect on NIHL[21,30]; and long-term exposure to the noises emitted from dental equipment[24,31] may contribute to hearing loss depending on the intensity, duration, and frequency of use of the devices[20,37]. Other themes focused on the importance of recognizing signs of NIHL[13,36] and adopting appropriate prevention methods. Methods such as sound-absorbing materials,[33] HPDs,[18] and proper training on use of HPDs [23,28] may be effective methods for preventing NIHL.

DISCUSSION

Eight specific topics identified from this literature review will be discussed under separate headings: 1) general oral health settings noise levels; 2) hearing damage due to ultrasonic scaler noise; 3) hearing impairment among oral health professionals; 4) HPDs; 5) benefits of wearing HPDs; 6) HPD education; 7) other hearing protection options; and 8) current use of HPDs in oral care offices.

General oral health settings noise levels

In order to understand the effects of sound on hearing, a brief description is required. Each sound produced has a frequency, Hertz (Hz), a rate at which the sound waves complete a cycle.[11] A healthy, young human can hear frequencies that range from 20 Hz to 20,000 Hz.[40] Although a person is able to hear sound waves in this range, the human ear is more sensitive to certain frequencies over others, meaning certain frequencies will be interpreted as louder even if they are not.[40] The A-weighted decibel scale was created to accommodate this so that lower frequencies are de-emphasized; the A-weighted filter assesses decibel levels at the noise level experienced by the listener.[11,40] It is also important to clarify that the decibel scale is a

logarithmic scale, therefore decibel levels do not cumulate by addition.[11] For example, when using the ultrasonic scaler and a low- or high-volume suction, the devices produce different frequencies and will be interpreted differently by the ear.[40]

Oral health professionals are exposed to many different types of noise—high- and low-speed handpieces, high- and low-volume suction, ultrasonic scalers and baths, and even noise related to loud client interactions throughout a workday—that contribute to increased noise levels. The noise levels from dental devices can accumulate very easily. This was evident in a simulated work environment where unobstructed suction noise levels, including both low and high volume, fell between 75 and 79 A-weighted dB (dBA)[19,26,32,35,38,39]; this range is within the recommended maximum 85 dBA exposure limit for an 8-hour workday.[8,12] Having an obstructed suction can increase the noise level to 96 dBA, which is similar to the noise levels reached when combining an unobstructed suction with a dental handpiece of 94 dBA,[18] both of which have a recommended 1-hour maximum exposure time according to the Canadian Centre for Occupational Health and Safety.[17] The presence of electric generators, aspirators, autoclaves, and compressors can also contribute to background noise. It is not known if this noise is damaging to hearing or just irritating to the clinician.[37]

Hearing damage due to ultrasonic scaler noise

Ultrasonic noise refers to sound with a frequency above the 20 kHz that the human ear can hear.[11,42] If the ultrasound is too strong it can create audible subharmonies within the ear which are interpreted as squeaking sounds[25] and could be harmful over the long term.[38] Ultrasonic scalers used in oral health settings produce high-intensity ultrasonic sound between 20 kHz and 50 kHz.[41]

Ultrasonic scalers on average have noise levels of 69 dBA to 84 dBA,[15,26] which is within the safe 8-hour occupational noise limit. Other studies found the average noise level for ultrasonic scalers to be 87.1 dBA[32,35,38] or even up to "107 dB at the one-third octave band of 25,000 Hz."[26] It should be noted that the majority of the frequencies in this octave band are completely inaudible to humans regardless of intensity.[43] While the measurement of 107 dB is above the recommended 87 dB, human ears are insensitive to this ultra-high frequency, so a person would not hear it.[43] The studies did not examine the cumulative noise level of the ultrasonic scaler and either the low- or high-volume suction, which are traditionally used together in practice. However, as previously mentioned, the different frequencies would be interpreted differently by the ear.[40]

A reduction in hearing, called a threshold shift, occurs when the ear decreases its sensitivity level in response to noise exposure, thereby raising the threshold required to hear sound; once a threshold shift occurs only noise louder than a certain threshold will be heard.[11,42] A temporary shift can occur after an exposure to loud or intense noise and will usually resolve within a day, or could take up to a week.[11,42] A permanent threshold shift will occur when the inner ear is damaged and the ability to hear is reduced permanently.[11,42]

A temporary threshold shift has been reported following the use of an ultrasonic scaler, causing an individual to require a louder stimulus than usual to hear the same frequency.[27,42] This temporary condition was found to last between 16 hours and 48 hours, but the researchers cautioned that a certain degree of permanent damage could take place.[27]

Dental hygienists have expressed concern over the risk of hearing loss as a result of using ultrasonic scalers. Lazar et al.[34] surveyed 273 dental hygienists who self-reported that ultrasonic scalers may contribute to hearing loss. Seventeen percent of the participants reported having hearing difficulties, such as tinnitus, specifically due to ultrasonic scaler use.[34] Arabaci et al.[42] reported in their review that, following the use of ultrasonics, a temporary shift in the hearing threshold and tinnitus may occur. However, when compared with the general population there were minimal differences in these symptoms. Wilson et al.[19], in a pilot study using pure-tone audiometry testing, revealed a statistically significant difference between a group of dental hygienists who frequently used ultrasonic scalers compared to a group that did not use these devices.[19] Upon further analysis, this same study found hearing was specifically affected at 3000 Hz and there was no significant difference between the groups at other frequencies.[19] Interestingly, no significant differences were found between right and left ears using pure-tone audiometry testing,[19] but when tested with otoacoustic emission, which determines the function of the inner ear cells, the left ear had a greater reduction than the right.[27,31] However, there was no indication of whether the participants were right or left handed, which would affect the positioning of the instruments.[27,31] Chopra et al.[27] additionally found through pure-tone audiometry testing that ultrasonic scalers have an immediate effect reduction on hearing.[27]

Hearing impairment among oral health professionals

There is evidence of hearing impairment to a certain degree among oral health professionals through pure-tone audiometry testing.[30,31] A cross-sectional study surveyed 100 general dental practitioners with at least 10 years of work experience. These practitioners self-reported a higher presumptive hearing impairment compared to a similar control group made up of 115 general medical practitioners.[20] The perceived hearing loss was not confirmed with any formal audiometric testing, which reduces validity and generalizability of the results of this study. Al-Omoush and colleagues[29] conducted a quantitative case–control study that included 244 dental professionals. The participants were divided into 4 test groups, with 1 control group consisting of 62 dental students. Otoscopy, tympanometry,

and pure-tone audiometry assessments were conducted and values were compared with those of the control group. Study findings revealed dental professionals had a higher prevalence of hearing loss than non-dental professionals.[29] In contrast, a different case–control study in which dental personnel received otoscopic exams and pure-tone audiometry testing showed no significant difference in hearing impairment between oral health professionals and the control group.[21] Similarly, Alabdulwahhab et al.[31], in a cross-sectional study, found no significant differences between dentists and those in the control group.

Oral health professionals could be exposed to different levels of noise depending on whether they are students or professors in a student clinic or depending on their specialty.[13,33] Pediatric clinics had the highest average and variability in noise levels, suggesting their personnel are at greatest risk for NIHL.[13] Meanwhile, students experience a large variability in noise exposure in preclinical and clinical settings depending on the skill exercises and client care that day, as well as class size and floor plan.[13] About 80% of dental students report noise annoyance in clinic, with some students reporting difficulty hearing phone conversations and symptoms of tinnitus.[33] Over half of students were not aware that noise levels could be dangerous and were unaware of measures they could take to protect themselves.[33] While the evidence supporting NIHL in oral health professionals is inconclusive, as there are so many variables involved, it is important to educate oral health professionals on the hearing risks that may be associated with their work environment.

Hearing protection devices

Hearing protection is recommended more frequently in dental offices now than in the past, but it is still uncommon for dental hygienists to use HPDs.[24] As more studies on this topic are conducted, there may be a rise in dental hygienists wearing HPDs. There are 2 main forms of HPDs: 1) passive noise control and 2) active sound control.[44]

Passive noise control devices work as physical barriers to sound.[44] There are several types of passive sound control devices, such as earmuffs, disposable foam earplugs, and ear canal plugs.[36,44] Earmuffs consist of sound attenuating material and soft ear cushions. These fit over the ear, have hard outer cups and a head band. The inability to communicate with clients and disinfect such devices eliminate them as a viable option for dental hygienists.[36] Another passive device is disposable foam earplugs. These HPDs are designed to be rolled into a thin cylinder and inserted in the ear canal where they expand to fit the user's ear canal.[36] These HPDs are disposable, which makes cleaning unnecessary, although the discarding of the devices does result in environment waste. The foam plugs are the least expensive form of HPDs. However, the cost of replacements may become a deterrent for use.[24,38] The ear plugs will decrease the amount of noise exposure but not as much as earmuffs. However, both earmuffs and earplugs may not be the best choices for dental practitioners as these devices muffle the sound of their own voice but more importantly inhibit the ability of the practitioner to communicate with their clients.[24] Since communication is an essential part of dental hygiene practice, the limiting nature of these HPDs does not make them viable noise prevention options.

Ear canal plugs are another type of passive HPD that is recommended. These devices come in 2 forms. The first are premolded, reusable plugs typically made of silicone, rubber or plastic. The second are canal caps, which consist of earplugs on a plastic or metal band. These devices are either inserted into the ear canal or sit at the opening of the ear canal.[24,36] The advantages of these HPDs are that they are reusable, they last 2 to 3 months, they are available in different sizes, they are generally inexpensive, and they can be cleaned.[24,36] In addition, the ear canal plugs provide the wearers with the ability to place them around the neck when not in use, which many practitioners find convenient.[36] The disadvantages of this type of HPD are that it is often difficult to find the correct size, some people may require a different size plug for each ear or require training for proper fit and insertion, and communication with clients and colleagues once again may be difficult.[24,36]

The active sound control devices electronically modify sound transmission, reducing unwanted noise instead of blocking noise.[36,38] These devices use hearing aid batteries, and they offer hearing protection from high-level sounds while allowing other sounds to be heard.[24,36] Therefore, the major benefit for the dental hygienist is that they enable 2-way communication with clients. In addition, the electronic HPD can be disinfected and tends to fit better than the previously discussed options. However, the electronic models are the most expensive of the HPDs, costing at least $100 for over-the-counter models and more for custom-made models. The higher initial price and the cost of replacement batteries may make these devices less attractive options for some practitioners.[24]

The consensus from clinicians is that the electronic models are the preferred HPD.[25,36] This is due to ease of use, comfort, feeling of openness, general pleasant appearance, and the ability to communicate with the client.[25,36] Two-way communication between client and practitioner is crucial as it is a major component in ensuring the success of care and maintaining client comfort and safety.[24,36]

Benefits of wearing hearing protection devices

Decreasing the risk of NIHL is the main purpose of an HPD. However, HPDs may also decrease the risk of both short- and long-term side effects from exposure to increased noise,[22] such as fatigue, nausea, headaches, irritation, tinnitus, and even hypertension.[14] Long-term benefits of wearing an HPD may include increased work performance and work satisfaction.[14-15]

Hearing protection device education

Special training on the use of HPDs is available to help practitioners effectively use these devices.[22,23] There is a moderate level of quality evidence demonstrating that the effectiveness of hearing protection is close to 8 dB better following instruction on the proper use of HPDs as compared to no instruction.[22,23] In addition, there is increased effectiveness in noise reduction rating with proper instruction on how to use the HPD, even when compared to an HPD with a higher level of protection used by someone who is not properly instructed.[23] It is also shown that having the HPD correctly sized to a person's ear canal results in higher usage of the device.[23]

One study of dental students implemented an educational program to increase their knowledge of hearing and how it may be affected in oral health care settings.[28] The researchers asked questions before and after the education program was provided. The pre-questionnaire noted a lack of knowledge of the risks of NIHL.[28] After the participants were educated on the risks of NIHL, the post-questionnaire revealed students were more likely to wear HPDs.[28]

While education on why a practitioner should wear HPDs is important, so is training prior to using HPDs. Learning the proper insertion techniques and application will improve the protection provided from these devices.[36] There is literature available online, credible YouTube videos, and websites on the proper use and insertion of HPDs. However, seeing the appropriate hearing specialist may ensure optimal selection and application of an HPD.[36]

Other hearing protection options

In all oral health settings, there is a risk of noise exposure among practitioners, but also potentially among the clients and other staff.[13,18-21,28] Given the possible exposure to damaging levels of noise in this setting, Ahmed et al.[33] recommended placing sound-absorbing materials in the walls when building dental offices.[33] Materials such as foam padding and fiberglass insulation will absorb sound more than wood, gypsum board, concrete, brick, and tile, which reflect sound.[45,46] Other recommendations have been based on the dental equipment itself.[24,25,33] Due to the excessive noise emitted by older models of dental equipment, it is recommended that such equipment be replaced with new, less noisy models.[24,25,33,39] Factors influencing the noise generation of dental equipment could be handpiece design, misuse or wear, and poor maintenance of the equipment.[24,25]

It is recommended that regular monitoring of noise levels in the office be conducted to ensure proper reduction protocols are incorporated, when necessary, to reduce the risk of NIHL.[14] The implementation of a hearing loss prevention program would be ideal in the oral health setting. Such a program would incorporate testing on noise exposure, audiometric testing, and training for all oral health care providers.[13] Incorporating a prevention program will ensure that dangerous noise levels are discovered in the early stages before causing any negative long-term hearing complications.

Current use of hearing protection devices in oral care offices

Avoiding excessive noise exposure is the best option for preventing NIHL.[8,24] Unfortunately, the total avoidance of noise is impossible in the oral health care setting. The options for reducing noise include modifying the equipment and/or the acoustic environment to produce less noise and/or wearing HPDs.[24,36] While the use of HPDs is presently uncommon among oral health care practitioners, education should be provided to help reduce exposure risk. Such education and awareness should increase the use of devices that do not interfere with communication.[23,24] Additionally, the inclusion of education on the prevention of NIHL within both dental hygiene and dental curricula is highly recommended. Awareness of this subject could encourage early action to protect the hearing of all oral health professionals.[28] Recognizing the risks of NIHL is essential to oral health professionals, and the use of preventive measures is highly recommended.[27]

CONCLUSION

This article indicates that dental hygienists along with other oral health professionals could be at risk for NIHL in their work environment. However, more research is necessary on the dental hygienists' exposure to high-frequency noise as a result of the use of ultrasonic scalers, and the long-term effects such exposure could have on hearing. Permanent hearing loss risk appears to be minimal for dental hygienists using ultrasonic scalers because they do not exceed the daily allowable occupational noise limit of 85 dBA. Temporary effects on hearing as a result of using these devices include tinnitus and threshold shifts. It is recommended that dental hygienists have regular hearing exams performed by audiologists. If the dental hygienist decides to wear HPDs, the active (electronic) HPDs are preferred as they are comfortable and allow communication with clients.

CONFLICTS OF INTEREST

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Exploring access in a volunteer free-service dental clinic

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PRACTICAL IMPLICATIONS OF THIS RESEARCH

- Improving access to oral health care for marginalized people is complex and often involves multiple stakeholders.
- Health brokers support marginalized people in obtaining needed services.
- Gaps in communications and delivery of services must be considered when establishing programs to meet a need in society.

ABSTRACT

Introduction: Marginalized, low-income individuals face many barriers to dental care, including but not limited to cost. The Student Health Initiative for the Needs of Edmonton (SHINE) dental clinic is a student-operated volunteer clinic offering free services to low-income individuals. This study aimed to explore the access to dental care needs of low-income groups, from community health brokers' perspectives. **Case description:** The study was deemed exempt from ethical approval (Pro00074745). Five semistructured interviews exploring access to dental care were conducted with health brokers purposefully selected from 4 different community outreach centres. Access was defined and analysed using Penchansky and Thomas' theory of access as modified by Saurman. **Results:** Interviews revealed lack of awareness of the SHINE clinic. Translation and interpretation support was an identified need, and there was concern for clients who fear discrimination in health care settings. **Conclusion:** Preliminary barriers to care at SHINE were identified. However, further investigation is required to understand how SHINE aligns with population needs.

RÉSUMÉ

Introduction : Les personnes marginalisées et à faible revenu sont confrontées à plusieurs obstacles en matière de soins dentaires, y compris, mais sans s'y limiter au coût. La clinique dentaire *Student Health Initiative for the Needs of Edmonton* (SHINE) est une clinique gérée par des étudiants bénévoles qui offre des services gratuits aux personnes à faible revenu. La présente étude vise à explorer les besoins d'accès aux soins dentaires de groupes à faible revenu du point de vue des intervenants de la santé communautaire. **Description du cas :** L'étude a été déclarée exempte de l'approbation éthique (Pro00074745). Cinq entrevues semi-structurées qui explorent l'accès aux soins dentaires ont été réalisées avec des intervenants de la santé, délibérément sélectionnés dans 4 centres d'assistance communautaire différents. L'accès a été défini et analysé au moyen de la théorie d'accès aux soins de Penchansky et Thomas, telle que modifiée par Saurman. **Résultats :** Les entrevues ont révélé un manque de connaissance de la clinique SHINE. Un soutien en matière de traduction et d'interprétation était un besoin établi et on s'inquiétait des clients qui craignent la discrimination dans les milieux de soins de santé. **Conclusion :** Des obstacles préliminaires aux soins chez SHINE ont été reconnus. Cependant, une enquête plus approfondie est requise pour comprendre dans quelle mesure SHINE correspond aux besoins de la population.

Keywords: access to care; dental clinic; fear of discrimination; free; health brokers; language barriers; low income; oral health; student; volunteer
CDHA Research Agenda category: access to care and unmet needs

INTRODUCTION

Poor oral health contributes to pain, infection, problems with speech and mastication, and increased inflammatory mediators correlated to systemic illnesses.[1,2] In addition to systemic effects, poor oral health impacts mental health by affecting one's ability to engage with people and the surrounding environment, creating stigma and social isolation.[1,3] Even though oral health is a significant component and predictor of general health and well-being, Canada's publicly funded health care system does not include dentistry.[4] Due to cost barriers alone, 22.4% of Canadians avoided seeking dental care in 2018.[5] Those in the lowest income quintile were least likely to seek dental care, even if dental coverage was available to them, suggesting there are further barriers.[5]

Health services in high-income countries are recognizing challenges in engaging marginalized populations.[6] Marginalized populations are defined as those experiencing inequalities in access to power and resources, and those

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who are socially excluded.[7] One solution to reducing health disparities faced by marginalized groups is to engage health brokers.[6] Health brokers are individuals who work or volunteer at community outreach centres that link marginalized populations to health services, producing beneficial health outcomes.[6] They possess knowledge of the needs and barriers their clients face in accessing health care, including dental care. Additionally, they are uniquely positioned to bridge boundaries between marginalized populations and health services to improve access.

CASE DESCRIPTION

Recognizing that significant gaps exist in access to oral health care, undergraduate dentistry students at the University of Alberta (Edmonton, Canada) established the Student Health Initiative for the Needs of Edmonton (SHINE) dental clinic in 2004. SHINE is a free service operated by volunteer undergraduate dentistry and dental hygiene students from the university. The initiative aims to reduce inequalities in dental health by increasing access to oral health services among low-income individuals.[8] Services offered at SHINE include dental hygiene care, restorative dentistry, and emergency procedures, such as tooth extractions. Clients are seen on a walk-in basis and triaged for treatment based on their age, level of pain, and infection. SHINE gives priority to youth but provides services to anyone who cannot afford dental care. Referrals to the University of Alberta School of Dentistry dental clinic are made for cases deemed too complex to be managed through SHINE. The referral process allows for continued care, free of charge, for children under the age of 18. However, depending on the type of treatment required, adults referred from SHINE may pay all or partial costs associated with receiving dental care at the School of Dentistry.

While SHINE is providing needed dental and dental hygiene treatment in the inner city, there is limited insight into SHINE's connection with the marginalized populations it aims to serve. Access is the measure of fit between a service and the population's needs.[9] Using Saurman's modified version of Penchansky and Thomas' theory of access, this study sought to gain the perspective of health brokers at community agencies in the inner city on SHINE's alignment with the access needs of the marginalized populations they serve.[9,10]

METHODS

Ethics approval was sought from the University of Alberta's Research Ethics Board (REB, Pro00074745). As a needs assessment to optimize services for populations the SHINE dental clinic aims to serve, the project was deemed outside the mandate of the REB.

This exploratory qualitative descriptive study used purposeful sampling to select health brokers who work closely with low-income and homeless individuals in the urban inner city area, arranging health and other services to meet their basic human needs. Five health brokers were selected from 4 different community outreach facilities, as their position and direct involvement with the inner city population made them ideal information-rich sources that could speak to this population's needs. Health brokers were not given any information regarding SHINE prior to the interviews.

Two undergraduate student research assistants, one in dentistry and one in dental hygiene, under the guidance of a principal investigator conducted semistructured individual interviews of approximately 40 minutes each. Interviews were audiorecorded and transcribed verbatim for latent content analysis. After completion of the interviews, an oral presentation was given to participants and others at the community agencies to improve awareness of SHINE. Saurman's modified version of Penchansky and Thomas' theory of access, as outlined in Table 1, was used to define access, and the data were coded according to Saurman's 6 domains of access.

Table 1. The dimensions of access

Dimension of access	Definition
Availability	Supply and demand
Accessibility	Ease of access to the location
Acceptability	Consumer perception of the service
Accommodation	Organization of the service to accommodate clients (e.g., adequate hours of operation)
Affordability	Financial and incidental costs associated with the service
Awareness	Communication and information about the service is known to stakeholders, clients, and community

Adapted from: Saurman E. Improving access: Modifying Penchansky and Thomas's theory of access. *J Heal Serv Res Policy.* 2016;21(1):36–39. Table 1. The dimensions of access (p. 37).[10]

RESULTS

Awareness

Awareness of SHINE was not a prerequisite for participation in this study. Interviews explored health brokers' awareness of SHINE, its services, the clients it serves, and more. Only 1 of the 5 participants was aware of SHINE, but all were familiar with the community health facility where SHINE is located.

The interviews confirmed how the health brokers support access to needed services: "We're a lot of the times, the first connection, or one of the few connections that they [marginalized individuals] have to the...public health system." Furthermore, health brokers acknowledged the need for dental services, explaining, "Oral health is probably one of the biggest things that I see people struggle with." Although the health brokers noted a lack of awareness among clients—"It's just that, they don't know that [dental care is] out there. They don't know what they

can do about it."—they also expressed a need for support to source dental care for their clients:

> *We probably do need more support to find dentists who would be willing to work with our families...it would be great if we could have some navigational support.*

Health brokers' awareness of SHINE's services would enable them to link their clients to SHINE, thus raising awareness of the clinic among marginalized population groups. Lack of awareness of SHINE among both health brokers and their clients led us to conclude that awareness is an access barrier. A secondary benefit of the interviews was the opportunity to share information about SHINE with the health brokers.

Overall, health brokers lacked awareness of the SHINE dental clinic. As a result, data available for analysis in other domains were limited. However, health brokers' knowledge of their clients' needs and the community location of SHINE enabled them to speak to aspects of each domain.

Availability

Dental services most needed by marginalized inner city populations, as described by health brokers, include oral health education, dental hygiene treatment, fillings, extractions, pain management, elimination of infections, and dentures. Pain was the motivating factor to seek care:

> *If you're not in pain [then] no one really thinks about the mouth.*

> *Common dental concerns are lack of hygiene leading to big cavities everywhere, and pain, and infection, stuff like that...we can't even put out crunchy peanut butter because they said that they are at risk of cracking a tooth.*

However, in pursuit of pain relief, marginalized people often undergo tooth extraction, resulting in extensive tooth loss: "So many of them have lost a lot of teeth... being able to set people up with getting dentures [would be valuable]." SHINE provides all of these services except for denture fabrication. Overall, the availability of dental services at SHINE was perceived as an asset. However, finding offices to pursue denture prosthetics for clients is an area for further investigation.

Accessibility

SHINE, located within a community health centre in the inner city, was thought to be a ideally situated by 3 of 5 health brokers. Its central location, proximity to other outreach facilities, and ease of access by public transit were considered assets. Location was deemed important because health brokers reported that their clients' primary sources of transportation were walking, bicycling, and public transit: "The majority of them either take the bus or walk." Two health brokers indicated that, although SHINE's location is in an ideal area for some low-income groups, it is not ideal for all of them, specifically new immigrant families. They described that different populations of low-income people require different settings to feel comfortable. Although the location was not deemed ideal for all low-income populations, SHINE was considered situated in a readily accessible location for many potential clients.

Acceptability

Data on the acceptability of SHINE were limited due to the health brokers' lack of awareness of the initiative. However, 1 broker suggested that the people who typically attend SHINE (e.g., individuals facing financial hardship, social barriers, and/or requiring addictions and mental health services)[11] may actually prevent other prospective clients from accessing its services:

> *Some of our mothers feel uncomfortable at that location. Without any discrimination of the population there...we actually don't bring our families to that health centre.*

Although SHINE was deemed to be geographically accessible, it may not be an acceptable setting for all prospective clients. Further inquiry into this perspective is required as it was reported by a single health broker.

Accommodation

Health brokers speculated that 2 barriers to care at SHINE might be limitations in language services and perceived discrimination. The language spoken by volunteers at SHINE is predominantly English. However, other languages may be understood and spoken depending on the available volunteers. One health broker explained:

> *We tend to work with [new immigrant and refugee] families who are most vulnerable, and so, the majority of them will have difficulties with English. So, my guess would be...maybe 70 percent of [this] population will have some English language barrier.*

Perceived oppression and marginalization among homeless and low-income individuals were also identified as an accommodation barrier to health care in general. As one health broker explained:

> *There's a lot of obstacles for people connecting with the healthcare system... Some of them are real, and some of them are perceived. You know, our demographic isn't always treated properly by the healthcare system... Oppression, marginalization, racism...*

As a result, "they don't like going to the doctor...they don't do anything until it's basically causing them an excessive amount of pain."

Affordability

SHINE offers free services. Although other cost barriers, such as transportation and childcare, may exist, no affordability barriers were identified.

DISCUSSION

A common theme that emerged from this project was low-income individuals' fear of discrimination in health care settings. There is a cultural incompatibility, indicating a poor fit of values, between the private practice model and the oral health needs of marginalized groups.[12] Dental clinics should consider how they can provide services in a culturally safe manner for marginalized population groups.[13] It is SHINE's goal to provide a culturally safe space. To that end, more insight is required into the acceptability of the clinic.

Unfortunately, among the 5 health brokers interviewed, there was limited awareness of the SHINE dental clinic. Awareness is an important dimension of access because health brokers cannot refer clients to a program they are not aware of.[10] This lack of awareness also hindered the gathering of data on availability, accommodation, and acceptability. Therefore, the project's ability to address the overall concept of access was limited. However, by interviewing health brokers and providing a post-interview presentation, the research team was able to inform them about SHINE, raising awareness and potentially more referrals to SHINE henceforth. This outcome will require further follow-up, which is already underway.

CONCLUSION

This exploratory qualitative study with health brokers who facilitate services in an inner city low socioeconomic area identified strengths and weaknesses of the SHINE dental clinic. Its strengths include affordability, accessibility, and availability of select services. Its weaknesses include lack of public awareness, limited translation services, and fear of discrimination among clients. Using individual interviews to collect the data resulted in a secondary outcome of educating, informing, and increasing awareness of SHINE among the health brokers, which may increase the use of the clinic by inner city groups.

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CONFLICTS OF INTEREST

The authors have declared no conflicts of interest.

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