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Statement of Purpose

The Journal of Dental Hygiene is the refereed, scientific publication of the American Dental Hygienists' Association. The JDH promotes the publication of original research related to the profession, education, and practice of dental hygiene and supports the development and dissemination of a dental hygiene body of knowledge through scientific inquiry in basic, applied and clinical research.

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Pathway to Our Future

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June is the time for celebrating graduations, looking ahead with our annual conference, and moving forward. As we look to the future, we sometimes need to assess our past. As two past presidents of the American Dental Hygienists' Association (1984 and 1990), we reflect with pride on our profession's progress, yet we still feel the struggle within the profession with so much to accomplish. In her book, "Lean In: Women, Work and the Will to Lead," Sheryl Sandberg notes that women often hold themselves back in their careers. She encourages the reader to seek challenges, take risks and pursue goals with gusto. We believe there are many parallels to the dental hygiene profession found in "Lean In." Like Sandberg, we are here to prompt, support, and inspire action.

Look at where we are in practice settings - with less or no supervision, opening of direct access across the country, improvements in Medicaid reimbursements, and advancements of services provided by dental hygienists. We are still charged when hearing questions regarding practicing to the full extent of our education, and somewhat defeated when there continue to be restrictive limitations in state practice acts and regulations.

Let's look at some examples of what our future could be if we were to collectively take action as clinicians and educators. Consider what the profession of dental hygiene would be if all educational communities joined to support baccalaureate degree as entry level and worked to support articulation and dual entry programs. What would happen if we stopped saying we do not have enough time to teach teledentistry, geriatrics, research, HPV, access to care, practice management and the whole list of content we know is needed in our curriculum? What would happen if we taught to the full level of our commitment to the public, regardless of state definitions? Or if we advanced our definitions to become universal and held to that premise, regardless of dental boards recreating restrictive practice acts? What would happen if we created extended curriculums, certifications, and continuing education to meet national needs?

Our progress to date is exciting and motivating. Look at the efforts to move dental hygienists into a category to receive vaccines early and administer the vaccines in many states. When we work together, supporting ADHA in its lobbying efforts and advance our profession, we can see the great rewards from these efforts. Our Task Force on Return to Work and the recent studies published in this journal regarding the practice of dental hygiene before and during COVID-19 are the tip of elevating our profession.

Yet, we are often our own worst enemies. We continue to fear practice acts, call ourselves hygienists instead of oral healthcare professionals, schedule "cleanings" instead of preventive health and wellness visits, while there are so many actions we could be taking to advance our profession. Even reading other professional publications for dental hygiene, we find that concepts of national licensure and standard scope of practice are still a dream. Driving across state lines should not determine a difference in our clinical practice abilities.

For the last 16 months, we have been focused on a pandemic. Eventually, COVID-19 will be resolved or we will move to an endemic. What will happen when we return to the status quo of employers determining what our dental hygiene practice will be or educators acquiescing to the rules of unknowing boards and commissions granting permission for our abilities to practice? Is that really what we want for our future? To settle? To let others determine what is in the best

interest of our profession? What would happen if we decided that if we can survive a pandemic, we are certainly capable of controlling our profession, and then take action?

Here are some thoughts for our future.

Educators

Teach beyond your state practice act to a national standard. Articulate with other programs for advanced degrees or certificates in higher skills as the new norm for our education. Question state practice acts and become actively involved in advocacy to create change, working together with both professionals and students. Research and publish on how dental hygienists utilize our professional standards of care, to document what is being taught and further performed in practice.

Practitioners

Document the care you are providing using standard codes and then publish the results of your treatment. Publishing your results in the literature will help build data needed for advocacy and changing practice acts. Continue to learn skills beyond your current education and seek certification opportunities. Follow advances in clinical practice being made in other states and be an advocate for nationwide change.

Students

Think critically, act autonomously, and use scientific evidence to base your clinical decisions. Learn how to conduct research to create the body of knowledge in the literature to support the profession and advocacy efforts.

We hope all of you will join us at the Educator's workshops (both in-person and virtual) at the annual conference, to engage in discourse and create the pathway to our future.

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Research

Integrating Dental Hygienists into Medical Care Teams: Practitioner and patient perspectives

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Abstract

Purpose: The Colorado Medical Dental Integration (MDI) project explored ways to leverage medical visits with the goal of expanding access to dental services through the integration of dental hygienists (DH) into medical practices. The purpose of this study was to explore the perceptions of DH and patient participants in the MDI project.

Methods: A concurrent, mixed-methods approach was used. Qualitative key informant interviews were conducted with MDI DHs. A quantitative survey was administered to patient-participants who had received MDI care 18-24 months into the practices' participation in the project. Interviews explored DH's perceptions of working as an integrated DH, factors impacting MDI implementation, the level-of-Integration into the medical team, and how ways to access to dental services were expanded through the MDI. Interviews were recorded, transcribed, and analyzed for recurring themes using an iterative process. A patient-participant survey, available in English and Spanish, assessed perceptions regarding MDI care. Descriptive statistics were used to analyze the data.

Results: A total of 17 dental hygienists, across 15 MDI practices, agreed to participate. Generally, participants endorsed working in MDI practices and identified factors that were facilitators and barriers to MDI care. A total of 390 patients were surveyed for a response rate of 33%; one half (52%) had attended > 1 MDI visit. Most (95%) were extremely satisfied with MDI care and very few barriers to MDI care were reported.

Conclusions: Integrating dental hygienists into medical practices was generally endorsed by both the DHs and patient-participants. Dental hygienists reported various challenges to the MDI approach, however most were surmountable.

Keywords: access to care, dental hygienists, interprofessional collaboration, collaborative practice**,** health promotion

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Introduction

Despite improvements in oral health prevention and treatment, many individuals lack adequate access to oral health services and consequently experience oral health disparities.[1] Integrating preventive oral health services into primary care has expanded over the past decades, yet, has faced challenges.[2-4] In a recent scoping review of medical-dental integration, various models of integration were described; however, none described the integration of dental hygienists into primary care medical teams.[5] More commonly, the term medical-dental integration has been used to describe the delivery of preventive oral health services by medical providers/teams (e.g. caries risk assessment, oral health examination, fluoride varnish application and a coordinated dental referral) at medical visits.[2,6,7] Patients have direct access to dental hygienists in 42 states.[8] Most literature describing dental hygienists working in non-traditional settings includes examples of employment in school settings and/or public health environments.[9,10] There are emerging descriptions of the dental therapists' experience,[11-13] but there is a paucity of literature describing or evaluating models that integrate dental hygienists into medical teams in primary care practices.

Colorado has been testing models of integrating dental hygienists into medical teams with the goal of expanding access to dental services for populations who have limited access to dental care due to insurance status, living in dental professional shortage areas and other barriers. Over the past

decade, the Delta Dental of Colorado Foundation (DDCOF) has supported medical-dental integration, beginning with the co-location of direct-access dental hygienists into medical practices (2007-2011).[14] In 2014 DDCOF expanded their original approach to a new model which integrated dental hygienists directly into medical care teams, allowing for the full scope of dental hygiene services to be delivered within the medical practices. Using a level-of-integration scale of one to six, where a level five or six includes having a common workspace, support staff members, electronic health record, workflows and treatment goals,[15] dental hygienists were integrated at a level of five or six with coordinated referrals to co-located dentists (when available) or outside community dentists. The purpose of this study was to explore dental hygienists' perceptions of working as a member of an integrated medical team and patients' perceptions regarding medical-dental integration (MDI) care. Factors impacting implementation of MDI, the level-of-integration of dental into medical teams, and how MDI expanded access to dental services were also examined.

Methods

This study was approved by the Colorado Multiple Institutional Review Board, Protocol 15-0263. A concurrent, mixed-methods approach was used; qualitative interviews were conducted with the MDI dental hygienist participants and a quantitative survey was administered to patient-participants who had received MDI care. Participants in each approach were independent, therefore both approaches were considered primary and analyzed independently. Results were integrated in the interpretation phase.

Key Informant Interviews

A semi-structured interview guide to explore dental hygienists' perceptions related to MDI was developed by the study team (Table I). A qualitative research expert piloted the interview guide and refined it to improve its validity and fit for the setting. All dental hygienists from the healthcare organizations participating in the MDI (n=15) project were invited to complete a semi-structured telephone interview during a two-month period in 2018. At that point in time, organizations were 18-24 months into MDI implementation. Each MDI dental hygienist received up to four email-invitations over a 2-month period. Two investigators conducted all interviews with only the interviewer and interviewee present. Interviews lasted approximately 30-60 minutes. Summary notes were made following each interview and reviewed by the study team during analysis. All interviews were audio-recorded and securely sent for verbatim transcription by an independent professional transcription service. No compensation was provided for participation.

Content analysis was used to identify themes and subthemes within and across all interviews.[16] A hybrid of both deductive and inductive approaches from data collection throughout the analysis was applied.[17] Themes and subthemes were formulated using team-based analysis. Trained qualitative data analysts iteratively read transcripts, individually coded three transcripts to develop and refine both the codebook and coding approach and met to discuss emergent themes. One analyst was a content expert and provided subject matter context to the evaluation. The team compared the individually coded text, discussed code definitions, and edited codes to accurately describe these data. All remaining transcripts were then coded using these agreed upon definitions.

Open and axial coding of transcripts were used to form the basis of analysis: open coding included labeling concepts and defining and developing categories based on the interview data and axial coding was used to confirm and explore relations between transcripts by applying a priori concepts to the data.[18] The analyst team met regularly to check biases and understand emergent themes and intercoder reliability was confirmed. A software program (ATLAS.ti 7.0; Scientific Software Development GmbH, Berlin, Germany) was used to complete coding and analysis.

Patient Satisfaction Survey

The parents of children and adult patients seen by the integrated dental hygienists in the MDI project (2016 and 2018) were asked to complete a paper survey (English/Spanish). The MDI clinical teams were instructed to ask all patients seen by the dental hygienist within the specific time frame of the study, to complete the survey and place it in an anonymous collection box/area. Surveys were written in English/Spanish and did not include participant identifiers. Six practices were excluded from the survey collection process: one practice exclusively served refugee patients (language/translation barriers), two school-based practices (parents did not attend visits), two practices had transitioned to a co-located model, and one practice had a dental hygienist on leave.

The survey was developed using questions from a previous study on co-location care satisfaction[14] and measured participants' perceptions regarding MDI care. The 20-item survey was piloted in a convenience sample of participants and then refined prior to administration. Four-point Likert scales were used to measure perceptions: satisfaction (extremely to not-at-all satisfied), barriers (big problem to not a problem) and attitudes (strongly agree to strongly disagree). Descriptive statistics were calculated to describe baseline socio-

Table I. Key informant interview questions	
Objectives	
Describe dental hygienists' perceptions regarding working in MDI practice.	Tell me what you think about working in a medical practice/ office without a dentist? Probe: what are some of the benefits of this arrangement? What are some of the challenges?
	If you were hiring a new dental hygienist to work on the project, what experience and characteristics would be important to look for?
	Would you recommend this kind of dental hygiene position to your friend? Why, why not?
	What additional knowledge or skills does a dental hygienist need for medical-dental integration work?
	How do you feel about the scope-of-practice you are providing?
	What are some of the things you considered when deciding whether to participate in the project?
Identify factors impacting implementation of medical-dental integration.	What has worked well in the implementation of the MDI project at your practice? What hasn't worked well?
	What were the biggest challenges you have encountered while working on this project?
	Describe the characteristics of your practice that made it easier to implement the MDI project? More difficult?
	Describe the characteristics of your organization that made it easier to implement this project? More difficult?
	Has your practice been able to devote enough time to work on medical-dental integration? If no, why not?
Assess level-of-Integration of dental hygienist into medical team.	How do you feel about your role in the practice? Are you "part of the team?"
	What do others at the practice think about the project? Probe: providers, staff, dentist(s) you're working with, patients?
	What does your practice/team do to solve problems? How are those approaches working?
	Describe the communication between you and your practice's staff. How about the communication between you and the referral dentist/dental office staff?
	Tell me about your practice's workflow and how you see patients. How is this workflow working? How could it be improved?
	What is the billing process for your services? What is your role in it? Whom do you work with for billing? How could it be improved?
Evaluate how medical-dental integration expands access to dental services.	Do you think this project meets the dental needs of your patients? If not, why not? If so, how so?
	What things need to change to better meet your patients' dental needs?
	What are some of the barriers patients in your practice face when trying to access dental care? How has this project addressed any of those barriers?
	Do you think that this project has addressed any of those barriers? If so, how? If not, why not?

demographics of the study population, and baseline and follow-up variables. Data are presented as means and ranges for continuous data and percent of whole for categorical data.

Results

The 15 participating MDI health care organizations included federally qualified health centers (n=6), nonprofit practices (n=5), school-based health centers (n=2), and private for-profit practices (n=2). A total of 17 dental hygienists employed as part of the MDI project agreed to participate, only one declined. Dental hygienists practicing in the MDI settings provided a variety of services including caries risk assessments, fluoride varnish applications, sealants, dental radiographs, scaling and root-planing. Characteristics of the MDI health care organizations are shown in Table II.

Qualitative Findings

Interview themes

Three major themes emerged as factors impacting successful medical-dental integration. Individual-level impacts included dental hygiene skills and personal characteristics. Practice-level impacts related to leadership support, workflow support (billing and front office/medical assistant (MA) support), scheduling DH visits, patient volume, and the a lack of onsite dentist. The system-level impacts included areas such as insurance policy limitations and insufficient reimbursements. Overall, the participant perceptions did not differ based on the type of health care organization in which they were employed.

Dental hygiene skills and personal characteristics

Certain dental hygiene skill sets and characteristics emerged as important for MDI success. Integration into the

Table II. Medical Dental Integration (MDI) organization characteristics, 2016

Practice	Type	Setting	Size[1]	Level of integration[2] (1- 6)	DH interviews (n=17)
1	Nonprofit	Urban	Small	5	1
2	FQHC	Urban	Medium	6	1
3	FQHC	Urban	Large	6	1
4	FQHC	Urban	Medium	5	2
5	FQHC	Rural	Small	5	1
6	Nonprofit	Urban	Small	5	2
7	FQHC	Urban	Large	5	1
8	Nonprofit	Urban	Small	5	1
9	Nonprofit	Urban	Small	5	1
10	Nonprofit	Urban	Small	4	2
11	Private/For-profit	Urban	Small	3	1
12	FQHC[3]	Rural	Medium	5	0
13	Private/For-profit	Rural	Small	4	1
14	FQHC (SBHC)[4]	Urban	Large	6	1
15	FQHC (SBHC)[4]	Rural	Small	5	1

1 Small: < 10,000; Medium: 10,000-50,000; Large > 50,000 unduplicated visits (2018 UDS data).

2 Level-of-Integration: see criteria

3 FQHC: Federally Qualified Health Center

4 SBHC: School Based Health Center

medical system was universally new to the participants and they possessed a range of professional skills and personalities. When asked what characteristics were necessary for this kind of work, participants replied that it was important for dental hygienists to be adaptable, problem-solvers, good negotiators, and able to work independently yet also build professional and clinical relationships. Participants also emphasized that willingness to "learn-by-doing" was required for success. One dental hygienist summarized:

> "It's a hard position…I am a one-person dental office, less the dentist, because I literally do everything, except for the scheduling. You have to be someone who is willing to be very thorough, be willing to switch up doing something at the drop-of-a-hat, be able to 'multitask on steroids."

Participants also expressed the importance of a being willing to work with challenging patient populations. Many of the MDI practices cared for vulnerable populations which required the dental hygienist to be compassionate and willing to meet the individual needs of the patient population.

> "…you definitely want someone here who has compassion for the demographic of people that we work with—a lot of homeless men. And I specifically work with foster care kids. I see a lot of child abuse and neglect."

Leadership support

The individual health care organization's support of the integration of the dental hygienist into the medical teams was essential. At medical practices where integration was successful participants described a supportive practice-site leader; within the practices with failed integration, participants described a lack of clinic leaders' support for the dental hygienist and/or the MDI concept. Successful practice leaders provided enabling/enforcing support such as clerical staff to schedule dental hygiene patients, billing staff to bill for the dental hygiene services provided, and medical assistants to screen patients who were eligible for integrated care and/or to complete warm hand-offs to dental hygienists for same-day services. One participant from a successfully integrated

practice shared how initial challenges were solved through the practice leadership.

> "It took almost 3 months to get her [a receptionist] trained and willing to just change the schedule… everyone is so resistant to doing additional work…the only way to get that done was to have leadership tell them they have to do it."

Participants reported that when a practice lacked leader support for dental hygiene appointment scheduling and billing, it appeared to impair the MDI process. One participant from a practice struggling with the MDI process stated that she had to do her own scheduling.

> "The dental program was not a priority for anyone... the lady who was in charge of scheduling…she really didn't care much about it and her staff, which is the front desk, they didn't care either."

Anecdotally, this particular practice's chief operating officer ended their MDI project work citing that the dental hygienist did not see enough patients.

Workflow support

Another practice-level theme that influenced the dental hygienists' integration was the delegation of work to other team members to support dental hygiene workflows. When work was delegated to other team members and the leadership was able to motivate staff to support integrated dental hygiene care, the MDI practice was more likely-to-succeed. For instance, when leaders delegated dental screening tasks to medical assistants and motivated them to complete these added tasks, practices were more successful with completing integrated dental hygiene visits. Also, at successful practices, medical assistants also helped check in DH patients and monitor patient flow. A participant from one successful MDI site described a strong working relationship between dental and medical staff.

> "We all work really well together. I can go straight to the MAs and MD and just tell them what we need and…if they see where there is a patient that needs [dental hygiene] care right away, they can come straight to us, and we are able to see that patient immediately."

Furthermore, this practice developed a check-in process that included each medical assistant routinely mentioning to their patients that dental hygiene services were available and "…if the patients are willing to be seen, we are able to see them. That isn't a problem for us." This was in contrast to what was experienced at practices with less-successful integration. For example, one participant from a practice that struggled with integration stated,

> "it has been extremely hard to get the medical assistants onboard to let the patient know that there is a hygienist in the office, and they can have their dental hygiene services here. In my opinion, I seem to be put as the low man on the totem pole."

However, a participant from a practice that had successfully integrated the dental hygienist into their setting shared,

> "The longer I was there, and the more people got accustomed to me, the more I felt a part of the team."

Also, a significant barrier to dental hygiene integration was the expectation that it was incumbent upon the dental hygienist (at some sites, sole responsibility) to fit the dental practice needs, billing, and identification of new patients, into the established medical practices' processes, patients, and practice billing structure and procedures. Yet, some practices had leaders who supported a culture that promoted the medical staff and providers working with the dental hygienist and made incremental changes in their culture to increase staff awareness and held them accountable for their role in making MDI successful (a "continuous improvement culture"). The ability of the medical practice to implement practice change incrementally appeared to be associated with successful integration. One participant shared,

> "We have weekly clinic meetings and we have biweekly staff meetings and bring up issues that we have, as well as the supervisors also discuss what issues that we're having that aren't working…[and] need to be dealt with."

Dental hygiene appointments

Participants reported a range of experiences with scheduling patients across the practices. The act of scheduling new and returning dental hygiene care visits was a key factor in how the participants perceived successful/unsuccessful integration. The MDI practice benefited when the administrative staff scheduled the dental hygiene patients. One example was a MDI within a school-based health center practice, co-located where children spent their days in the classroom. In such settings, the dental hygienists could more easily see patients,

> "…[I have] a list of kiddos I can pull from class… being able to schedule and do that from the get-go was a huge thing that played a huge role in it for families [to access dental care at her site").

Workflow support in regard to scheduling dental hygiene care visits was mentioned by other participants as important factors to MDI success.

Low patient volume

Participants working in small practices with low patient volume faced particular challenges including the frequency

of low-patient visit days impacting the opportunities for MDI visits, combined with a high no-show rate. One DH shared,

> "Well, it was slow. It was real slow; a typical day, three patients, probably if lucky enough, 4 to 5….and there would be days that I had nobody…and there were a lot of patients who would not show up."

Lack of an onsite dentist

Another practice-level challenge was not having an onsite-dentist for restorative dental services. A few of the participants expressed that they believed it was a unique and exciting opportunity to practice independently from dentists, however, most participants described difficulties associated with not having an onsite dentist. This created a barrier for patients to access restorative dental care and was particularly concerning to the participants. Low-income and patients with emergent needs were noted to be particularly vulnerable. One participant stated,

> "…sending children to off-site clinics is kind of a barrier to care because it's hard for families to get to the clinic where the dentist is."

Challenges for patients to receive dental care from a dentist also included a lack of capacity on referral dentists' schedules to absorb the dental hygienists' patients. One participant noted that,

> "…there are not enough dentists providing the actual dental care, even with a 'backdoor' clinical relationship between the dental hygienist and dental practice."

Finally, participants described challenges with practicing solo and not having a dentist, "…just to run things by" to help make a clinical determination or, for instance, to approve their use of anesthesia or nitric oxide with a periodontal patient.

Insurance eigibility

Though it was mentioned less frequently, the need to verify the patients' insurance status was described as a barrier for several MDI practices. In Colorado, medical and dental insurance portals are separate. Additionally, medical claims are traditionally paid by diagnosis and dental claims are paid by procedure (with frequency limitations). Since few of the front office administrators had started this program with in-house knowledge or experience with handling dental insurance, MDI practices had to invest time into teaching the staff how to check and confirm dental insurance eligibility and coverages for patients, or else the dental hygienists in each MDI practice were required to complete these activities.

Dental insurance reimbursement

Some participants described frustration with providing services that were eventually not reimbursed. A variety of reasons were cited for denying dental claims including dental insurance benefit changes, lack of expertise in accurately submitting the insurance claims, providing services prior to coverage, and changes in coverage. Some participants stated that keeping up with benefit changes took time away from providing direct care and was a frustrating aspect of the MDI project. One participant expressed, "I wish that Medicaid would settle down. They just change the rules all of the time."

Quantitative Results

Patient and parent surveys

A total of 1,196 patient-participants were provided integrated dental hygiene care during the months surveyed in the participating MDI practices. One-third of the participants (n=390) completed the paper survey. Respondent demographics are shown in Table III. In general, the respondents favored the MDI care they received. A majority reported being satisfied with the care (100% extremely/very), more likely to recommend the MDI practice with a dental hygienist to friend/family than one without (95% strongly agree) and were likely to return to the dental hygienist in the future (95% strongly agree). Most reported that they were more likely to take self/child to a dental hygienist located within the medical office than outside (75% strongly agree). More than three-quarters (78%) agreed that MDI care was more convenient than traditional care. Patient and parent perspectives regarding MDI care are shown in Table IV.

Regarding barriers to utilizing dental hygiene care in a MDI setting, a little more than one half of the respondents (52%) reported that it was problematic that the dental hygienist was not able to fill cavities. General barriers to receiving MDI care are shown in Table V.

Discussion

In this mixed-methods investigation into the perceptions of dental hygienists and patients/parents participating in medical dental integration programs, both the dental hygienists and patient/parents endorsed the benefits of integrated dental hygiene services. Dental hygienist participants reported various, but not unsurmountable, barriers to providing integrated care. Dental hygienists working in this non-traditional MDI model were enthusiastic about providing care to an underserved population, however they identified challenges and reported that working in this non-traditional setting required unique skills. These skills have been similarly described in an investigation of extended-function dental hygienists by Delinger et al.[9] Dental hygienists working in an extended function capacity needed to be entrepreneurs

Table III. Patient/parent demographics

Practice setting*	All	1	2	3	4	5	6	7	8	9
Surveys completed	390	12	16	19	18	104	100	19	28	74
Reported number of dental hygiene visits during the survey month**	1196	55	314	144	260	133	120	53	28	89
Response Rate	33%	22%	5%	13%	7%	78%	83%	36%	100%	83%
Characteristic	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n(%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Age (years)										
0 - 12	155 (40)	2 (17)	–	3 (16)	14 (78)	14 (13)	74 (74)	6 (32)	7 (25)	35 (47)
13 -18	67 (17)	0 (0)	–	10 (53)	3 (17)	2 (2)	18 (18)	6 (32)	10 (36)	18 (24)
Greater than 18	87 (22)	9 (75)	4 (25)	3 (6)	0 (0	42 (40)	0 (0	0 (0	10 (36)	19 (26)
(no response n=81)										
Hispanic or Latino/Latina (no response n= 35)	188 (48)	6 (50)	4 (25)	9 (47)	4 (22)	49 (47)	54 (54)	5 (26)	18 (64)	39 (53)
Dental insurance plan										
Medicaid	240 (62)	8 (67)	7 (44)	6 (32)	13 (72)	44 (42)	73 (73)	10 (53)	13 (46)	69 (93)
State Child Health Insurance	23 (6)	0 (0)	0 (0)	1 (5)	0 (0)	1 (1)	10 (10)	4 (21)	0 (0)	3 (4)
Private	13 (3)	0 (0)	0 (0)	0 (0)	2 (11)	8 (8)	3 (3)	0 (0)	0 (0)	0 (0)
None	56 (14)	2 (17)	4 (25)	10 (53)	1 (6)	38 (37)	8 (8)	4 (21)	1 (4)	0 (0)
Don't know/ Missing	58 (15)	2 (16)	5 (31)	2 (10)	2 (11)	13 (12)	7 (7)	1 (5)	14 (50)	1 (1)
(no response n=27)										
One or more visits with a dental hygienist?	201 (52)	2 (17)	4 (25)	9 (47)	6 (33)	65 (62)	70 (70)	8 (42)	13 (46)	27 (36)

* Six of the 15 MDI practices did not participate in the data collection process

** Participants were surveyed during the 18th month of the MDI program

with good communication skills, demonstrate the ability to network, problem solve, think critically, and possess strong administrative skills.[9] Patient and parent satisfaction levels were similar to perceptions previously reported by recipients of dental hygiene services co-located with medical providers.[14]

Medical-dental integration studies reported in the literature have primarily focused on preventive oral health services delivered by medical providers/teams such as caries risk assessments, oral health examinations, fluoride varnish applications and coordinated dental referrals.[2,6,7] Barriers reported by medical teams relating to the provision of these services in the medical office setting have been almost exclusively at the provider- or practice-levels.[3,4] Additional barriers have included lack of training,[3] and lack of sufficient time to plan for change or the logistics of providing these services.[3, 4]

In comparison, this study employed a unique model of oral health promotion in the medical setting and provides new results to the literature. The embedded dental hygienists in this MDI project provided full-scope dental hygiene care within the medical practice. While some of the reported practice-level barriers were similar regardless of the approach, such as lack of efficient workflow/logistics, it is noteworthy that lack of time did not emerge as a theme in this study. Rather, a low patient volume was mentioned by some participants. This may be due to the finding that medical providers providing oral health services commonly focus on young children and already incorporate oral care into the existing medical care visit,[2,6,7] whereas the embedded dental hygienists in MDI practices provided care to a broader spectrum of patients and the appointments were separate from medical visits.

Table IV. Patient/parent perspectives regarding Medical Dental Integration

MDI practice setting	All	1	2	3	4	5	6	7	8	9
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
How satisfied are you with the dental care received from the dental hygienist in this medical office? (extremely/very) (no response, n=13)	371 (95)	12(100)	16(100)	17 (89)	7(94)	104 (100)	95(95)	17(89)	28 (100)	74(100)
It is more convenient to get dental care from a dental hygienist located in the medical practice than a traditional dental office. (strongly agree) (no response, n=4)	304 (78)	10 (83)	14 (88)	11 (58)	13 (72)	80 (77)	87 (87)	19 (100)	11 (39)	62 (84)
I am more likely to take myself/my child to a dental hygienist located in medical office than a traditional dental office. (strongly agree) (no response=7)	291 (75)	9 (75)	11 (69)	17 (74)	8 (44)	75 (72)	89 (89)	16 (84)	12 (43)	58 (78)
I am more likely to take myself/my child to medical office that has a dental hygienist than medical office without a dental hygienist. (strongly agree) (no response=12)	274 (70)	7 (58)	10 (63)	12 (63)	12 (67)	72 (69)	82 (82)	16 (84)	11 (39)	55 (74)
Getting dental care at same time as medical care makes sense. (strongly agree) (no response=13)	329 (84)	10 (83)	13 (81)	13 (68)	16 (89)	87 (84)	90 (90)	17 (89)	16 (57)	68 (92)
Do you plan on bringing yourself/your child to the dental hygienist in this office in the future? (strongly agree) (no response=5)	357 (92)	12 (100)	16 (100)	18 (95)	12 (67)	98 (94)	97 (97)	16 (84)	21 (75)	67 (91)
Would you recommend this medical office to a friend or family member because a dental hygienist works here? (yes/no) (no response=6)	372 (95)	12 (100)	15 (94)	19 (100)	16 (89)	101 (97)	96 (96)	16 (84)	24 (86)	73 (99)

Table V. Reported patient/parent barriers to using integrated dental hygiene care in a medical setting

		All	1	2	3	4	5	6	7	8	9
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
The dental hygienist is not in this medical office at convenient times. (no response = 29)	Not a problem,	249 (64)	8 (67)	7 (44)	7 (37)	10 (56)	86 (83)	54 (54)	11 (58)	16 (57)	50 (68)
	Somewhat of a problem	47 (12)	1 (1)	0 (0)	8 (42)	0 (0)	9 (9)	17 (17)	4 (21)	2 (7)	6 (8)
	A big problem	19 (5)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	11 (11)	2 (11)	1 (4)	4 (5)
	Don't know	44 (11)	3 (25)	3 (19)	2 (11)	2 (22)	6 (6)	11 (11)	1 (1)	8 (29)	8 (11)
Takes too much time to see both the medical provider and the dental hygienist on the same day. (no response = 24)	Not a problem,	284 (73)	11 (92)	7 (44)	10 (53)	15 (83)	75 (72)	74 (74)	13 (68)	7 (25)	63 (85)
	Somewhat of a problem	30 (8)	0 (0)	1 (1)	5 (26)	0 (0)	9 (9)	6 (6)	1 (19)	5 (18)	3 (4)
	A big problem	12 (3)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	7 (7)	3 (19)	0 (0)	1 (1)
	Don't know	40 (10)	1 (8)	2 (13)	1 (1)	0 (0)	18 (17)	7 (7)	0 (0)	7 (25)	4 (5)
I am/my child is afraid to see the dental hygienist. (no response = 26)	Not a problem,	308 (79)	12(100)	8 (50)	12 (63)	13 (72)	85 (82)	76 (76)	18 (95)	25 (89)	59 (80)
	Somewhat of a problem	36 (9)	0 (0)	1 (1)	5 (26)	1 (1)	11 (11)	12 (12)	0 (0)	1 (4)	5 (7)
	A big problem	3 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (4)
	Don't know	16 (4)	0 (0)	1 (1)	0 (0)	1 (1)	3 (3)	6 (6)	0 (0)	1 (4)	4 (5)
Cost to see the dental hygienist is too high. (no response = 26)	Not a problem,	272 (70)	10 (83)	5 (31)	17 (90)	10 (56)	69 (66)	77 (77)	12 (63)	16 (57)	56 (76)
	Somewhat of a problem	26 (7)	1 (1)	0 (0)	0 (0)	3 (17)	10 (10)	6 (6)	0 (0)	4 (14)	3 (4)
	A big problem	12 (3)	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)	0 (0)	6 (32)	1 (1)	3 (4)
	Don't know	51 (13)	1 (1)	3 (25)	0 (0)	2 (1)	18 (17)	11 (11)	0 (0)	7 (25)	9 (12)
Too busy to take myself/my child to dental hygienist. (no response = 33)	Not a problem	303 (78)	9 (75)	7 (44)	14 (74)	11 (61)	83 (80)	88 (88)	18 (95)	19 (68)	54 (73)
	Somewhat of a problem	43 (11)	2 (2)	0 (0)	3 (16)	3 (17)	13 (13)	3 (3)	0 (0)	7 (25)	12 (16)
	A big problem	4 (1)	0 (0)	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)	2 (3)
	Don't know	6 (2)	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)	1 (1)	0 (0)	1 (1)	2 (3)
Dental hygienist doesn't take my/my child's dental insurance. (no response = 36)	Not a problem,	276 (71)	10 (84)	5 (31)	17 (90)	12 (67)	73 (70)	75 (75)	12 (63)	15 (54)	57 (77)
	Somewhat of a problem	12 (3)	1 (1)	0 (0)	0 (0)	1 (1)	2 (20)	3 (3)	1 (5)	0 (0)	4 (5)
	A big problem	19 (5)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)	8 (8)	3 (16)	1 (0)	5 (7)
	Don't know	43 (11)	0 (0)	2 (2)	0 (0)	0 (0)	18 (17)	6 (6)	0 (0)	12 (43)	5 (7)
Dental hygienist does not fill cavities. (no response = 27)	Not a problem,	180 (46)	6 (50)	4 (25)	1 (5)	12 (67)	50 (48)	52 (52)	5 (26)	11 (39)	39 (53)
	Somewhat of a problem	56 (14)	1 (1)	0 (0)	13 (68)	0 (0)	16 (15)	6 (6)	6 (32)	2 (7)	12 (16)
	A big problem	28 (7)	0 (0)	0 (0)	1 (1)	0 (0)	8 (8)	12 (13)	2 (11)	2 (7)	3 (4)
	Don't know	74 (20)	5 (49)	3 (2)	1 (1)	3 (17)	23 (22)	22 (22)	4 (21)	12 (43)	14 (19)

Dental hygienist participants in this study also commonly mentioned the healthcare organizations' lack of experience with providing dental services such as unfamiliarity with dental insurance and lack of leadership support, issues that were less commonly reported in investigations of medical providers providing preventive dental services themselves. Regardless of the approach, barriers to providing preventive oral health services in the medical office exist but are surmountable. Evidence supports the efficacy of oral health promotion by medical providers on reducing dental disease,[6,7] however, more investigation is needed to explore the impact of integrating dental hygienists into medical care teams on oral health outcomes.

System-level challenges, including insurance payment policy restrictions, have been cited in the literature when describing the barriers to providing dental hygiene services outside of traditional dental practice settings.[9,19] Dental hygienists interviewed in this study shared that insurance barriers included not being able to bill under a medical providers' license (which led to limited reimbursement) as well as providing dental hygiene care within the constraints of dental-insurance-recall-frequencies. These arbitrary con-straints limited the type of care provided and the frequency of the dental hygiene care visits despite the risk for oral diseases. In a survey of expanded-access dental hygienists in Oregon, barriers to working outside of traditional dental practices included challenges with insurance reimbursement and difficulty obtaining a collaborative agreement/cooperating facility.[19] An investigation of direct-access dental hygiene care in Kansas reported similar barriers in addition to dental hygienists not being able to directly bill for services rendered.[9] Participants interviewed in this study also mentioned reim-bursement concerns including the lack of dental insurance in addition to challenges in keeping appraised of dental-benefit updates.

Study participants rarely mentioned challenges with establishing a collaborative agreement with a dentist. More commonly, dental hygienists in this study noted challenges in finding dentists to refer patients with untreated dental decay. This barrier has also been cited in previous work investigating barriers to medical providers providing preventive dental services.[4] While integrating dental hygiene care into medical settings expanded access to dental services, system-level barriers persisted including disparities in dental insurance coverage and differences in how medical and dental claims are reimbursed. Comprehensive healthcare insurance, which includes both medical and dental coverage, has the potential to reduce these barriers.

Findings from this study are similar to those describing behavioral health integration in medicine. Specifically, factors cited to be important to behavioral health integration include having an empowered leadership team, integrated care processes, and workflows.[20] In a qualitative study of integrated behavioral health specialists, similar facilitators and barriers were identified, including the importance of leadership support for building new models, the benefits of any prior experience with integration, and the importance of support from others doing similar work.[21-23] Developing efficient workflows was also cited by the dental hygienist participants interviewed in this study and have been noted as critical to the successful of behavioral health integration.

This study adds to the literature describing stakeholders' perceptions with integrating dental hygienists into medical care teams. Strengths include reporting comprehensive perceptions of dental hygienists working in a variety of MDI healthcare systems. Limitations of this study include a lack of generalizability. Although 42 states allow direct-access to dental hygienists, practice acts vary state-by-state so the level of independent care provided in Colorado may not apply to all direct-access states. While patients/parents were intentionally surveyed 18 months into their practices' participation in MDI, patients' experiences varied as each practices' approach to the MDI model were customized based on the practice size and population. The participating dental hygienists reported the number of patients seen during the month that the survey was collected, and the authors cannot confirm that all patients received a survey. Additionally, while the survey had been used previously in a similar study,[14] the instrument was not validated. Also, reporting bias may have impacted the responses as well as missing data.

Conclusions

Results from this study support that this innovative approach of integrating dental hygienists into medical practice settings provided patients with a favorable alternative access to oral health care services. Challenges to this medical-dental integration approach included dental insurance limitations, challenges with integrating the dental hygiene care workflows, limitations on the dental hygienists' ability to restore decay, and a lack of available dentists to provide restorative care to vulnerable populations. However, many of these challenges were surmountable. Building a dental hygiene workforce ready to deliver integrated care is warranted for the future.

Disclosure

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Research

Aerosols in Ultrasonic Instrumentation: Comparison of particle spread utilizing saliva ejectors versus high-volume evacuation

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Abstract

Purpose: The emergence of SARS-CoV-2 has generated renewed interest in the potential transmission of viral contaminants via ultrasonic scaler-generated aerosols. The purpose of this study was to use controlled experimental conditions to quantify the range, direction, and concentration of aerosolized and splatter droplet spread across distances up to 106 inches from the source of the ultrasonic scaling procedure on a manikin patient head.

Methods: A dental simulation unit (DSU) was used to facilitate ultrasonic instrumentation performed on a typodont located within a manikin patient head. A 9 x 9-foot section of white paper was placed on the floor directly beneath the DSU. White paper was also placed on the adjacent countertops for identification of possible spread. Methylene blue dye was mixed with reverse-osmosis (RO) water and placed in the reservoir of the ultrasonic scaler. Experimental tests were run with high-volume evacuation (HVE) and a with a saliva ejector. Photographs of the paper and droplets were taken and analyzed by computer software to identify all droplets captured on the paper.

Results: Particle counts show that HVE use is associated with a reduction in total particle count for each zone evaluated, with the largest reduction seen in regions closest to the origin. Using HVE on the DSU demonstrated a 99% reduction in particles and 50% reduction in the range of particles.

Conclusion: Dental health care providers should use HVE when generating aerosols during ultrasonic instrumentation procedures to reduce particle spread in health care settings.

Keywords: aerosols, ultrasonic scalers, ultrasonic instrumentation, high-volume evacuation, saliva ejectors, dental health care providers

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Introduction

Aerosols are a common byproduct of many dental procedures, including ultrasonic scaling, tooth preparation with a dental handpiece, and the use of three-in-one air-water syringes.[1] Existing evidence suggests that scaling and debridement procedures performed with ultrasonic instruments and water coolant produce the greatest aerosol and operatory contamination relative to other dental procedures.[2,3] Magnetostrictive and piezoelectric ultrasonic scalers typically oscillate between 20 – 42 kHz to remove plaque and calculus, as well as other potential aerosol contaminants with copious water lavage.[4] However, ultrasonic scaling generates aerosols even in the absence of water, most likely due to the vibration of the insert.[3]

Numerous bacteria and viruses reside in the oral cavity and respiratory tract.[1] These can be transported via aerosols, facilitating the spread of infectious diseases, including tuberculosis, pneumonia, influenza, and others.[5] The 2019 emergence of SARS-CoV-2, also known as COVID-19, has sparked renewed interest in the potential transmission of viral contaminants in health care settings, with emphases on the production and spread of dental aerosols.

Prior studies have demonstrated that the greatest surface area of contamination from ultrasonic scaling procedures can be found within one foot of the operative site and detected up to four feet away.[2] Cumulative contamination observed following ultrasonic scaling revealed that bacterial aerosols could be

detected at a horizontal distance of 100 cm and a vertical distance of 50 cm from a patient's oral cavity.[6] However, these studies relied on "spot collection" wherein small sampling surfaces (filter discs, agar plates, or cassettes) were positioned at various locations throughout the examination room or operatory. While informative, given the small size of aerosolized particles (less than 50 microns)[7] relative to the large footprint of a treatment room, such methods require extrapolating total particle dispersion from intermittent data points with many gaps. These studies intentionally avoided the use of high-volume evacuation (HVE) and did not explicitly test the effect of the suction at the source of contamination, the patient's mouth. Without the use of HVE, these studies present a "worst case scenario" of droplet spread.[2,6,7]

Creation of a controlled experimental environment would allow for the range, direction, and concentration of aerosolized and spatter droplets to be measured and quantified during routine ultrasonic scaling. In an experimental environment, the use of the system's HVE could be compared to the saliva ejector (SE) to assess their impact on particle spread and potential for each approach to facilitate infectious disease spread. The purpose of this study was to use controlled experimental conditions to quantify the range, direction, and concentration of aerosolized and splatter droplet (greater than 50 microns)[7] spread across distances up to 106 inches (8.83 feet) from the source of the ultrasonic scaling on a manikin patient.

Methods

Experimental parameters and conditions

Two experimental tests were conducted in a large university dental simulation clinic equipped with all necessary dental equipment. No individuals were present beyond those directly involved with the study to limit the production of non-experimental aerosols. A dental simulation unit (DSU) (A-dec 41L; Newberg, OR, USA) equipped with a manikin head and face mask (Frasaco; Greenville, NC, USA) was positioned in full recline and situated such that the labial region of the mouth was 28 inches above the floor.

A large, continuous 9-foot x 9-foot section of white paper was placed on the floor directly beneath the DSU. A square, 8 x 8-foot perimeter was drawn onto the paper and the cardinal directions labeled to allow future digital orienting. A symbol was drawn immediately below the mouth of the DSU unit (hereafter referred to as "origin" or "zone 0"), as well as the footprint of the DSU unit, operator chair, and operator foot pedal (Figure 1). Additionally, two 48 x 18-inch sections of paper were placed on countertop surfaces beyond the floorplan directly across from the seated operator position.

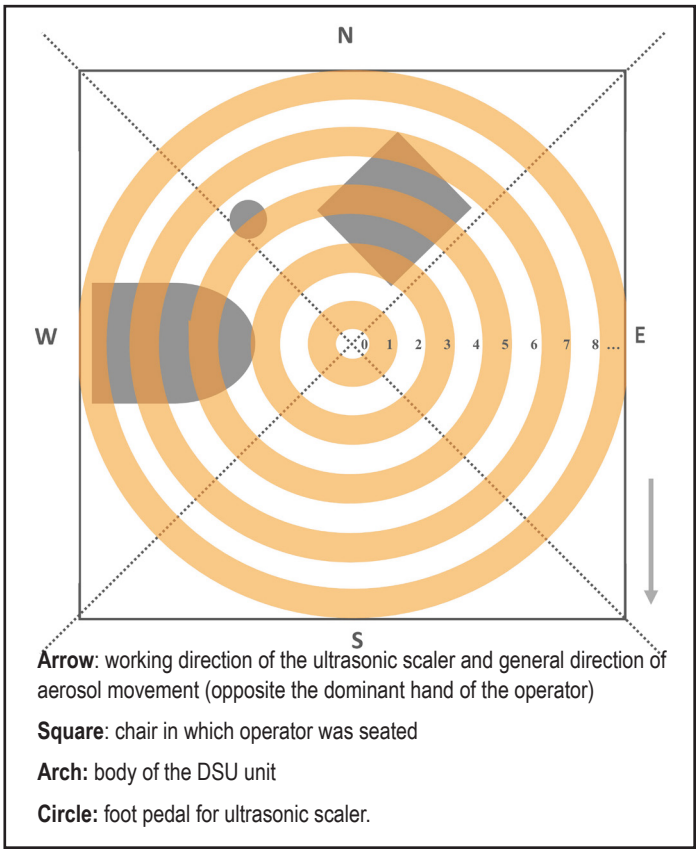


Figure 1. A quadrant system (not to scale) with concentric rings was used to photograph, organize and analyze the aerosol stain data. The zones consist of a series of nested concentric rings each situated with perimeters 3 inches apart (refer to Table I).

These served to detect any dispersion of particles beyond the 4-foot radial range of the floor paper. Both countertops were positioned 34.5 inches above the floor. One paper covered a countertop surface whose distance ranged from 51-69 inches from the origin, and the other 88-106 inches from the origin.

In order to visualize aerosolized particles and/or splatter, methylene blue dye was mixed with reverse osmosis (RO) water at a concentration of 0.5g dye to 500cc of water. This was added to the water reservoir of a magnetostrictive ultrasonic scaler. The operator, an experienced registered dental hygienist, wore protective eyewear, a mask with attached shield, a full coverage gown, and gloves, while performing the ultrasonic scaling procedures. Multiple temperature readings were taken prior to each experiment to ensure a consistent water evaporation rate would occur. The paper temperature was measured with an infrared video thermometer (CEM; Shenzhen Everbest Machinery Industry Co., Ltd, Shenzhen, China). The mean temperature for test one (SE) was 21.0°C (range 20.8 – 21.4) and for test two (HVE) was 20.1°C (range 19.9 – 22.0).

A 30 kHz magnetostrictive ultrasonic insert (Dentsply Sirona; Charlotte, NC, USA) was used for both tests. The power and lavage settings were set at 50%, which corresponded to a water flow rate of 18 mL/min as confirmed in prior studies. Both experiments required the operator to perform ultrasonic scaling on teeth numbers 6-11 (universal numbering system) for 5 minutes. A digital timer was used to record the time. The only difference between the two tests was the method of evacuation used: the first test used the system's saliva ejector (SE) exclusively, while the second test used only the system's HVE. Both evacuation systems were positioned and adjusted by the same experienced operator during the scaling procedures (Figure 2).

Figure 2. Dental simulation unit showing the operator performing ultrasonic scaling on teeth # 6-11 using HVE.

Since the airflow rates of the HVE and SE were expected to affect the study outcomes, airflows with the DSU and those in a nearby dental clinic were measured. Measurements made with a thermo-anemometer (Fieldmaster; Extech Instruments; Nashua, NH, USA) showed an average airflow of 0.58 ± 0.16 M/sec with the DSU's HVE, which is considerably lower than the 2.17 ± 0.31 M/sec flow rate measured for the HVE in the clinic. Interestingly, the SE measurements for the DSU and the clinical units were comparable at 0.1-0.2 M/sec. At the conclusion of each testing cycle, all particle collection papers were allowed to sit undisturbed for 10 minutes to allow further aerosol dispersion and any stain-bearing particles settled on the paper to fully dry. Ten minutes was considered sufficient time to allow particles 7.4 um and larger to settle out and dry on the paper.[8] The papers were moved, allowed to set for additional time, and prepared for imaging.

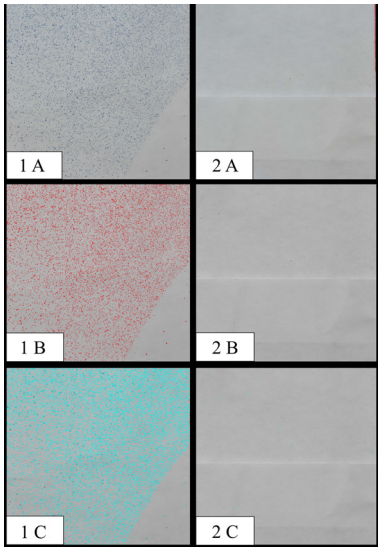
Data collection protocols

Each of the floorplans was overlain with a grid composed of 3 x 3-inch boxes. Each grid box was given a unique alphanumeric label that served not only as a landmark for photograph stitching, but also as a means to digitally orient each photograph in the subsequent composite images. The floorplan was systematically photographed using a digital single lens reflex camera and zoom lens (Nikon D3400, and AF-P DX NIKKOR 18-55mm, Nikon USA; Melville, NY, USA) with flash, on a tripod with a fixed position of 12 inches perpendicular to the floor.

High quality images were imported into an imaging software Photoshop version 20.09 (Adobe; San Jose, CA, USA)xx0x0 where they were reoriented and merged to generate high resolution composite images reflecting large regions of the floorplan. The composite images were exported as uncompressed TIFs and imported into ImageJ[9] where they were scaled and digitally thresholded to isolate the blue-stained particles (Figure 3). Regions-of-interest (ROIs) were manually created to isolate specific zones (Table I). Particle counts for each ROI were calculated using ImageJ's native analyze particles feature. After analysis, the original image was compared to the digital particle rendering and data points reflecting any obvious non-stain particles (e.g., hair, dust, debris) were identified. These, along with any particle whose circularity index was less than 0.5 (i.e., particles with a highly linear profile), were excluded from all subsequent analyses. These conservative measures ensured isolation of true aerosolized and splatter particles.

Figure 3. Image series showing the reduction in detectable particle concentrations on the floor while ultrasonic scaling using a SE (left) and while using HVE (right).

Each square represents a commensurate 3 x 3-inch section taken from the southern quadrant of the floor (4.5-7.5 inches from origin).



Note: The curved outline of the operator's shoe is visible in images reflecting SE use only, with evidence that the foot was moved part-way through the test.

A: Raw image showing blue-stained particles

B: Particles isolated after digital thresholding

C: Particles identified and subsequently quantified for analysis.

Results

Particle dispersion

In total, 166,137 particles were identified for test one (SE only) and 1,655 for test two (HVE), indicating an overall reduction of 99% with the use of HVE (Figure 4). The furthest zone with detectable particles when using HVE was zone 8 (22.5 - 25.5 inches), nearly half the distance seen when using

Table I. Zone and zone distance from origin

Orientation	Zone	Zone Range from Origin (in)
Origin	0	0 -- 1.5
	1	1.5 -- 4.5
	2	4.5 -- 7.5
	3	7.5 -- 10.5
	4	10.5 -- 13.5
	5	13.5 -- 16.5
	6	16.5 -- 19.5
	7	19.5 -- 22.5
	8	22.5 -- 25.5
	9	25.5 -- 28.5
	10	28.5 -- 31.5
	11	31.5 -- 34.5
	12	34.5 -- 37.5
	13	37.5 -- 40.5
	14	40.5 -- 43.5
Furthest Detectable Particle	15	43.5 -- 46.5
	16	46.5 –49.5

Table II. Particle count by zone.

Zone	SE*	HVE**	% Reduction with HVE
0	12012	22	545
1	71273	95	749.24
2	48046	141	339.75
3	15852	241	64.78
4	10169	158	63.36
5	4211	105	39.1
6	1849	174	9.63
7	623	139	3.48
8	184	17	9.82
9	12	0	NA
10	2	0	NA
11	2	0	NA
12	2	0	NA
13	0	0	NA
14	0	0	NA
15	3	0	NA

* Saliva ejector alone
** High-volume evacuation alone

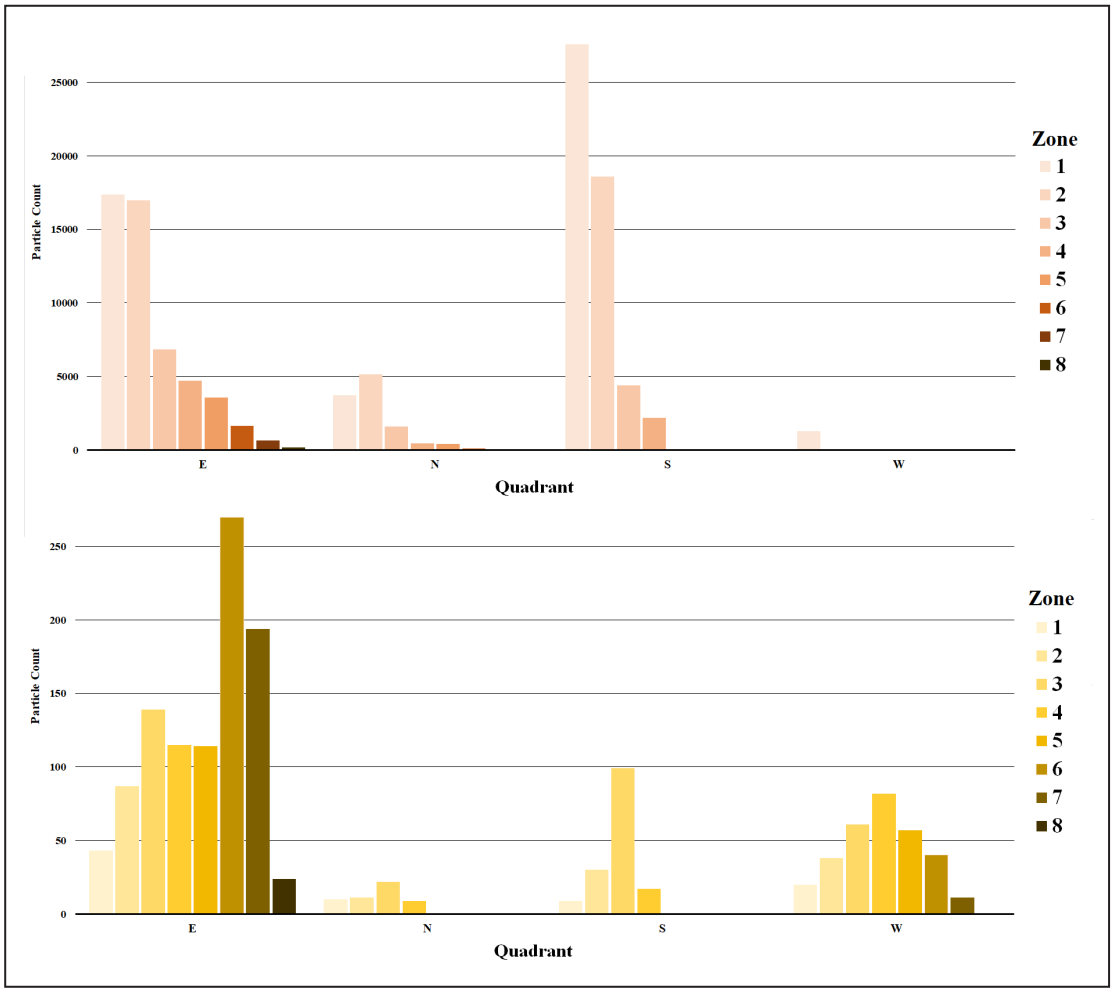


Figure 4. Particle count by quadrant. Saliva ejector (SE) (Red Orange) and High-volume evacuation (HVE) (Yellow orange).

Differences in scale for particle count: SE: 0 – 30,000, HVE: 0 – 300.

an SE only (zone 15, or 43.5 - 45.6 inches) (Table II). Neither test was associated with spread of aerosols beyond 4 feet as evidenced by the fact neither counter surface possessed detectable aerosol staining after the wait time. Anecdotally, aerosol staining was seen on the operator face mask and face shield following both tests, however this was not quantified.

Particle counts show that HVE use is associated with a reduction in total particle count for each zone evaluated, with the largest reduction seen in regions closest to the origin and the smallest in regions beyond zone 7 (Table II). There was a 340-750% reduction in particle count in zones immediately below and adjacent to the manikin's mouth (Figure 3).

Test one (SE) shows the highest concentration of particles in both the southern (45% particles) and eastern (44% of particles) quadrants, which were situated opposite to the working hand of the operator in the expected direction of fluid flow (refer to Figure 1 for quadrant and floorplan orientation). Particle rates were low in the northern (10%) and nearly absent in western quadrants (< 1%), to the right and towards the feet of the patient/manikin, respectively. As seen in Figure 3, particle count distributions in each quadrant decreased with increasing distance, with zones closest to the origin having a higher number of particles despite these zones being smaller in total size.

In test two (HVE), the highest particle concentration was seen in the eastern quadrant (66%), followed by the western (21%), southern (10%) and northern (3%) quadrants. In addition to having fewer particles overall, the distribution of particles differs when using HVE (compared to the SE) in that there was not a linear decrease in particle count with increased distance. Rather, the particle distribution within each quadrant roughly followed a bell curve, with particle counts peaking in zones 3-5 (7.5 – 16.5 inches from origin), though counts for the eastern quadrant are higher and more variable across zones. This may indicate that use of HVE is disproportionately effective at capturing particles in zones situated less than 17 inches from origin.

Discussion

Results support the use of HVE to effectively reduce the total spread of both splatter and aerosolized droplets that exit a patient's oral cavity during ultrasonic scaling procedures. Previous research shows such particles routinely transport viruses, blood, and supra- and sub-gingival dental plaque[6] creating an avenue for infectious disease transmission in the absence of proper personal protective equipment and aerosol mitigation methods such as HVE.

High concentrations of bacterial aerosols have been identified by culturing colony-forming units from the patient following ultrasonic scaling procedures.[10] Importantly, the use of high-volume evacuation during ultrasonic scaling on human subjects reduces bacterial spread as evidenced by a lower number of colony-forming units on blood agar plates placed in the treatment operatory during the procedure.[11] Evidence of viral transmission via splatter and aerosol is more limited; however, it is known that viral agents can be carried by aerosolized body fluids depending on the size of the viral agent, the transporting particle, and certain environmental conditions including relative humidity and temperature.[12, 13] While the assessment of bacterial and viral agents were beyond the scope of this study, results indicate that the application of HVE likely reduces the spread of disease by limiting the spread of potentially infectious fluids.

The results of this study also show a significant reduction in settled particles detected following ultrasonic scaling with HVE compared to the exclusive use of a SE. These findings corroborate work by Jacks,[14] who found a 90% reduction in the concentration of particles created by an ultrasonic scaler with the use of HVE compared to a SE alone. These results are significant, as dental hygienists in private practices and dental clinics often work independently without the aid of a dental assistant. As a result, they may be less likely to employ HVE during ultrasonic scaling procedures.

Based on these findings and those of other related studies, clinicians working without a dental assistant should make every effort to use some form of HVE rather than relying exclusively on the SE. One promising way to allow simultaneous ultrasonic instrumentation and HVE by a single operator would be an HVE attachment with an integrated mirror or mouth pieces coupled with an HVE attachment. However, more research on the degree to which such systems also reduce particle spread and concentration are needed, in addition to research on the practicality of such systems for dental hygienists.

The greatest particle concentrations following ultrasonic scaling were identified in the southern and eastern regions surrounding the patient, which in these experiments, were situated directly opposite the working arm of the operator, in the general direction of water flow from the ultrasonic scaler (Figure 2). This is consistent with prior research showing the greatest surface area contamination following ultrasonic scaling was found between the four and six o'clock positions of the patient's head (equivalent to the southern region in this study).[2] Similar to this study, no contamination was found at distances over four feet from the patient's oral cavity.[2]

Results of this study support the conclusion that a dental health care provider may reduce their exposure to splatter and aerosols by at least 99% by using HVE. The DSU used in this study had an HVE air flow rate that was approximately 25% of that found in a clinical chair. It is reasonable to assume that a clinical HVE unit would provide an even greater reduction in the number of particles detected. Eliminating aerosols and splatter at the source will also limit the production and spread of particles and downstream contamination risk. Importantly, the biggest reduction in particle count with HVE was seen in zones closest to the operator and dental assistant (i.e., less than 2 feet from the source). This suggests that the biggest benefit to using HVE is for those proximate individuals most at risk - the dentist, dental hygienist, and dental assistant.

In addition to HVE use, preprocedural mouth rinses can also reduce the risk of infectious disease transmission at the source, decreasing the number of bacterial and viral agents present in the oral cavity and limiting the production of contaminated aerosols. Chlorhexidine gluconate is an effective preprocedural antibacterial mouth rinse, reducing 61% - 93% of bacteria detected on blood agar plates following dental prophylaxes.[15, 16] Furthermore, a 0.2% chlorhexidine gluconate pre-procedural mouth rinse used in conjunction with HVE has demonstrated significantly greater reduction of contaminated aerosols than a pre-procedural mouth rinse or HVE alone[16]. One percent hydrogen peroxide and 0.2% povidone iodine have been recommended as potentially effective against SARS-CoV-2 due to the susceptibility of the virus to oxidation,[17] with viral inactivation within 15 seconds when using 0.5%, 1%, 1.5% povidone iodine mouth rinses.[18] While more research is needed, early results suggest that incorporating a combination of HVE and pre-procedural rinses into dental hygiene best practices will significantly reduce the risk of patient-to-dental health care provider viral and bacterial disease transmission. This is particularly true when added to the existing use of personal protective equipment, cleaning and sterilization practices, and engineering protocols (e.g., barriers).

This study had limitations. The composition and contents of the aerosol droplets produced in-vivo were not studied in this set of in-vitro experimental tests. Particulates such as bacteria, viruses, and other organic and inorganic material contained in clinically produced aerosols were not examined. Future clinical studies may further clarify components of aerosol droplets produced during ultrasonic instrumentation. In addition, the size of the airborne droplets was not measured, but rather the size of the spots left after the drops landed on the white paper. Droplets were measured according to post-splatter size, which may have been larger than the droplets expelled from the ultrasonic scaler.

Conclusion

This study addressed the importance of adding critical engineering equipment controls to reduce dental health care providers exposure to potentially infectious materials. Results of this study demonstrate that use of HVE can reduce splatter and aerosol production by up to 99% and reduce the distance that particles disperse by up to 50%. The broader clinical relevance of these results is twofold: use of HVE reduces potential disease exposure to dental health care providers, and the use of HVE restricts the range that particles may spread (e.g., to nearby operatories or examination rooms). High volume evacuation systems should be used in conjunction with other mitigating controls for all aerosol-generating dental procedures.

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Research

Knowledge, Attitudes, Practices of Dental Professionals Regarding the Infection Control Guidelines for Dentistry Prior to the COVID-19 Pandemic

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Abstract

Purpose: The purpose of this study was to explore the knowledge, attitudes, practices and barriers faced by dental health care professionals (DHCP) regarding the Centers for Disease Control and Prevention (CDC) infection control guidelines in dental settings and summary (2003, 2016) prior to onset of the SARS-CoV-2 (COVID-19) pandemic.

Methods: A descriptive, cross-sectional study design was used to create a 42-item electronic survey. A convenience sample of dental assistants registered dental hygienists, and dentists (n=397) was recruited through professional dental social media groups, face-to-face recruitment, and snowball sampling. Descriptive statistics were used to analyze the data.

Results: The completion rate was 66.7% (n=265). The mean knowledge score for the CDC infection control guidelines was 58%. Less than half (39%) of the respondents were able to correctly identify hand hygiene as the most important measure in preventing the spread of infections among patients and DHCP. One third (33%) of the respondents were unaware of the CDC guidelines regarding respiratory hygiene/cough etiquette measures in dental settings. Participants indicated that the greatest barrier in following infection control guidelines was a heavy workload (37%), followed by time restraints (25%), and expense (15%).

Conclusion: Although DHCPs reported familiarity (perceived knowledge) with 2003/2016 CDC infection control guidelines in dentistry, their knowledge and practices were inadequate. This information may serve as a baseline for future consideration of infection control continuing education as a requirement for licensure, particularly given the impact of the COVID-19 pandemic.

Keywords: dental health care providers, infection control, knowledge, attitudes, infection control practices

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Introduction

One of the most noteworthy influences on the oral healthcare profession was the emergence of the human immunodeficiency virus (HIV) in 1981.[1] This epidemic transformed the clinical oral health care setting, leading to better understanding of disease transmission and prevention and a greater application of infection prevention and control measures in the dental setting.[1] Prior to the COVID-19 pandemic, dental healthcare professionals (DHCP) ensured infection control in dentistry by following the guidance of the Centers for Disease Control and Prevention (CDC). The CDC document, Guidelines for Infection Control in Dental Health Care Settings, 2003,[2] provided key recommendations to prevent and control infectious disease transmission in dental settings. In 2016, the CDC published a summary guide based on the 2003 guidelines. This guide highlights the existing CDC recommendations on the basic infection prevention principles, reaffirms standard precautions as the foundation for preventing the transmission of infectious agents during patient care, and provides links to the full guidelines and source documents for more detailed background on the recommendations. Another feature of the 2016 summary document was more detailed descriptions and checklists regarding administrative measures for instrument processing and disinfection, infection prevention education and training,

respiratory hygiene and cough etiquette, dental unit waterline quality, and safe injection practices.[3] While these resources have been free and readily available for all DHCP in the United States (US), research shows not all DHCP were in compliance with the CDC guidelines.[4]

Although reports of transmissions of bloodborne pathogens (BBPs) in dental settings are uncommon, there is evidence that breaches in infection control protocols by DHPs are the leading cause of these transmissions.[5-7] Breaches include a case of patient-to-patient transmission of Hepatitis B Virus (HBV) in a dental practice setting, the acute HBV infection of five individuals in a free dental clinic, and the first recorded case of patient-to-patient transmission of Hepatitis C Virus (HCV) within an oral surgery practice.[5] Research continues to show inconsistencies in infection control compliance in all aspects of the dental setting.[1,4,8] Both the CDC as well as the Occupational Safety and Health Administration (OSHA) guidelines are frequently breached within dental laboratories, making these settings one of the most vulnerable infection control areas within dentistry.[8] In studies conducted in the US, there continues to be a low level of compliance in regard to having an exposure control plan (ECP),[9] maintaining and monitoring dental unit water quality, medical safety device use, recording percutaneous injuries, and having a designated infection control coordinator.[4] Underreporting of violations, failure to link dental setting transmissions due to the long incubation period of HBV, HCV and the asymptomatic progression of Human Immunodeficiency Virus (HIV), are common limitations found in research focused on disease transmission in dentistry.[5-6]

Knowledge, attitudes, and perceptions of infection control protocols have a direct connection to infection control compliance, and breaches within the dental profession[10-13] Though research has shown compliance in infection control protocols to be generally lower in developing countries due to financial constraints, basic knowledge in this area should not be deficient regardless of location and economic status.[11] Furthermore, the recent discovery of the novel COVID-19 virus should encourage all members of the dental team to be well versed in such guidelines, and the attitudes of DHCPs in following CDC infection control guidelines should be closely observed. The purpose of this study was to examine DHCPs knowledge, attitudes, practices and barriers regarding the CDC infection control guidelines in dentistry (2003, 2016). The study was completed prior to identification of COVID-19 in the US.

Methods

The MCPHS University's Institutional Review Board granted this study an exempt status under 45 CFR 46.104d(2)(i) and assigned protocol number IRB120419B.The study design was a descriptive, cross-sectional survey, with a convenience sample of DHCPs (dental assistants, dental hygienists, and dentists; n= 397) within the United States. In order to participate the DHCP needed to be at least 18 years of age, must be assisting with or providing patient care in a clinical setting in the US at least one day/week, and be fluent in reading and speaking English. Dental assistants did not have to be DANB certified, licensed, or graduated from a CODA accredited program. Those not meeting one or more of the criteria were excluded from participation. A power analysis (G*Power) for the most conservative planned statistical test (one-way ANOVA, two-tailed, four groups) using a medium effect size (f=0.25), α=.05, and 80% power suggested a minimum sample size of n=180. Adjusting for expected attrition of 30% the final recommended sample size was n=257.

Survey Instrument

This survey was designed based on the literature consisted of the following sections: demographics (4 items), familiarity with the 2003 CDC infection control guidelines and the 2016 Summary (9 items), infection control knowledge (10 items), participants' current practices in infection control (8 items), barriers with one open-ended question to report additional barriers (8 items), attitudes in seeking information on infection control (3 items) for a total of 42 items. The ten familiarity (perceived knowledge) questions were paired with the ten related knowledge questions. The pairing of these sections helped to identify the knowledge of each participant more accurately and to subsequently compare these responses to how familiar the individual reported being with each subject. A Likert scale of 1 (not familiar) to 5 (very familiar) was used to measure respondent's familiarity while the Likert scale of 1 (extremely unlikely) to 7 (extremely likely) was used to determine the likelihood of DHCP to further their infection control knowledge within the next 12 months.[15]

The survey instrument was validated using the content validity index (CVI) to evaluate the relevance of each survey questions to the study variables[16] and was conducted with five content raters who had background and expertise in infection control. The validation process resulted in a S-CVI= 0.97 and revisions were made based on feedback. The survey was pilot tested with dental professionals (n= 10) who met inclusion criteria to assess comprehension and readability. Feedback given by the content raters resulted in slight edits to the survey content as well as to the implementation of an additional question.

The survey was administered to a convenience sample recruited through professional dental social media groups including, Facebook, LinkedIn, and Instagram, as well as face-to-face recruitment at a large dental conference in New England. Snowball sampling to obtain a larger sample size of practicing dentists was also used.[17]

Data Analysis

For the descriptive portion of this study, the sample demographic information and response to survey questions was summarized and reported with measures of variance (e.g. standard deviation). Next, all variables were analyzed for statistical assumptions including normalcy and co-linearity. Variables were assessed for transformation to address issues of non-normal distributions. Outliers were identified and removed, however if the findings are consistent when including outliers, those cases were used in the main analysis. The data was analyzed for missing data and any participant with less than 80% completion was removed from parts or the whole analysis.

Two or more predictors were used to explore the relationship between variables, for continuous variables correlation (Pearson or Spearmen), for categorical variables chi-square tests of independence, and multiple regression (linear, logistic, ordinal, multinomial) for modeling. To test for differences in means between categorical variables t-tests or ANOVA was used, and in the cases where the distribution did not meet assumptions for the Normal model, the non-parametric equivalent (Wilcoxon U, Kruskal-Wallis) was utilized. Whenever appropriate adjustments to family wise error (e.g. Bonferroni) were made for multiple statistical tests. The acceptable alpha level for was set at .05 for hypothesis testing and all measures of effect size (e.g. 95% Confidence Interval, R^2, Phi Coefficient) were determined and reported.

Results

A total of 397 DHCPs opened the survey link; the completion rate was 67%. The mean age of the participants was 42.3 years and had 19.4 years in practice. Most participants were dental hygienists; two-thirds of the respondents were from the Midwest. Sample demographics are shown in Table I.

Participants were asked a series of familiarity (perceived knowledge) questions regarding CDC Infection Control Guidelines (2003, 2016) as shown in Table II. Three-quarters of the respondents reported infection control training was mandatory in their state for license renewal while 10% did not know. All state of practice responses were recoded into the five US regions (West, Southwest, Midwest, South, and Northeast) (Table I). A chi-square test of independence was used to evaluate the relationship between region of practice and infection control licensure requirement. The Midwest had the highest number of participants indicating infection control continuing education was a requirement for licensure (n=155, 86%) while the Southwest had the lowest (n=6, 50%, $\chi^2(8)=24.1$, $p=0.002$, phi=0.30).

Table I. Demographics (n=265).

		Mean	SD
Age		42	13
Years in practice		19	14
		n	%
What is your most current profession in dentistry?	Dental Assistant	36	14
	Dental Hygienist	218	82
	Dentist	11	4
Where do you practice?	West	18	6.9
	Southwest	12	4.6
	South	20	7.7
	Midwest	180	69.0
	Northeast	31	11.9

Participants stated they were very familiar to extremely familiar with CDC recommendations regarding dental unit waterline maintenance (63%); dental handpiece infection control practices (80%); the term and meaning of standard precautions (73%); hand hygiene (96%); OSHA bloodborne pathogen standard (85%); CDC recommendations regarding critical items (81%); biological testing (67%); and respiratory hygiene and cough etiquette (73%) (Table II).

Knowledge of CDC Guidelines

Two-thirds of respondents correctly answered 6-9 (out of 13) of the knowledge questions while just one-third of the participants correctly answered items related to the guidelines for treatment of dental unit water lines, the provision of tissues and no-touch disposal receptacles, and hand hygiene as the most important measure to prevent spread of infection (Table III). Only a small percentage of respondents (15%) correctly answered the knowledge regarding the dental health care setting's need to encourage persons with symptoms of respiratory infections to sit as far away from others as possible. An independent sample t-test test of independence was calculated to investigate the relationship between state licensure requirement and knowledge score, but was not statistically significant, $p=0.75$.

Table II. Familiarity (perceived knowledge) responses (n=265).

		n	%
Is Infection Control training mandatory in your state for license renewal?	Yes	207	78
	I don't know	26	10
	No	32	12
CDC recommendations regarding dental unit waterline maintenance concerning infection control practices.	Extremely familiar	79	30
	Very familiar	87	33
	Moderately familiar	74	28
	Slightly familiar	19	7
	Not familiar at all	6	2
CDC recommendations regarding dental handpiece infection control practices.	Extremely familiar	123	46
	Very familiar	90	34
	Moderately familiar	38	14
	Slightly familiar	9	3
	Not familiar at all	5	2
CDC recommendations regarding how often infection control education should be completed.	Extremely familiar	126	48
	Very familiar	67	25
	Moderately familiar	39	15
	Slightly familiar	20	8
	Not familiar at all	13	5
The term and meaning of standard precautions.	Extremely familiar	176	66
	Very familiar	73	28
	Moderately familiar	11	4
	Slightly familiar	3	1
	Not familiar at all	2	1
CDC recommendations regarding hand hygiene.	Extremely familiar	192	73
	Very familiar	61	23.
	Moderately familiar	4	2
	Slightly familiar	5	2
	Not familiar at all	3	1
The OSHA Blood Borne Pathogen Standard.	Extremely familiar	152	57
	Very familiar	75	28
	Moderately familiar	29	11
	Slightly familiar	7	3
	Not familiar at all	2	1
The CDC recommendations regarding critical care items.	Extremely familiar	128	48
	Very familiar	88	33
	Moderately familiar	34	13
	Slightly familiar	9	3
	Not familiar at all	6	2
CDC recommendations regarding biological testing	Extremely familiar	119	45%
	Very familiar	59	22%
	Moderately familiar	50	19%
	Slightly familiar	25	9%
	Not familiar at all	12	5%
CDC recommendations regarding respiratory hygiene/cough etiquette	Extremely familiar	132	50%
	Very familiar	61	23%
	Moderately familiar	43	16%
	Slightly familiar	14	5%
	Not familiar at all	15	6%

Infection Control Practices

Infection control practices are shown in Table IV and V. Providing a mask for people with a visible respiratory infection while in the reception area was the category reported with the least compliance (41%). Three-quarters (77%) of respondents completed an infection control continuing education course annually. Nearly half (43%) of the respondents did not know how often their dental unit waterlines were tested to ensure Environmental Protection Agency (EPA) standards of drinking water while a majority (87%) reported completing weekly biological testing on their sterilizers.

Infection Control Barriers

DHCPs ranked barriers to following infection control guidelines in practice from one to seven, with one being the most relevant barrier within their practice and seven being the least barrier within their practice. The greatest barrier found was a heavy workload (34%), followed by time restraints (25%), expense (15%), and lack of training (13%). The barrier DHCPs found to be the least relevant barrier was lack of good role models (2%) which was ranked as seventh. In the open-ended question, a common trend stated by DHCPs was lack of supplies. In particular, there were not enough handpieces available to comply with proper sterilization methods.

Infection Control Education

Most DHCPs (75%) were extremely likely to further their infection control knowledge by attending an infection control continuing education class within the next 12 months. Less than half of participants (44%) reported they were extremely likely to read the CDC guidelines regarding infection control in dentistry or take an online infection control course (44%) within the next 12 months.

Table III. Knowledge items (n=265).

	Incorrect		Correct	
	n	%	n	%
All dental units should use systems that treat water to meet EPA drinking water standards of _____. *Correct response*: 550 CFU/ml	185	70	80	30
Dental Handpieces (low and high speed) *Correct response: Should be heat sterilized after every patient.*	10	4	255	96
Infection Control training should be provided at a minimum, annually. *Correct response: True*	20	8	245	92
Standard precautions _____. *Correct response:* Apply to all patient care	3	1	262	99
The most important measure to prevent the spread of infections among patients and dental personnel is _____. *Correct response: Hand hygiene*	162	61	103	39
The OSHA BBP Standard was created to _____. *Correct response: Help protect DHCP from blood exposure and sharps injuries*	171	65	94	36
_____ items should always be heat sterilized. *Correct response: Critical*	32	12	233	88
If a/an _____ item is heat sensitive, dental healthcare personnel should replace it with a heat tolerant or disposable alternative. *Correct response: Semi-critical*	201	76	64	24
What is the most accepted method for monitoring the sterilization process? *Correct response: Biological indicators*	51	19	214	81
The CDC recommends dental practices encourage persons with symptoms of respiratory infections to sit as far away from others as possible. *Correct response: True*	225	85	40	15
The CDC recommends dental practices post signs at entrances to patients with symptoms of respiratory infection to cover their mouth and noses when coughing or sneezing. *Correct response: True*	105	40	160	60
The CDC recommends dental practices provide tissues and no-touch receptacles for disposal of tissues *Correct response: True*	184	70	81	31

Discussion

This study explored the level of knowledge, practices, attitudes and barriers faced by DHCPs regarding the CDC Guidelines for Infection Control in Dental Health Care Settings (2003) and the Summary of Infection Prevention Practices in Dental Settings: Basic expectations for safe care in dentistry (2016), prior to the COVID-19 pandemic. In the area of knowledge, the findings in this study were consistent with the systematic review by Khanghahi[12] concerning the overall knowledge of infection control practices. Although the majority of participants stated they were moderately to extremely familiar with CDC guidelines pertaining to dental unit waterlines; hand hygiene; OSHA bloodborne pathogen standard; and respiratory and cough etiquette, these were the areas where participants in this study were found to be the least knowledgeable.

Infection control practices carried out in clinical settings prior to COVID-19 were examined and it was found that almost half of participants did not know if their dental unit waterlines were tested to ensure compliance with the established Environmental Protection Agency standards for drinking water. Furthermore, 70% could not correctly identify the standards raising concerns regarding whether the CDC regular training on infection control policies and guidelines is taking place.[3] Lack of knowledge regarding the contamination levels of dental unit waterlines can ultimately be detrimental to immunocompromised patients in addition to posing a public health concern.[3]

While most participants reported performing weekly biological testing to monitor sterilizers, some respondents did not follow this CDC recommendation at all. Similarly, participants stated there were times when both high and low speed handpieces do not go through the proper sterilization process after each patient. Wiping dental handpieces with a disinfectant in between patients is a direct breach of infection control guidelines which could result in disease transmission as was the case for five individuals

Table IV. Mean responses to practice items (n=265).

	Mean	SD*	95% Lower CL**	95% Upper CL**
What percentage of time do all handpieces (low, high speed) get heat sterilized after each patient?	80%	33	76	84
How often do you perform hand hygiene during a typical 8-hour workday? Times per day	32	25	29	35
What percentage of time do critical items get heat sterilized after each patient?	94%	19	92	96
What percentage of time do semi-critical items get heat sterilized after each patient?	86%	26	83	90
What percentage of time does your office provide a mask for people with a visible respiratory infection while in the reception area?	41%	46	35	46

*SD = standard deviation of the mean

**Lower and Upper CI = 95% confidence interval of the mean.

Table V. Practice items (n=265).

		n	%
How often do you test dental unit waterlines to ensure it meets the EPA standard for drinking water?	Once a month	101	38
	Once a year	18	7
	Every 6 months	33	13
	I do not know	113	43
How often do you complete infection control continuing education?	Once a year	205	77
	Twice a year	8	3
	Biannually	35	13
	I do not complete	17	6
How often does your practice perform biological testing?	Once a week	231	87
	Once a month	22	8
	Once every 3 months	2	1
	We have no set standard	10	4

who became infected with HBV after visiting a portable dental clinic.[18] Blood borne disease transmission is a possible consequence of not following CDC guidelines for sterilization and monitoring sterilizer efficacy[2,3] due to the long incubation period of some of these pathogens.

Participants in this study reported washing their hands a total of 32 times in a typical 8-hour workday, yet the majority of respondents were unable to correctly identify that hand hygiene was classified by the CDC as the most important measure in preventing the spread of infections among patients and providers.[3] This finding leads researchers to hypothesize that while the practice of hand hygiene may be high within DHCPs, the knowledge behind the rationale for the practice is lacking. Lack of knowledge can be associated with poor hand hygiene practices leading to bacterial transmission to patients. This was exemplified in the case of an oral surgery patient who died due to bacterial endocarditis complications traced to the lack of hand hygiene and aseptic technique compliance of a DHCP during the administration of medications.[7]

Results from this study identified the top three barriers to following the CDC infection control guidelines to be a heavy workload, time restraints, and expense, which were consistent with findings in previous studies.[10] Dental health care providers should develop team-based strategies to alleviate these barriers with the goal of protecting their patients as well as themselves. In general, dentists in the US are the direct supervisors of both dental hygienists and dental assistants, and ultimately oversee supply costs and patient load within a dental practice. Targeting more intense infection control instruction strategies toward practice owner employers/supervisors may promote positive change and foster a culture that follows CDC guidance more closely.[10]

One of the most significant findings in this study was the lack of knowledge regarding respiratory hygiene and cough etiquette in dentistry.[2,3] One-third of the respondents were not aware of the CDC guidelines for respiratory hygiene and cough etiquette guidelines for dental health care settings and patients with a visible respiratory infection were provided with a mask while in the reception area only 41% of the time. Varying answers to the respiratory hygiene, cough etiquette, and hand hygiene items revealed areas needing to be further addressed by the dental profession prior to the emergence of the novel respiratory disease, COVID-19.[19] More emphasis needs to be placed on the significance and the mitigation of the transmission respiratory diseases in infection control courses for DHCPs.

Although the study attempted to analyze state and regional differences regarding continuing education licensure requirements for infection control, the only state with an adequate sample size was Massachusetts and the only region was the Midwest, which limited the analysis. This area needs further research with a larger sample for each state. Given the gaps in actual versus perceived knowledge regarding infection control guidelines, it may also be prudent to also assess the way continuing education is delivered. Currently the norm is passive lecture with no assessment mechanism. An emerging trend for a variety of professions is for the licensee to develop a comprehensive plan for continuing professional development (CPD) rather than simply listing the number of hours of continuing education.[20,21] Continuing professional development plans require the licentiate to demonstrate application of learning, evaluation, and reflection to verify continuing competence within their discipline.[20,21]

Limitations of this study included convenience sampling, self-report bias, self-selection bias, and misrepresentation of DHCPs who do not participate in social media forums, or who do not have regular access to the Internet, and social desirability. The sample was largely made up of mostly registered dental hygienists and is not representative of the demographic balance of DHCPs. Some states do not require licensure of dental assistants so there could have been a wide range of educational experiences and background for this group; however, they were only a percentage of the sample. More research is needed regarding infection control practices in dental laboratories. In addition, infection control knowledge (perceived and actual), practices and education related to interim and updated CDC and OSHA guidelines post-COVID-19 warrant further investigation. Findings from this study may serve as a baseline for comparison.

Conclusion

Although DHCPs reported familiarity (perceived knowledge) with the CDC Guidelines for Infection Control in Dental Health Care Settings (2003) and the Summary of Infection Prevention Practices (2016) their actual knowledge and practices prior to the COVID-19 pandemic were not consistent with the perceived knowledge. The lack of basic knowledge regarding CDC infection control guidelines in dental health care settings is particularly concerning given the global emergence of the novel COVID-19 virus. Evidence-based infection control protocols will continue to evolve in dentistry and DHCPs must be responsible for incorporating the latest guidance into practice. Results of this study also provides evidence supporting the need for infection control continuing education as a requirement for licensure.

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Research

Impact of Ergonomic Training on Posture Utilizing Photography and Self-assessments among Dental Hygiene Students and Practitioners

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Abstract:

Purpose: Dental health care professionals are at high risk of developing work-related musculoskeletal disorders. The purpose of this study was to determine the at-risk regions for developing musculoskeletal strain and evaluate the training effects of photography and self-assessment on the postures among dental hygiene students and clinical practitioners.

Methods: This randomized control design study took place over a four-week period. A convenience sample of dental hygiene students (n=20) and registered dental hygienists (n=20) agreed to participate and were randomly assigned to training and control groups. All participants were photographed in the dental hygiene clinic completed ergonomic self-evaluations, using a Modified-Dental Operator Posture Assessment Instrument (M-DOPAI) during week one and four. Participants in the training group used photographs captured by the study investigators to complete ergonomic self-assessments during weeks two and three. Photographs from week one and four were evaluated by four calibrated raters using the M-DOPAI.

Results: The top regions at-risk for musculoskeletal strain, identified by the raters, were the head and upper arms. Conversely, the top regions at-risk for musculoskeletal strain identified through the participants' self-assessments were the head and trunk. A mixed-design ANOVA revealed that feedback with photography resulted in improved ergonomic scores. A mixed-design ANOVA of Kappa coefficient values between clinician and rater scores revealed the feedback with photography increased the accuracy of the ergonomic self-assessments.

Conclusion: Training involving self-assessment utilizing photographs resulted in improvements in ergonomic scores and the accuracy of ergonomic self-assessments after four weeks. Improved postures and reduced risks for musculoskeletal disorders may be sustained with periodic ergonomic self-assessments using photography.

Keywords: dental hygienists, dental hygiene students, ergonomics, posture, self-assessments, musculoskeletal disorders

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Introduction

Despite the high risk of dental hygiene professionals developing work-related musculoskeletal disorders (WMSDs),[1-5] incongruities exist between the clinicians' perceived and actual postures while providing patient care. Most surveyed dental professionals reported experiencing musculoskeletal pain despite being aware of neutral ergonomic positions.[2] Areas frequently associated with reported pain among dental hygienists include the neck, back, shoulders, and hands/wrists.[1,6-9] The typical work schedule for the typical dental hygienist in clinical practice, which includes the delivery of dental hygiene care for 45-60 minutes for up to 8 patients a day, 7-8 hours a day, 3-4 days a week, has been associated with reported moderate to severe pain.[8] Musculoskeletal pain has been reported to begin within the first six to ten years of clinical practice, although some clinicians may experience pain sooner.[10, 11] As WMSDs progress, many dental hygienists seek therapy for pain, take time-off, and may become unable to practice clinically.

The postures of dental hygienists are dependent upon the clock-positioning of the patient in relation to the operator, which is defined in the textbooks used in entry-level dental hygiene programs.[12,13] With the patient's head at 12:00 o'clock, right-handed operators provide treatment from the 8:00 o'clock to 1:00 o'clock position whereas left-handed

operators provide treatment from the 4:00 o'clock to 11:00 o'clock position.[12,13] Although most dental hygienists prefer and utilize a seated position from the rear or 11:00-1:00 o'clock positions when delivering dental hygiene care, these positions may actually be contributing to the development of musculoskeletal disorders.[14-16]

The availability of personal equipment, such as stools and magnification loupes, can impact the postures of dental operators. Stool choice may also influence the development of musculoskeletal pain since dental hygienists provide care in seated and static positions. The use of saddle seats have been shown to promote neutral positions with the anterior tilt of the lower lumbar spine, which allows for the relaxation of this region of the spine.[17] Although dental hygienists may consider utilizing saddle seats in clinical practice settings, they are not routinely provided in most dental offices due to the additional cost of the specialized seat and the prevalence of their use by dental hygienists is unknown. The use of magnification loupes has been increasing among dental hygienists for many reasons. The current trend in dental hygiene programs is to require the purchase and use of magnification loupes by dental hygiene students early in their education.[18] However, there is a disparity in which more dental hygiene students own magnification loupes than the dental hygiene faculty members.[18,19] As more dental hygiene students are required to purchase and use magnification loupes, future dental hygiene educators will have regularly utilized and experienced the associated benefits of these devices. Dental hygienists have reported experiencing reduced musculoskeletal pain and perceived improved accuracy with the use of magnification loupes.[20]

The transition from an academic clinical environment with long appointment times to private practice settings with shorter appointment times may also affect the development of musculoskeletal pain. From informal faculty observations in student clinic settings, dental hygiene students tend to accommodate their patients at the expense of their personal postures. During the development of indirect vision skills, dental hygiene students may often overcome feelings of frustration by compromising their postures to use direct vision. Habits formed in the student clinical environment may later translate into professional practice and the progression of musculoskeletal pain.

Although clinicians may be aware of general principles of ergonomics, a disconnection exists in the application of ergonomic recommendations.[21] Because dental hygienists typically work independently in a clinical setting, the individual clinician has the responsibility of self-identifying and self-correcting postural problems. Self-assessment involves the accurate judgment of an individual's performance using detailed criteria and corresponding with a validated measure of one's performance.[22] Accurate self-assessments are especially necessary for independently practicing clinicians. When postures extend beyond acceptable criteria, dental hygienists may unknowingly incur detrimental effects that may lead to WMSDs. Without intervention, the lack of awareness of postural problems may lead to the progression of musculoskeletal pain.

Feedback using self-assessment and photography has been previously shown to improve ergonomic scores and the accuracy of ergonomic self-assessment among dental and dental hygiene students over a four-week period.[23,24] However, it remains unknown whether this intervention would be effective with practicing clinicians. The purpose of this study was to determine the regions at greatest risk for developing musculoskeletal strain and to evaluate the effect of an interventional training involving photography and self-assessment on posture and the accuracy of ergonomic self-assessments among dental hygiene students (DHS) and registered dental hygienists (RDH).

Methods

This randomized control study was approved by The Ohio State University Biomedical Institutional Review Board, (2017H0343, 2018H0157). A convenience sample of 29 junior-year dental hygiene students (DHS) enrolled during autumn 2017 in The Ohio State University baccalaureate dental hygiene program and 20 registered dental hygienists (RDH) employed during the summer 2018 at The Ohio State University College of Dentistry were recruited to participate. The DHS and RDH participants were assigned into one of two groups (control and training) using random sampling program in SPSS Version 25 (IBM, Chicago, IL, USA). Two faculty raters and two key personnel were recruited from The Ohio State University, Division of Dental Hygiene to participate as evaluators in this study. After explaining the rationale and the research study design, all participants signed written informed consent forms prior to starting the study.

Sample

Dental hygiene student participants were enrolled in a preclinical dental hygiene course and received one hour of didactic instruction on ergonomics at the beginning of the term. During the four-week study, all DHS participants practiced implementing all the pre-clinical exercises which included posterior area specific curettes, ultrasonic scalers, universal scalers, and intra- and extra-oral examinations in all areas of the mouth. The RDH participants were employed

on a part-time or full-time basis as professors, clinical instructors, or dental hygiene practitioners. During the four-week study, all RDH participants performed their usual patient care procedures. The use of magnification loupes, with or without coaxial illumination, and saddle seats was not required for participation in the study.

Instrument

A modified-dental operator posture assessment instrument (M-DOPAI) with 12 components was utilized for the self-assessments and rater evaluations (Table I). This instrument was modeled after the Branson et al. Posture Assessment Instrument (PAI) consisting of 10 components, which was tested for validity and reliability for imaged and real-time postures,[25] and the Maillet et al. Posture Assessment Criteria (PAC), which added two components involving the upper arms.[26] The criteria for the components were detailed within the M-DOPAI. Each component score had one of three categories: acceptable (1 point), compromised (2 points), or harmful (3 points). Eight of the 12 components included a harmful category. The total scores ranged from 12 to 32 with the lower scores being more acceptable. Thus, the most ideal postures scored 12 points whereas the most harmful postures scored 32 points. Figure 1 provides images of front and profile views representing a typical seated posture.

Figure 1. Front and profile posture images

Legend: The front view allowed for the evaluation of the trunk (side to side and rotation); head and neck (side to side and rotation); elbows (level); shoulders (level); and wrists (flexion or extension). The profile view allowed for the evaluation of the hips; trunk (front to back); head and neck (front to back); upper arms (in relation to torso); shoulder (relaxed or slumped); and wrists (flexion or extension).

Table I. Comparison of areas at-risk for musculoskeletal strain, identified by raters, between DHS (n=29) and RDHs (n=20)

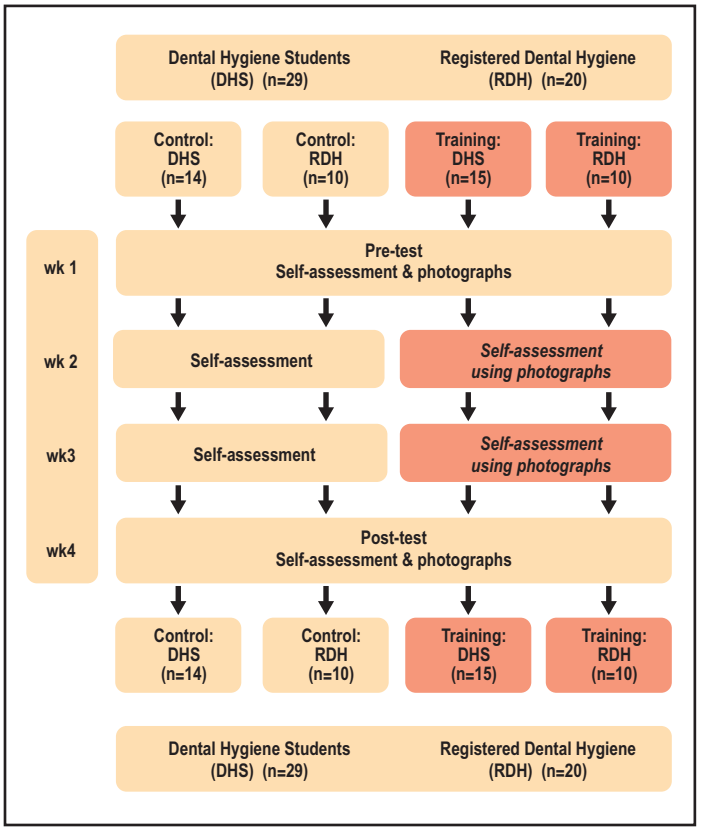
Body Area		mean	SD	F	Sig
Hips (leveled)	DHS	1.12	.329	.562	*p*>.05
	RDH	1.18	.385		
Trunk (front to back)	DHS	1.22	.421	.708	*p*>.05
	RDH	1.30	.464		
Trunk (side to side)	DHS	1.29	.459	3.134	*p*>.05
	RDH	1.48	.554		
Trunk (rotation)	DHS	1.17	.425	4.746	*p*<.05*
	RDH	1.38	.490		
Head (front to back)	DHS	1.84	.696	.002	*p*>.05
	RDH	1.85	.533		
Head (side to side)	DHS	1.53	.537	.019	*p*>.05
	RDH	1.55	.552		
Head (rotation)	DHS	1.22	.421	4.194	*p*<.05*
	RDH	1.43	.559		
Upper arms (parallel)	DHS	1.64	.742	.356	*p*>.05
	RDH	1.55	.677		
Upper arms (elbows)	DHS	1.71	.562	.003	*p*>.05
	RDH	1.70	.468		
Shoulders (slumped/relaxed)	DHS	1.33	.473	1.211	*p*>.05
	RDH	1.23	.423		
Shoulders (leveled)	DHS	1.22	421	4.617	*p*<.05*
	RDH	1.43	.501		
Wrists (flexed/extended)	DHS	1.26	.442	3.884	*p*<.05*
	RDH	1.10	.304		

*Significance set at p-values <.05.

Procedure

The study occurred over the course of four weeks; the flow is illustrated in Figure 2. During week one, all participants were photographed twice in their respective clinical settings, without sound or flash (front and profile views) and all participants independently completed a pre-test ergonomic self-evaluation using the M-DOPAI without viewing the photographs or receiving any feedback. In order to generate valid self-assessments, each participant was provided with general instructions to read through each of the 12 components of the M-DOPAI and was asked to self-assess their postures using the criteria (score of 1 representing the best and a score of 3 representing the worst).

Figure 2. Study procedure flow



During weeks two and three, participants in the control group independently completed weekly ergonomic self-assessments without viewing photographs or receiving feedback from the principal investigator. Participants in the training group had two additional photographs without sound and flash taken weekly (front and profile views) and completed a weekly ergonomic self-assessment with the principal investigator using the photographs during each of the two weeks. The principal investigator facilitated the self-assessments by guiding the participant through each of the twelve components. The principal investigator would either agree with the participant's self-assessment or guided the participant to re-evaluate their assessment.

All images were captured, without sound or flash, and displayed for the participants' self-assessments using tablet technology (Galaxy Note 10.1, Samsung, Ridgefield Park, NJ, USA). At week four, all participants were photographed the final two times (front and profile views), without sound or flash, and independently completed a post-test ergonomic self-assessment without viewing the photographs or receiving any feedback from the principal investigator. Participants were provided with the same general instructions, as provided during the pre-test.

The participants' pre-test (week one) and post-test (week four) photographs were each evaluated for an ergonomic score using the consensus of two faculty and two key personnel raters. The agreement of three of the four raters provided consensus of the scores and defined the gold standard for the data analysis. The four raters received group didactic instruction from the principal investigator on ideal neutral ergonomic positioning[12,13] and the recognition of any deviations from neutral positioning. The raters were also provided with a detailed orientation to each of the 12 components of the M-DOPAI and a practice application of the M-DOPAI to an imaged posture. Raters independently evaluated the photographs and the scores were compared to generate consensus scores achieved with the agreement among three of the four raters.

Data analysis

Data were analyzed using SPSS Version 25 (IBM, Chicago, IL, USA). Descriptive statistics and one-way ANOVA were used to evaluate the variances between the sample groups. The accuracy of self-assessments was calculated with the comparison of self-assessment scores and rater scores, serving as the gold standard, at the following timepoints: pre-training (week one) and post-training (week four). Inter-rater reliability levels were calculated using Cohen's Kappa coefficient because it analyzed data in nominal scale and accounted for agreement due to chance.[27-29] Kappa scores ranged from less than 0 (no agreement) to 1 (perfect agreement). Slight agreement values ranged from 0.00-0.20, fair agreement values ranged from 0.21-0.40, moderate agreement values ranged from 0.41-0.60, full agreement valued ranged from 0.61-0.80, and perfect agreement values were greater than 0.81.[27-29] Variances between the sample groups were evaluated using mixed-design ANOVA. Significance levels were set at p-values <0.05.

Results

A total of 49 participants completed the study: 29 dental hygiene student (DHS) participants (14 in the control group and 15 in the training group) and 20 registered dental hygienist (RDH) participants (10 in the control group and 10 in the training group). All DHS participants were female and there were no significant differences in the two groups regarding mean years of age (M=21.4, sd=3.6). Nineteen of the RDH participants were female and there were no significant differences in the two groups regarding mean age (M=45.22, sd=11.69), hours worked per week (M=25.03, sd=14.85), or number of years in clinical practice (M=20.66, sd=12.65).

The first aim was to determine the regions, identified by the *raters*, most at-risk for musculoskeletal strain among DHS and RDH. The top three regions identified as most at-risk by

the raters were the head-front to back (DHS- $M=1.84$, sd=.696, RDH- $M=1.85$, sd=.533), upper arms-elbows (DHS- $M=1.71$, sd=.562, RDH- $M=1.70$, sd=.468), and upper arm- parallel (DHS- $M=1.64$, sd=.742, RDH- $M=1.55$, sd=.677). One-way ANOVA was used to determine significant differences in the mean scores for the body regions between DHS and RDH groups. The scores for the RDHs were significantly higher in the areas of trunk (rotation) ($F(1,96)=4.746$, $p<.05$), head (rotation) ($F(1,96)=4.194$, $p<.05$), and shoulders (leveled) ($F(1,96)=4.617$, $p<.05$) than the DHS group. The scores for the DHS were significantly higher in the area of wrists (flexed/extended) ($F(1,96)=3.884$, $p<.01$) than the RDHs. Rater comparisons of areas most at risk for musculoskeletal strain for DHS and RDHs is shown in Table 1.

The second aim was to determine the regions, identified through the *self-assessments*, most at-risk for musculoskeletal strain among DHS and RDHs. The top three self-assessed regions that were identified as most at-risk were the head-side to side ($M=1.80$, ssd=.456), head-front to back ($M=1.57$, sd=.540), and trunk-side to side ($M=1.57$, sd=.540). The top three rater-evaluated regions identified as most at-risk were head-front to back ($M=2.12$, sd=.600), upper arms-elbows ($M=1.86$, sd=.612), and upper arms- parallel ($M=1.69$, sd=.822). One-way ANOVA was used to determine significant differences in the mean scores for the body regions between self-assessment and rater evaluations. Self-assessments scores were significantly higher in the regions of trunk (front to back) ($F(1,96)=18.062$, $p<.001$), trunk (side to side) ($F(1,96)=18.935$, $p<.001$), trunk (rotation) ($F(1,96)=6.114$, $p<.01$), head (side to side) ($F(1,96)=27.881$, $p<.001$), head (rotation) ($F(1,96)=20.915$, $p<.001$), shoulders (leveled) ($F(1,96)=7.291$, $p<.01$), and wrists ($F(1,96)=5.476$, $p<.05$) than the rater-evaluation scores. However, the rater-evaluation scores were significantly higher in the regions of head (front to back) ($F(1,96)=22.841$, $p<.001$) and upper arms (elbows) ($F(1,96)=6.861$, $p<.01$). The comparisons of areas at risk for musculoskeletal strain between participants' self-assessments and rater evaluations is shown in Table II.

The third aim was to determine the effect of feedback involving photography and self-assessment on the accuracy of ergonomic self-assessments among DHS and RDH shown in Table III. A 2x2x2 mixed-design ANOVA was calculated to examine the effects of the group (control group and training group), status (DHS and RDH) and time (pre-test and post-test) on reliability (Cohen's Kappa coefficient between self-assessment and rater-evaluations). Significant interactions were found with time (pre-test and post-test) x group (control group and training group) ($F(1,45)=7.262$, $p<0.01$). A main effect for group (control group and training group) was found to be significant ($F(1,45)=4.733$, $p<0.05$). Post hoc analysis using one-way ANOVA revealed a significant increase in agreement with the training group at the posttest ($F(1,48)=4.866$, $p<0.05$). The training caused a significant increase in agreement in the training groups comprised of DHS and RDH participants compared to the control groups comprised of DHS and RDH participants.

Table II: Comparison of areas at-risk for musculoskeletal strain between self-assessments and rater evaluations (n=49)

Body Area		mean	SD	F	Sig
Hips (leveled)	Self	1.18	.391	1.324	*p*>.05
	Rater	1.10	.306		
Trunk (front to back)	Self	1.43	.500	18.062	*p<.001**
	Rater	1.08	.277		
Trunk (side to side)	Self	1.57	.540	18.935	*p<.001**
	Rater	1.16	.373		
Trunk (rotation)	Self	1.37	.487	6.114	*p<.01**
	Rater	1.14	.408		
Head (front to back)	Self	1.57	.540	22.841	*p<.001**
	Rater	2.12	.600		
Head (side to side)	Self	1.80	.456	27.881	*p<.001**
	Rater	1.29	.500		
Head (rotation)	Self	1.51	.545	20.915	*p<.001**
	Rater	1.10	.306		
Upper arms (parallel)	Self	1.51	.582	1.631	*p*>.05
	Rater	1.69	.822		
Upper arms (elbows)	Self	1.55	.542	6.861	*p<.01**
	Rater	1.86	.612		
Shoulders (slumped/relaxed)	Self	1.22	.422	1.796	*p*>.05
	Rater	1.35	.481		
Shoulders (leveled)	Self	1.43	.500	7.291	*p<.01**
	Rater	1.18	.391		
Wrists (flexed/extended)	Self	1.29	.456	5.476	*p<.05**
	Rater	1.10	.306		

*Significance set at p-values <.05.

TABLE III. Summary of the effects of photography and self-assessment on inter-rater reliability between student self-assessment and rater scores

Tests of within-subjects effects					
Source*	**Type III Sum of Squares**	**Df**	**Mean square**	**F**	**Sig**
Time	0.131	1	0.131	4.130	*p<0.05*
Time Group	0.231	1	0.231	7.262	*p<0.01*
Time Status	0.004	1	0.004	0.129	*p*>0.05
Time Group Status	0.013	1	0.013	0.419	*p*>0.05
Error	1.433	45	0.320		

Tests of between-subjects effects					
Source*	**Type III Sum of Squares**	**Df**	**Mean square**	**F**	**Sig**
Intercept	3.079	1	3.079	43.400	0.00
Group	0.187	1	0.187	2.629	*p*>0.05
Status	0.042	1	0.042	0.586	*p*>0.05
Group Status	0.336	1	0.336	4.733	*p<0.05*
Error	3.192	45	0.071		

*Note: The independent variable "Time" had the two conditions: "pre-test" vs. "post-test"; the independent variable "Group" had the two conditions "control" vs. "training"; and the independent variable "Status" had the two conditions "DHS" vs. "RDH."

Discussion

The purpose of this study was to determine the most at-risk regions for developing musculoskeletal strain and to evaluate the effect of training involving photography and self-assessment on the postures and the accuracy of ergonomic self-assessments among DHS and RDHs. The top at-risk regions for musculoskeletal strain, as identified by the raters, were the head and upper arms. The top regions at-risk for musculoskeletal strain, as identified through self-assessments, were the head and trunk. The training with feedback using photography improved ergonomic scores and the accuracy of the ergonomic self-assessments in the experimental group.

Over time, static postures in compromised positions may lead to musculoskeletal disorders.[30] Based upon the rater evaluations, the most compromised regions identified by both students and practicing clinicians were the forward flexion of the head and the forward placement and abduction of the upper arms. However, RDHs were more likely to further compromise their postures with the rotation of the head/neck, rotation of the trunk, and unleveled shoulders than the DHS. Static and compromised repeated positioning of these regions has been identified as a contributor to the development of musculoskeletal disorders.[9,31]

The physical demands of providing dental hygiene care may cause dental hygiene students and practicing clinicians to compromise their personal postures for better visualization or to prevent the disruption of patient comfort.[10] The participants in this study may have been aware of this reality based on the comparisons between self-assessments and rater evaluations. Both the DHS and RDHs self-rated their trunk, head, and shoulder positions as more severely compromised than the rater evaluations. This is contrary to the tendency of students to positively overestimate self-assessment scores, which may impact learning or the improvement of skills.[32] In general, both dental hygiene students and registered dental hygienists have a more negative perception of their postures than the reality of their actual positioning.

A paradox exists in which dental hygiene clinicians possess an awareness of their possible compromised postures but lack either the motivation to improve postures or an understanding of how to maintain visualization. The use of magnification loupes or having ergonomics education may account for a decreased likelihood of reporting musculoskeletal problems.[7] The major impetus for improving postures is usually pain.[33] However, chronically compromised postures increase the risk of and contribute to the initiation of musculoskeletal disorders. Evidence has shown that musculoskeletal disorders for dental hygienists may begin as early as during their entry-level clinical programs.[4,34] After entry into clinical practice, dental professionals remain at higher risk for developing work-related musculoskeletal disorders, so any improvement in ergonomic scores may benefit their well-being and career longevity.[6,35-7] This provides support for conducting periodic ergonomic self-assessments using quick, objective, and easily-accessible methods such as photography-assisted self-reflection.

Ergonomics training combined with captured photographs has been shown to be a feasible and practical method to improve self-awareness and postures among dental and dental

hygiene students.[23, 24] Discussions during the training sessions promoted the students' development to become autonomous, self-regulated, and com-petent student clinicians.[32] Tendencies among students to overestimate their abilities may hinder the acquisition of knowledge and reduce the ability to improve their work habits.[38] The end goal is to develop the automatic reflective practice in self-correction from the continual practice of self-assessment.[39] The formation of these habits and the progression of ergonomic self-assessment skills can be promoted throughout their clinical experience as students and later on as practicing dental hygienists.

The present study corroborates evidence reporting that students with self-assessment training (training group) tend to yield more accurate self-assessments of their performance.[38] Comparing the agreement between clinician and rater scores, the accuracy of the training groups' ergonomic self-assessment scores improved significantly from week one to week four. The method utilized in the present study combined the independent completion of a self-assessment by the clinician along with formative feedback from the principal investigator. During the self-assessment session, the principal investigator engaged all participants with reflective Socratic questioning (i.e. What do you think about the front to back position of your head?) to provoke the participant to critically think and identify discrepancies in their evaluations. With increasing awareness of a problem, the likelihood of making adjustments to remedy those problems increases. When students overestimate their abilities, this may hinder the acquisition of knowledge or the improvement of their skills.[32]

Limitations of this study included the use of convenience samples at a single research site, the use of still imaged postures, and the raters' subjective evaluations of angulation of the imaged postures using objective criteria. The DHS had program requirements to purchase and use magnification loupes, and this may have contributed to increased forward flexion, depending on the angle of declination or the mounting of the lenses. Future research studies should include the use of larger sample sizes to increase the generalizability of the results, the use of technology to improve the objective measurement of postures and long-term effects of ergonomics training with photography.

Conclusion

The head and upper arms were identified as the top regions at-risk for musculoskeletal strain based on calibrated rater evaluations of the participant photographs. However, the head and trunk were self-assessed as the top regions at-risk for musculoskeletal strain by dental hygiene students and partitioners. Training involving self-assessment strategies utilizing photographs resulted in improvements in ergonomic scores and the accuracy of ergonomic self-assessments in students and practicing clinicians after four weeks. Improved postures and reduced risks for musculoskeletal disorders may be sustained using photography and periodic ergonomic self-assessments.

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Interprofessional Education: Medical and dental hygiene student competencies during the delivery of patient care

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Abstract

Purpose: Interprofessional education (IPE) helps prepare health care students for collaborative delivery of patient care. The purpose of this pilot study was to evaluate changes in self-perceived collaborative competencies of dental hygiene and medical students after a live patient care IPE experience.

Methods: Dental hygiene (n=23) and medical students (n=26) were paired for a single-encounter IPE experience with adult patients. Following the collaboration, participants completed the 20-item, seven-point Likert scale retrospective pre-test/post-test Interprofessional Collaborative Competencies Attainment Survey (ICCAS) to assess changes in perceived collaborative competencies as a result of the IPE experience. Participants reflected on current and prior self-perceived interprofessional collaborative competence in the areas of communication, collaboration, roles and responsibilities, collaborative patient/family-centered approach, conflict management/resolution, and team functioning. Descriptive statistics were used to analyze the data.

Results: All participants (n=49) completed the IPE survey for a response rate of 100%. Pre-test mean scores ranged from M=5.40, SD=.46 to M=6.31, SD=1.23 and post-test scores ranged from M=6.09, SD=.46 to M=6.72, SD=.86 for all participants. All paired item mean score differences were statistically significant ($p \leq .05$) indicating increased self-reported collaborative competence.

Conclusions: A live patient care IPE experience created a positive perception of collaborative competence among medical and dental hygiene student participants. Dental hygiene curricula should include IPE, including live patient experiences to foster students' collaborative competence and preparation for interprofessional collaboration in the workplace.

Keywords: dental hygiene students, health care students, interprofessional education, collaborative competence, interprofessional collaboration

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Introduction

Dental and medical professionals share a common goal of optimizing patient health and quality of life. Historically, these professions have been independent of each other with defined areas of emphasis, despite the bi-directional relationships between oral and systemic health.[1] However, as patient populations present with multiple comorbidities due to chronic and complex diseases, it is increasingly important for medical and dental disciplines to embrace a collaborative model of health care delivery.

Interprofessional collaborative practice is defined by the World Health Organization as "when multiple health workers from different professional backgrounds work together with patients, families, careers, and communities to deliver the highest quality of care."[2] This approach increases efficiency, reduces costs, and improves patient health outcomes.[3,4] A centralized and collaborative practice approach could mitigate challenges of access to care and optimize disease management with fewer appointments.[5] Furthermore, the literature shows patient health outcomes are negatively affected by the failure of health care professionals to communicate and work together.[6-8]

Preparation for this type of health care delivery should begin with collaborative competencies developed by intentional curriculum and purposeful training of students across a range of health sciences educational programs.[9]

Interprofessional education (IPE) is when two or more students from different occupations learn with, about, and from each other to improve health outcomes.[2] Inclusion of interprofessional education can transform outdated, static curriculum of health professional education and equip graduates for collaborative practice delivery models.[10]

In 2001, the Institute of Medicine (IOM) published a report urging interprofessional education and evidence-based decision making to be incorporated in the curriculum for health professional students.[11] Since that time, the Interprofessional Education Collaborative Board published the Core Competencies for Interprofessional Collaborative Practice document for the purposes of guiding curriculum development for health professions education and improving health outcomes of patients.[12] The core competencies consist of four categories: values/ethics for interprofessional practice (IP), roles/responsibilities (RR), interprofessional communication (CC), and teams and teamwork (TT).[12] The American Dental Association's Commission of Dental Accreditation (CODA) which sets standards for dental hygiene edu-cation programs cites the need for IPE curriculum in standard 2-15: "Graduates must be competent in communicating and collaborating with other members of the healthcare team to support comprehensive patient care."[13]

However, the implementation of patient-centered IPE experiences in health science academic institutions has been found to be slow and inadequate.[14] Furthermore, most IPE research has focused on nurses and physicians, while excluding other heath science disciplines.[15] Since this area of research has not been fully explored, there is a lack of literature available for allied health educators to utilize when deciding on educational best practices for designing and implementing IPE curricula.

Surveys of United States (US) dental hygiene program directors have identified the overall value placed on IPE, how it has been implemented into academia, and barriers to implementation. In 2015, 59% of surveyed dental hygiene program directors reported IPE was a priority, but curriculum overload (76%) and scheduling (92%) were cited as barriers to implementation.[16] Subsequently in 2017, program directors reported curriculum overload (76%), faculty calibration (48%), and outcomes assessments (32%) as barriers.[17] A survey revealed interprofessional pedagogy was viewed positively by Northeastern US dental hygiene program directors; however, 72% reported IPE was not in the curriculum or only in the beginning stages of implementation.[18] More recently, Tolle et al. surveyed US dental hygiene program directors in 2019 and found 73% had positive attitudes toward IPE, but time constraints was the top barrier to implementation.[19]

A wide range of health care professional students have been studied for self-perceived changes in competencies following IPE experiences using the Interprofessional Collaborative Competencies Attainment Survey (ICCAS).[20-23] Haber et al. surveyed nurse practitioner, medical, and dental students using the ICCAS before and after an IPE case study and clinical simulation and identified a statistically significant increase in overall mean scores for perceived collaborative competencies from pre- to post-tests.[21] Likewise, in studies which surveyed medical students in IPE experiences with pharmacy, occupational therapy, and physical therapy students found there was a statistically significant increase from pre-test to post-test scores on all 20 ICCAS items indicating increased self-perceived collaborative competencies as a result of single-encounter IPE experiences.[20,22,23]

Interprofessional education studies of dental hygiene students have been reported and measured with a variety of research designs and instruments. Allen et al. conducted a qualitative study of dental hygiene students who wrote reflection papers upon completion of a service-learning activity with nursing students and the results indicated learning was reinforced in the RR category.[24] McGregor et al. conducted a retrospective pre-test/post-test of students from dental hygiene, dentistry, nursing, occupational therapy, pharmacy, and physical therapy (n=300) who completed a one-hour course about IPEC core competencies.[25] Results from the Student Perceptions of Interprofessional Clinical Education survey demonstrated statistically significant increases in students' positive impressions of IPE following the course.[25] Coan et al. used the ICCAS survey to study nursing and dental hygiene students after an IPE experience with hospital patients and found significant increases in perceived development of interprofessional competencies among all students.[26] Infante et al. utilized a researcher-designed pre-test/post-test survey for nursing, dentistry, dental hygiene, and medical students who participated in IPE to create personalized health plans for homeless people and identified increases in confidence in completing IPE tasks with patients and understanding training of other disciplines when comparing survey scores.[27] Despite variations in IPE experiences and research design among these studies, positive changes occurred in the dental hygiene students' reinforcement of IPEC competencies,[24] their view of IPE,[25] development of interprofessional competencies,[26] and confidence with IPE tasks.[27]

Interprofessional education experiences can range from didactic theoretical classroom presentations, case studies and simulations to real-time experiences. The purpose of this pilot study was to evaluate changes in self-perceived collaborative competencies of dental hygiene and medical

students after a single-encounter IPE experience during live patient care in a dental hygiene care clinic at one university. More specifically, the perceived collaborative competencies in the areas of communication, collaboration, roles and responsibilities, collaborative patient-centered approach, conflict management/resolution, and team functioning of dental hygiene and medical students were assessed.

Methods

This study was granted exempt status from the Old Dominion University (ODU) Institutional Review Board. Senior students from the ODU entry-level bachelor's degree dental hygiene program and third- and fourth-year students from the Eastern Virginia Medical School were invited by email to participate in a live patient IPE experience at an on-campus dental hygiene care facility, at an appointed time over the course of one year. Prior to the IPE experience, the medical students were given policies and procedures for the dental hygiene facility and a list of evidenced-based readings on oral-systemic links.

Each medical student was paired with a senior dental hygiene student during the provision of clinical care to an adult patient. Medical students observed dental hygiene care delivery and engaged in unscripted open verbal dialogue with their dental hygiene student partner during the live patient appointments consisting of various phases of the dental hygiene process of care. For example, medical students observed dental hygiene students as they conducted medical/dental history interviews, extra/intra oral examinations, periodontal assessments, nonsurgical periodontal therapy, and provision of patient education that included evidence-based care and considerations for oral-systemic links.

Dental hygiene and medical student participants were asked to complete the Interprofessional Collaborative Competencies Attainment Survey (ICCAS) to assess changes in perceived collaborative competencies following the IPE experience. The IPE experience was not assessed for academic grading purposes but counted towards community engagement curriculum requirements.

Survey instrument

The ICCAS is a 20-item self-assessment survey based on "six core collaboration competencies: communication, collaboration, roles and responsibilities, collaborative patient/family-centered approach, conflict management/resolution, and team functioning."[28] Each of the retrospective pre- and post-test items are answered on a seven-point Likert scale with 1=strongly disagree, 7=strongly agree, and a "not applicable" option. The survey prompts participants to retrospectively reflect on their current and prior self-perceived collaborative competence following an IPE experience.[29] The expectation of this retrospective research design is that learners will better understand slight differences in perceived competencies and be able to better rate their prior competency abilities following the IPE experience.[28] The ICCAS is a valid and reliable survey, with Cronbach's alpha scores for all 20 pre- and post-test items reported as 0.94-0.97 and 0.95-0.98 respectively.[29-31]

Participants were given the paper ICCAS survey immediately following the IPE experience. Participants were provided a cover letter and informed that participation was voluntary and consent was implied by completing and returning the survey. Responses were kept anonymous by using a participant-created unique identifier number. Statistical analysis included demographic descriptors, paired samples t-tests, and Cohen's d effect scores. Cohen's d effect sizes were calculated for each pair as the *t* statistic divided by the square root of the sample size; adjustments were made to reflect missing values. Effect sizes were interpreted as "large" for differences greater than 0.8, "moderate" for those between 0.79 and 0.50, and "small" as those less than 0.5.[32] Statistical significance was set at alpha ≤ 0.05.

Results

A total of 26 medical students and 23 dental hygiene students participated in a single-encounter live patient IPE experience and retrospectively completed the pre- and post-test ICCAS survey based on the IPE experience. All participants (n=49) completed the IPE experience and survey for a response rate of 100%. Three dental hygiene students collaborated with medical students twice during two different dental hygiene appointments but completed the survey following the first encounter only. Data revealed all dental hygiene participants were female (n=23, 100%) and most medical students were male (n=18, 69%). The majority of participants were between the ages of 25 – 34 years (n=32, 65%). When asked if they had previously participated in an interprofessional learning experience, 73.4% (n=36) reported 1-2 events, 14.3% (n=7) reported 3-4 events, 8.2% (n=4) reported 5 or more events, and 4.1% (n=2) reported they had not. Demographic data are shown in Table I.

Dental hygiene and medical student participants combined

Calculated mean scores for all participants (n=49) showed ICCAS item pre-test responses ranged from M=5.40, SD=.46 to M=6.31, SD=1.23 and post-test responses ranged from M=6.09, SD=.46 to M=6.72, SD= .86. A paired samples t-test compared pre-test and post-test mean scores and revealed participants increased in paired mean differences

Table I. Participant demographics (n=49)

Characteristics	n (%)
Discipline and Gender	
Medical student	26 (53.0)
Male	18 (69.0)
Female	8 (31.0)
Dental hygiene student	23 (46.9)
Male	-
Female	23 (100.0)
Age (all participants)	
18-24	16 (32.7)
25-34	32 (65.3)
35-44	1 (2.0)
Previous IPE experiences	
Medical students	
0	1 (3.8)
1-2	18 (69.2)
3-4	3 (11.5)
5 or more	4 (15.4)
Dental hygiene students	
0	1 (4.3)
1-2	18 (78.3)
3-4	4 (17.4)
5 or more	-

for each of the 20 items following the IPE experience, ranging from .340 to .809 showing students self-reported their perceived collaborative competence as having increased as a result of participation. Based on two-tailed paired samples t-tests, all paired item mean score differences were statistically significant ($p \leq .05$) showing increases in self-reported perceived collaborative competency because of the IPE experience. The pre-and post-test ICCAS items, paired samples t-test results and *p*-values for all participants are shown in Table II. Cohen's *d* effect sizes were large for five paired items (d=0.80 to d=0.94) and moderate for fifteen paired items (d=0.54 to d=0.77) from the ICCAS survey and are shown in Table III.

Table II. Paired mean differences and *p*-values for ICCAS items (all participants, n=49)

Pre-test and post-test ICCAS Items	Paired mean differences*	p-values** (2-tailed)
Promote effective communication among members of an IP team	.735	.000
Actively listen to IP team members' ideas and concerns	.408	.000
Express my ideas and concerns without being judgmental	.408	.000
Provide constructive feedback to IP team members	.489	.000
Express my ideas and concerns in a clear, concise manner	.408	.000
Seek out IP team members to address issues	.809	.000
Work effectively with IP team members to enhance care	.625	.000
Learn with, from and about IP team members to enhance care	.681	.000
Identify and describe my abilities and contributions to the IP team	.531	.000
Be accountable for my contributions to the IP team	.429	.000
Understand the abilities and contributions of IP team members	.694	.000
Recognize how others' skills and knowledge complement and overlap with my own	.574	.000
Use an IP team approach with the patient to assess the health situation	.638	.000
Use an IP team approach with the patient to provide whole person care	.717	.000
Include the patient/family in decision-making	.340	.001
Actively listen to the perspectives of IP team members	.447	.000
Take into account the ideas of IP team members	.426	.000
Address team conflict in a respectful manner	.381	.001
Develop an effective care plan with IP team members	.604	.000
Negotiate responsibilities within overlapping scopes of practice	.532	.000

*Paired differences calculations based on "before" responses subtracted from "after" responses (post-test > pretest).

***p*-value significant at ≤.05

Table III. Cohen's d effect sizes and differences for ICCAS items (all participants, n=49)

Constructs	ICCAS item	Cohen's d scores	Differences
Communication	1. Promote effective communication among members of an IP team		Large
	2. Actively listen to IP team members' ideas and concerns	0.61	Moderate
	3. Express my ideas and concerns without being judgmental	0.61	Moderate
	4. Provide constructive feedback to IP team members	0.75*	Moderate
	5. Express my ideas and concerns in a clear, concise manner	0.56	Moderate
Collaboration	6. Seek out IP team members to address issues	0.88*	Large
	7. Work effectively with IP team members to enhance care	0.77*	Moderate
	8. Learn with, from and about IP team members to enhance care	0.69*	Moderate
Roles and Responsibilities	9. Identify and describe my abilities and contributions to the IP team	0.63	Moderate
	10. Be accountable for my contributions to the IP team	0.63	Moderate
	11. Understand the abilities and contributions of IP team members	0.94	Large
	12. Recognize how others' skills and knowledge complement and overlap with my own	0.80*	Large
Collaborative Patient/Family-centered approach	13. Use an IP team approach with the patient to assess the health situation	0.73*	Moderate
	14. Use an IP team approach with the patient to provide whole person care	0.71*	Moderate
	15. Include the patient/family in decision-making	0.54*	Moderate
Conflict management/ resolution	16. Actively listen to the perspectives of IP team members	0.68*	Moderate
	17. Take into account the ideas of IP team members	0.65*	Moderate
	18. Address team conflict in a respectful manner	0.58*	Moderate
Team Functioning	19. Develop an effective care plan with IP team members	0.85*	Large
	20. Negotiate responsibilities within overlapping scopes of practice	0.74*	Moderate

*Survey items left blank by participants and "N/A" responses were considered as missing values and not counted in the sample size for calculations.

Dental hygiene student participants

Self-reported pre-test mean scores for dental hygiene students revealed their lowest score (M=5.36) was for item six, which asked about perceived ability to seek out IP team members to address issues in the collaboration core competency area. Scores were highest (M=6.55) for item 16 which asked about perceived ability to actively listen to perspectives of IP team members in the conflict management/ resolution competency area. After the IPE experience, their lowest mean score (M=6.27) was for item four which asked about perceived ability to provide constructive feedback to IP team members in the communication competency area and the highest (M=6.86) occurred for items 16-17 in the conflict management/resolution competency area. The largest mean increase for a paired item among dental hygiene students was .913 for item one, which asked participants about their ability to promote effective communication among members of an interprofessional team. The smallest mean increase for a paired item was .261 for item three which asked participants about their ability to express their own ideas and concerns without being judgmental.

Among dental hygiene student participants, all 20 paired item competencies mean score increases were statistically significant with alpha scores ≤ 0.05; four had large effect sizes (d=0.96 to d=0.81), fifteen were moderate (d=0.53 to d=0.78), and one was small (d=0.48). For dental hygiene participants, large effect sizes were found in four domains: communication, collaboration, roles and responsibilities, and team functioning. The communication domain had one small effect size for dental hygiene student participants. Paired sample t-test results of mean scores before and after the IPE experience and paired mean differences of dental hygiene student participants are shown in Table IV.

Table IV. Paired sample t-test results of mean scores before and after the IPE experience and paired mean differences[**]

	Dental hygiene students				Medical students			
ICCAS items and constructs	**Mean before**	**Mean after**	**Paired mean differences**	**p-values (2-tailed)**	**Mean before**	**Mean after**	**Paired mean differences**	**p-values (2-tailed)**
Communication								
1	5.65	6.57	.913	.000*[a]	5.81	6.38	.577	.001*[b]
2	6.48	6.83	.348	.008*[b]	6.15	6.62	.462	.005*[b]
3	6.48	6.74	.261	.030*[c]	5.96	6.50	.538	.001*[b]
4	5.77	6.27	.500	.002*[b]	5.44	5.92	.480	.001*[b]
5	6.00	6.48	.478	.018*[b]	5.88	6.23	.346	.004*[b]
Collaboration								
6	5.36	6.23	.864	.001*[a]	5.44	6.20	.760	.000*[a]
7	5.95	6.59	.636	.003*[b]	5.85	6.46	.615	.000*[a]
8	5.77	6.59	.818	.004*[b]	5.88	6.44	.560	.001*[b]
Roles and responsibilities								
9	5.87	6.39	.522	.011*[b]	5.69	6.23	.538	.002*[b]
10	6.04	6.61	.565	.001*[b]	6.00	6.31	.308	.018*[b]
11	6.13	6.70	.565	.000*[a]	5.58	6.38	.808	.000*[a]
12	6.00	6.48	.478	.002*[b]	5.67	6.33	.667	.000*[a]
Collaborative Patient/Family-centered approach								
13	5.57	6.38	.810	.003*[b]	5.69	6.19	.500	.001*[b]
14	5.65	6.40	.750	.005*[b]	5.73	6.42	.692	.001*[b]
15	5.86	6.45	.591	.002*[b]	6.20	6.32	.120	.083[c]
Conflict management/resolution								
16	6.55	6.86	.318	.005*[b]	6.04	6.60	.560	.001*[b]
17	6.45	6.86	.409	.004*[b]	6.12	6.56	.440	.005*[b]
18	6.42	6.84	.421	.007*[b]	6.04	6.39	.348	.029*[c]
Team functioning								
19	5.77	6.41	.636	.001*[a]	5.69	6.27	.577	.000*[a]
20	5.95	6.55	.591	.002*[b]	5.44	5.92	.480	.001*[b]

**Paired differences calculations were based on "before" responses subtracted from "after" responses (post-test > retrospective pre-test).

Cohen's d effect sizes values are denoted as: [a] "Large," [b] "Moderate," [c] "Small"

**p*-value significant at ≤.05

Medical student participants

Self-reported pre-test mean scores for medical student participants revealed their lowest score (*M*=5.44) was for the items on providing constructive feedback (item 4), seeking out team members to address issues (item 6), and negotiating overlapping responsibilities (item 20); all from the communication, collaboration, and team functioning core competency areas. Medical student participant pre-test mean scores were highest (*M*=6.20) for their responses regarding perceived ability to include the patient/family in decision-making (item 15) from the collaborative patient/family-centered approach competency area.

Following the IPE experience, medical students had the lowest mean scores (*M*=5.92) for items in the communication

and core competency areas, while they scored highest (M=6.20) for perceived ability to include the patient/family in decision making (item 15). The largest mean increase (.808) was for the paired item 11 which asked about perceived ability to understand the abilities and contributions of IPE team members. The smallest mean increase (.120) was for the paired item 15 which asked about perceived ability to include patient/family in decision-making. Among medical student participants, all paired item mean score increases were statistically significant, except for one paired item (number 15, p=.083). Of the nineteen statistically significant paired items, five had large effect sizes (d=0.82 to d=1.01), thirteen were moderate (d=0.50 to d=0.77), and one was small (d=0.49). Large effect sizes were found in three domains: collaboration, roles and responsibilities, and team functioning, one small effect size was found in the conflict management/resolution domain. Paired sample t-test results of mean scores before and after the IPE experience and paired mean differences for medical student participants are shown in Table IV.

Discussion

The importance of interprofessional collaboration is well documented in the literature[6-8] and IPE learning experiences have been recognized as important for incorporation into all dental hygiene educational programs in accreditation standards.[13] There are numerous ways to design IPE experiences including case studies, classes, simulation, and/or live patient care; each potentially resulting in increased collaborative competence for participants. Assessing the changes in student perceived collaborative competence resulting from live patient experiences similar to the current study is needed to assist educators with the implementation of effective IPE curriculum. It is critical for all dental hygiene educational programs to incorporate IPE into the curriculum and one strategy may be collaboration with other neighboring health care education programs to create IPE experiences to increase collaborative competencies across disciplines.

Dental hygiene student participants in the current study demonstrated statistically significant increases between mean retrospective pre-test and post-test scores in each of the 20 items on the ICCAS. Similarly, Coan et al. found statistically significant increases among dental hygiene students for 80% of the ICCAS items.[26] Three other dental hygiene student IPE studies found increases in collaborative competencies and their perceptions of IPE; however, making comparisons is difficult due to variations of the research design and instruments.[24,25,27] Generally, data from the current study and others suggest students may have positive increases in their perceptions of collaborative competency outcomes as a result of IPE experiences with other healthcare students; supporting the idea that IPE helps meet the ADA CODA accreditation standard 2-15 for communication and collaboration competence with other healthcare team members.[13] These findings support the implementation of IPE into dental hygiene curricula to prepare students for establishing effective work rapport with other health care providers after graduation.

The effect size of paired ICCAS items among dental hygiene students in the current study and participants in the study by Coan et al. were compared. In the current study, large effect sizes were found for the following paired items: promoting communication among team members (item 1), seeking team members to address issues (item 6), understanding abilities and contributions of team members (item 11), and developing effective care plan with team members (item 19) among dental hygiene participants. Coan et al. found 17 of the ICCAS items had large effect sizes for dental hygiene participants which included the same items found in this study.[26] In contrast, paired item three, "express my ideas and concerns without being judgmental," was the only item with a small effect size in this study, whereas Coan et al. did not find any small effects.[26] It is not clear why dental hygiene participants in the current study had a small effect size for this particular item; however, their overall agreement for perceived ability to express their own ideas and concerns without being judgmental increased after the IPE experience.

In the current study, there was a statistically significant increase in self-perceived collaborative competence for medical student participants in 19 (95%) ICCAS items which is similar to results of several other studies.[20-23] Nagge et al. found 95% of ICCAS items were statistically significant among medical student participants.[20] While MacKenzie et al. and Wheeler et al. did not separate their data to look at medical student participants alone, results of their study showed a statistically significant increase between pre-test and post-test scores for 100% of the ICCAS items in a mixed group of participants.[22,23] Data from the current study and others suggests medical students demonstrate benefits from IPE with students from other health care disciplines.

Effect sizes of paired ICCAS items among medical student participants of this study and research by Nagge et al. were compared. Results from both studies revealed large effect sizes for seeking team members to address issues (item 6) working effectively with members to improve care (item 7), understanding abilities and contributions of team members (item11), and recognizing how others' skills and knowledge complement my own (item 12).[20] Additionally, there was a large effect for develop effective care plan with team members

(item 19) in the current study among the medical student participants. In contrast, paired items, addressing conflict in respectful manner (item 18) and including patient/family member in decision-making (item 15), were the only ones with small effect sizes among medical student participants in both studies.[20] There may have been a small effect size for addressing conflict in respectful manner among medical student participants in the current study due to a lack of conflict during the IPE experience since the design of this activity did not include a problem-based scenario that would require conflict resolution. Medical students likely did not perceive a change in their ability to handle team conflict since this was not a challenged aspect for them in the IPE experience.

Results from this study showed a statistically significant increase in self-perceived collaborative competence among all participants in each of the ICCAS items, with the exception of the paired item regarding including patient/family members in decision-making (item 15) for the medical student participants. Similarly, Coan et al. who studied dental hygiene and nursing students, and Nagge at al. who studied medical and pharmacy students, also found this item regarding the inclusion of a patient/family member in decision-making did not have a statistically significant difference between mean pre-test and post-test scores for participants.[20,26] During the live patient IPE experience for this study, most medical student participants did not interact with patient family members since patients often came to the appointment alone, which may explain why there was not a significant increase from pre-test to post-test scores.

The effect sizes of paired ICCAS items among all participants of the current study and all participants in similar IPE studies utilizing the ICCAS were compared. In the current study, each item had moderate or large effect sizes when responses from all participants were combined. This is promising and reinforces the hypothesis that the change effect was not likely the result of chance alone. In the current study, large effect sizes were found among all participants for paired items including promote effective communication among team members (item 1), seeking out team members to address issues (item 6), understanding the abilities and contributions of team members (item 11), and recognizing how others' skills and knowledge complement my own (item 12). Similarly, large effect sizes were found in other studies using the ICCAS for item one,[20,22] item six,[20,22,23] item eleven,[20,23] and item twelve.[20,22,23] These findings indicate that the perceived collaborative competencies in the domains of communication, collaboration, and roles and responsibilities were most affected by the IPE experience.

Paired ICCAS items, seeking out team members to address issues (item 6), and understanding abilities and contributions of team members (item 11), and developing effective care plan with team members (item 19) revealed statistically significant large effect sizes among both dental hygiene and medical students indicating an increase of self-perceived competence for those areas. It is important for health care providers to collaborate with the common goal of optimizing health and quality of life for mutual patients. Increases in self-perceived competence for seeking out other team members is promising and indicates that these future professionals are likely to recognize the value of specialized expertise held by other health care providers and request collaborative assistance to best address oral-systemic health concerns. Large effect sizes for seeking out team members to address issues (item 6), understanding abilities and contributions of team members (item 11), and developing effective care plan with team members (item 19) indicates both professions mutually benefitted from working together. In consideration of best practice standards, intentional curricula planning for future IPE experiences could positively impact health care students when these competencies are taught collaboratively.

The current study found no small effect sizes when the data from all participants was combined, similar to the findings of MacKenzie et al.[20] and Nagge et al.[22] In contrast, Wheeler at al. found small effect sizes for eight ICCAS items; however, the IPE activity was focused on the roles and responsibilities domain which may explain why several small effect sizes were found in other domains.[23]

Results from this study suggest a single-encounter live patient collaborative experience contributed to a positive perception of collaborative competencies for medical and dental hygiene students. A benefit of collaborating during time already devoted to patient care may help avoid a barrier identified by Furgeson et al., that scheduling time within the curriculum for IPE can be challenging.[16] Inviting medical students to participate during live patient care allowed this IPE experience to count towards community engagement curriculum requirements without impinging on didactic classroom time. Likewise, this IPE experience did not require students to devote time to extra assignments in addition to what was already required in their respective programs; thereby avoiding the curriculum overload barrier cited by Furgeson et al.[16] Live patient care IPE experiences may have a positive impact without requiring major expenditures of time and effort by already taxed faculty and students. Considering there was a low investment of time and preparation, the favorable outcome resulting from this experience is promising as a way to facilitate collaborative competence.

Dental hygiene student IPE research has been conducted with a variety of experiences and instruments making it difficult to compare and synthesize results. Future research utilizing validated instruments like the ICCAS would help fill a gap in the literature by making it feasible to compare results and extract meaningful conclusions. Future research should include live patient IPE experiences inclusive of the four core competency domains and all phases of the dental hygiene process of care.

This study had limitations. Participants consisted of a convenience sample of medical and dental hygiene students from one metropolitan area and therefore results are not generalizable to other populations. The retrospective pre-test/post-test survey design may contribute to recall bias in participants. The survey design did not allow participants to elaborate on their ICAAS scoring process, which may have given valuable insight to better understand the paired mean increases. Additionally, paired students collaborated during different phases of the dental hygiene process of care which may have affected how certain ICCAS items were scored. The IPE experience was not designed to intentionally challenge perceived competency in conflict and collaboration with family members. It is possible that in some patient cases, these competency areas may have arisen in conversation between paired students in an inherent way, but this aspect was not ensured and if these had been purposefully built into the experience, the outcome scores may have been different.

Conclusion

A live patient care IPE experience increased perceived collaborative competence among dental hygiene and medical student participants. Including IPE experiences during scheduled clinical time periods may help overcome obstacles such as timing and curriculum rigor constraints, since no didactic class time is required. Dental hygiene curricula should include IPE experiences that incorporate live patient collaborations as an effective method to foster students' perceived collaborative competence and future interprofessional collaboration in the workplace.

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Psychological Effects of Sharps Injuries on Students, Faculty and Staff in a Dental School Setting

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Abstract

Purpose: Dental health care professionals (DHCP) are routinely exposed to occupational hazards, such as sharps, putting them at risk of exposure to blood borne pathogens in addition to experiencing psychological effects post-injury. The purpose of this study was to investigate the psychological effects of sharps injuries for students, faculty, and staff at the University of Minnesota School of Dentistry (UMN SOD).

Methods: A mixed-mode, electronic and paper, research design was used for the 51-item survey. Participants were recruited from the UMN SOD and included students, faculty, and staff. The survey consisted of items from the Perceived Stress Scale (PSS-10) and Modified Patient Health Questionnaire (PHQ-9). Scores were compared between participants who had and those who had not experienced a sharps injury in the past year.

Results: A total of 262 surveys were included in the statistical analysis for a 23.5% response rate. Fifty-six participants (21%) self-reported a sharps injury within the past year. Of those respondents, over half (67%) reported experiencing feelings of anxiety and increased stress (50%) while waiting for blood test results.

Conclusion: A majority of participants who reported a sharps injury felt anxious and/or stressed during the month following the injury. While participants may have experienced overall increased stress and anxiety, these findings were not statistically significant. Further research is needed to assess the psychological effects of sharp injuries in DHCPs.

Keywords: dental health care professionals, sharps injuries, percutaneous injuries, blood borne pathogens, occupational stress

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Introduction

Health care workers (HCW), including dental health care professionals (DHCP), are exposed to sharps injuries, however, the exact incidence is unknown due to underreporting.[1,2] Sharps injuries place DHCPs at risk of acquiring blood borne infections including hepatitis B and C, and human immunodeficiency virus.[3] Even in instances where blood borne pathogens are not acquired, studies have found that HCWs may experience psychological effects following sharps injuries.[4,5] Sohn found significantly higher HAM-A (Hamilton Anxiety Scale) and BDI (Beck Depression Inventory) scores among HCWs with experience of a sharps injury as compared to those with no experience of a sharps injury.[1]

Psychological effects experienced by HCWs post sharps injury may also impact work attendance and family relationships.[4] Research by Jeong et al. revealed that following a sharps injury, participants stated that it would be difficult to continue work in a dangerous environment.[3] Another study found that despite no seroconversion, participants experienced anxiety and/or stress disorders, which necessitated a prolonged leave of absence.[5] Regarding family relationships, Gershon et al. found that HCWs may feel the need to alter their sexual practices post sharps injury as a means to reduce their partner's risk of infection presenting challenges for couples who want to start a family.[6]

The occupational hazard of sharps injuries has been recognized in the literature, but there is a gap in the literature regarding the psychological effects of such injuries[1,4] particularly among DHCPs. The purpose of this study was

to investigate the psychological effects, specifically stress and depression, of sharps injuries for students, faculty, and staff in a dental school setting.

Methods

This study was approved by the University of Minnesota (UMN) Institutional Review Board (STUDY00006142) and took place from May to December 2019. A cross-sectional, descriptive, mixed mode survey design was used to investigate the psychological effects of sharps injuries. A convenience sample of UMN School of Dentistry (SOD) faculty, staff, and students (residents, dental, dental hygiene, and dental hygiene/dental therapy) with UMN emails, received an electronic survey (n=1,113). Students, staff, and faculty who worked and/or attended classes at the UMN SOD met the study inclusion criteria. Survey respondents who indicated never working with sharps in their role at the UMN SOD were excluded from the study and further data analysis.

Participants were provided a cover letter describing the study and consent form prior to beginning the survey. Follow-up emails were sent to all non-responders after two weeks. To increase the response rate, paper surveys were provided to faculty within the UMN SOD to distribute to dental, dental hygiene students and specialty residents. A lead dental assistant distributed paper surveys to staff. Participants were asked not to complete a paper survey if they had already responded to the electronic survey. Participants were given the opportunity to enter their name and email for a change to receive one of the ten $40 Target gift card incentives. At the end of the survey, participants were provided with information on the mental health resources available at UMN. Participants could use those resources to self-refer if they felt as though they needed psychological support due to a sharps injury.

Survey instrument

The survey consisted of 51 items including demographic questions, background questions, the Perceived Stress Scale (PSS-10) and Patient Health Questionnaire (PHQ-9). The PSS-10 and PHQ-9 were chosen because they have been used extensively in the literature, have established reliability and validity, and are easy to administer.[7] Both scales consist of ten Likert-type response questions with a total score range of 0-40 for the PSS-10 and a range of 0-27 for the PHQ-9. A PSS-10 score of 0-13 indicates low stress, 14-26 moderate stress, and 27-40 high stress. A PHQ-9 score of 0-4 indicates minimal depression, 5-9 mild depression, 10-14 moderate depression, 15-19 moderately severe depression, and 20-27 severe depression. There were 21 multiple choice background items, which inquired about experience of a sharps injury in the past year (if any). If a participant selected that they never work with sharps in their role, they skipped to the end of the survey and their data was excluded from analysis. The survey took an estimated 10-15 minutes to complete.

The survey was piloted among 16 faculty and staff at the UMN SOD. Minor revisions were made to the PHQ-9 to insert "in the last month…" rather than "over the last 2 weeks…" for consistency with the PSS-10 timeframe. One item on the PHQ-9 was modified from "In the last month, how often have you been bothered by thoughts that you would be better off dead or of hurting yourself in some way" to "in the last month, how often have you been bothered by thoughts of hurting yourself in some way." Cronbach's alpha was utilized to determine the internal consistency of the PHQ-9 due to the modification. The Cronbach's alpha score for the first 9 questions of the PHQ-9 was 0.83, which is considered to be strong internal consistency and it can be assumed that the reliability of the PHQ-9 was not affected by the modification.

Data analysis

Demographics, self-reported experience with a sharps injury, stress scores measured by the PSS-10, and the depression score measured by the modified PHQ-9 were analyzed. To test whether there was a difference between mean PSS-10 scores among participants who had experienced a sharps injury and those who had not, a Poisson generalized linear model with robust standard errors using the outcome of PSS-10 score and primary predictor of sharps injury status, with adjustment for the potential confounders of academic status (i.e., student/resident, staff, or faculty) and age, was used. An analogous model was fit to test whether there was a difference in the mean modified PHQ-9 depression scores among participants who had experienced a sharps injury, as compared to those who had not. Both models were also fit with further adjustment for self-reported depression status. For all models, the estimated mean difference in scores (stress or depression) between those who had, versus those who had not experienced a sharps injury, was reported with a 95% confidence interval (CI) (.05 alpha).

Results

Out of 1,113 surveys distributed (electronic and paper) 319 surveys were returned Thirty-four were excluded from analysis as the participant indicated never working with sharps as part of their work role and six participants responded to both the paper and electronic survey. Of the duplicates, only the most recent responses were included in statistical analysis. Another 17 surveys were excluded due to missing data on the

outcomes of interest (PSS-10 and/or modified PHQ-9) leaving a total of 262 participants who met the inclusion criteria for a 23.5% response rate.

Sample characteristics

The majority of study participants were students (66%), female (69%), single (57%), and Caucasian (84%). Over one-third of the participants reported that the risk of experiencing a sharps injury is worrisome (40%). The majority of participants were familiar with the UMN SOD sharps injury reporting protocol (86%) and nearly all participants self-reported having received the hepatitis B vaccine (99%). Fifty-six (21%) of the respondents experiencing a sharps injury within the past year. Students reported the majority of the sharps injuries (82%) as compared to faculty (7%) and staff (11%). Within the student population, third year dental students were the group with the highest proportion (29%) of sharps injury experience. Sample demographics are shown in Table I.

Characteristics of sharps injuries

Most participants (80%) who reported sharps injuries indicated working with sharps 4 to 7 times per week with 69% experiencing one injury over the past 12 months. Participants indicated that their injuries were due to a lack of concentration (41%), feeling rushed (39%), and a stressful environment (27%). Not all sharps injuries were caused by needle sticks. Other dental instruments, including burs and explorers, accounted for the most injuries (46%), followed by scalpel (27%), needles (21%), and ultrasonic tips (5%). Sixteen percent of the participants indicated that their injury occurred in a preclinical and/or laboratory situation. The majority of participants felt that their most recent sharps injury was avoidable (90%) and

Table I. Sample characteristics and attitudes (n=262)

	No sharps injury* (n=206)	Sharps injury* (n-56)	Total* (n=262)
	n (%)	n (%)	n (%)
Role			
Students	126 (61)	46 (82)	172 (66)
First year dental students	17 (8)	6 (11)	23 (9)
Second year dental students	14 (7)	8 (14)	22 (8)
Third year dental students	21 (10)	16 (29)	37 (14)
Fourth year dental students	23 (11)	4 (7)	27 (10)
First year dental hygiene students	17 (8)	4 (7)	21 (8)
Second year dental hygiene students	11 (5)	0 (0)	11 (4)
First year dual degree students	3 (1)	2 (4)	5 (2)
Second year dual degree students	3 (1)	2 (4)	5 (2)
Other	2 (1)	1 (2)	3 (1)
Resident	15 (7)	3 (5)	18 (7)
Staff	38 (18)	6 (11)	44 (17)
Faculty	42 (20)	4 (7)	46 (18)
Age*	28 (25, 43)	26 (24, 30)	27 (25, 37)
Female	144 (70)	36 (64)	180 (69)
Marital status			
Married	86 (42)	11 (20)	97 (38)
Widowed	3 (2)	0 (0)	3 (1)
Divorced	9 (4)	0 (0)	9 (4)
Single	105 (52)	44 (80)	149 (57)
Latino origin	9 (4)	1 (2)	10 (4)
Race†			
Caucasian	173 (86)	47 (87)	220 (84)
African American	7 (4)	2 (3.7)	9 (3)
American Indian or Alaskan native	4 (2)	0 (0)	4 (2)
Asian	20 (10)	6 (11)	26 (10)
Other	8 (4)	1 (2)	9 (3)
Received Hepatitis B vaccine	191 (98)	54 (100)	245 (99)
Risk of sharps injury is worrying	75 (36)	31 (55)	106 (40)
Familiar with sharps injury reporting protocol	177 (86)	49 (88)	226 (86)

* Summaries are median (first quartile, third quartile) or n (percent) where percent is of non-missing data.

† Respondents were able to select more than one category.

indicated that they were familiar with the UMN SOD sharps reporting protocol (88%). However, less than half reported their sharps injury after it occurred (39%). Fifty-three percent self-reported that their reason for not reporting was that the "infection risk was low". One participant stated that they did not report their most recent injury because they were treated poorly by staff after reporting their first injury and decided that it was not worth the trouble to report sharps injuries.

Following their most recent sharps injury, over half of the respondents (67%) reported feeling anxious and/or stressed in the month following the injury. Of those who reported their sharps injury, the majority felt anxious (67%) and stressed (50%) while waiting for blood test results. However, the majority (82%) felt as though they received adequate support, and they did not feel that their injury negatively impacted personal relationships (96%) or career satisfaction (91%). Characteristics of reported sharps injuries are shown in Table II.

PSS-10 (stress) and modified PHQ-9 (depression) scores

The mean PSS-10 (stress) score for participants who had experienced a sharps injury in the past year was 15 (moderate stress levels), compared to a mean score of 13 (low stress levels) for participants who had not experienced an injury. After adjusting for academic status and age, participants with a sharps injury in the past year had a mean PSS-10 score that was 5.8% higher than participants without a sharps injury (95% CI: 9.1% lower to 23% higher; p=0.46). Participants who had experienced a sharps injury in the past year had a mean modified PHQ-9 (depression) score of 4.2, indicative of minimal to mild depression compared to a mean score of 3.7 (minimal depression) for participants who had not experienced a sharps injury. After adjusting for academic status and age, participants who reported a sharps injury in the past year had a mean modified PHQ-9 score that was 6.3% higher than participants without a sharps injury (95% CI: 19% lower to 40% higher; p=0.66). PSS-10 (stress) and modified PHQ-9 (depression) scores are shown in Table III.

After adjusting for self-reported depression status, participants with a sharps injury had mean PSS-10 (stress) scores that were 1.2% higher (95% CI: 14% lower to 19% higher; p=0.88) and mean modified PHQ-9 (depression) scores that were 2.7% higher (95% CI: 22% lower to 35% higher; p=0.85) than those without a sharps injury. Although results indicated higher mean PSS-10 (stress) and mean modified PHQ-9 (depression) scores for participants who experienced a sharps injury in the past year, it was not at a level of statistical significance. PSS-10 (stress) and modified PHQ-9 (depression) scores are shown in Table III.

Discussion

This survey assessed the psychological effects, stress and depression, of sharps injuries for students, staff, and faculty at the UMN SOD. While the low response rate hindered the ability detect statistically significant differences in stress and depression scores between students, staff, and faculty who had or had not experienced a sharps injury, there was clinical significance to the findings. Participants who had experienced a sharps injury in the past year reported feelings of anxiousness and/or stress during the month following their injury. Of those who reported their injury after it occurred, the majority felt increased levels of anxiety and stress while waiting for blood test results, which were similar to findings of previous studies.[1,8]

Nearly half of the participants in the current study indicated that the risk of experiencing a sharps injury is a worrisome occupational risk, with females and students identifying this risk more frequently, similar to an international study of Polish health care workers.[9] When looking at the predominately female group of dental hygiene students in this study, there were only 4 sharps injuries reported as compared to 28 who did not report any injuries. Perhaps gender plays a role in this finding. Because women find the risk of experiencing a sharps injury to be worrisome, they may be more careful to prevent these injuries. However, when comparing the participants who had experienced a sharps injury to those who had not, participants who had experienced an injury were more worried about the risk of future injuries. Fear of the possibility of repeated sharps injuries among HCWs has been reported in the literature.[3] Studies have found that HCWs may be even more worried if the sharps injury involved a high-risk patient or if the infection status of the source patient was unknown.[3,10] In this study, three of the participants whose most recent sharps injury involved a high-risk patient all self-reported experiencing anxiety while waiting for blood test results.

In addition to the increased levels of anxiety among HCWs and students regarding the risks associated with a sharps injury, individuals with less experience also report higher incidence of sharps injuries due to lack of inexperience along with multiple encounters with patients.[11] The participants in this study with the highest incidence of sharps injuries were students, with third year dental students reporting the most injuries. Third year dental students are just beginning clinical encounters with patients and may be more prone to sharps injuries due to their lower skills. When comparing first year dental hygiene students to second year dental hygiene students, the first-year students reported four injuries, whereas second year students had none. First year dental hygiene students complete a local anesthesia and pain management

Table II. Characteristics of sharps injury (n=56)

	Sharps injury n (%)
Frequency of sharps use	
Rarely	2 (4.0)
Once per week	3 (5.0)
2-3 times per week	6 (11.0)
4-7 times per week	45 (80.0)
Number of sharps injuries during the past year	
1	38 (69.0)
2	10 (18.0)
3	5 (9.0)
4	-
5	1 (2.0)
>5	1 (2.0)
Timing of most recent sharps injury	
Within the past month	16 (29.0)
Within the past 1-6 months	25 (45.0)
Within the past 6-12 months	14 (25.0)
Feelings during the month following most recent sharps injury*	
Scared	12 (21.0)
Depressed	2 (4.0)
Stressed	16 (29.0)
Anxious	21 (38.0)
Upset	10 (18.0)
Fine	32 (57.0)
Most recent sharps injury negatively impacted personal relationships	
Yes, slightly	2 (4.0)
No	53 (96.0)
Most recent sharps injury decreased career satisfaction	
Yes, slightly	5 (9.0)
No	51 (91.0)
Most recent sharps injury was avoidable	44 (90.0)
Setting or situation of most recent sharps injury	
While setting up/before seating the patient	6 (11.0)
During use of the sharp	25 (45.0)
After use of the sharp	15 (27.0)
Research use	1 (2.0)
During preclinic/lab	9 (16.0)

	Sharps injury n (%)
Cause of most recent sharps injury*	
Unfamiliar technique	13 (23.0)
Patient moved their head/body	4 (7.0)
Injured by a third party (i.e., another provider)	2 (4.0)
Tiredness	3 (5.0)
Lacking concentration	23 (41.0)
Feeling rushed	22 (39.0)
Stressful environment	15 (27.0)
Unsafe instrument placement	10 (18.0)
Accidental	2 (4.0)
Not being careful	1 (2.0)
Other	2 (4.0)
Type of injury for most recent sharps injury	
Needle	12 (21.0)
Scalpel	15 (27.0)
Ultrasonic tip	3 (5.0)
Other dental instrument	26 (46.0)
Most recent sharps injury involved a high-risk patient	3 (6)
Reported most recent sharps injury	22 (39.0)
Received adequate support after reporting**	18 (82.0)
Time to receive blood test results§	
<1 month	17 (94.0)
1-6 months	1 (6.0)
Feelings while waiting for blood test results***	
Scared	5 (28.0)
Depressed	1 (6.0)
Stressed	9 (50.0)
Anxious	12 (67.0)
Upset	3 (17.0)
Fine	5 (28.0)
Reason for not reporting sharps injury**	
Takes too much time	6 (18.0)
Infection risk was low	18 (53.0)
Not familiar with the reporting protocol	4 (12.0)
Other	19 (56.0)

*Respondents were able to select more than one category.

**Respondents who reported

***Respondents who went through blood testing

Table III. PSS-10 (stress) scores and modified PHQ-9 (depression) scores

	No sharps injury* (n=206)	Sharps injury* (n=56)
	n (%)	n (%)
PSS-10 score	13 (6.8)	15 (6.8)
PSS-10 stress assessment		
Low stress (0-13)	110 (53.0)	26 (46.0)
Moderate stress (14-26)	90 (44.0)	26 (46.0)
High stress (27-40)	6 (3.0)	4 (7.0)
Modified PHQ-9 score	3.7 (3.9)	4.2 (3.3)
PHQ-9 depression assessment		
No to minimal depression (0-4)	144 (70.0)	36 (64.0)
Mild depression (5-9)	48 (23.0)	17 (30.0)
Moderate depression (10-14)	10 (5.0)	3 (5.0)
Moderately severe depression (15-19)	2 (1.0)	-
Severe depression (20-27)	2 (1.0)	-

Summaries are mean (standard deviation) or n (percent) where percent is of non-missing data.

course where they complete multiple injections on student partners. Lack of experience with the administration of local anesthesia may increase students' likelihood of experiencing sharps injuries, a finding that was also identified in surgeons in training.[11]

The majority of sharps injuries in this study were reported by students with lack of concentration, feeling rushed, and stressful environment identified as the most common perceived causes. Students have busy schedules and may rush from lecture to clinic, creating a stressful transition to the clinic environment and put them at risk of experiencing a sharps injury. Additionally, even though the majority of the participants were familiar with the sharps injury reporting protocol, fewer than half reported their sharps injury. This finding regarding underreporting is consistent with the literature.[1,2,8,12] Underreporting of sharps injuries occurs for a variety of reasons including the time involved to make a report and perceived low risk of infection,[13] the most common reason for not reporting a sharps injury by participants in this study. Participants may have felt this way because their injury occurred in preclinic/lab and did not involve a real patient. The misperception that instruments used in preclinic/lab are sterile, may have led to inappropriate post-exposure management.[13] Health care workers may also fear the social consequences of reporting a sharps injury. Reasons for nonreporting include concerns that the injury will be considered an indication of poor work performance and fears that they will be blamed for their injury.[3] One participant in the current study stated that they had been treated poorly by staff after reporting a previous injury, which influenced them in deciding not to report their most recent injury.

It is critical to educate dental and dental hygiene students about sharps injuries and the necessary steps to take if they experience a sharps injury. However, results from this study showed that not all sharps injuries are reported. Students may not alert faculty or staff that they experienced a sharps injury in a preclinic or clinic session. Even if students do not alert faculty or staff, students have been taught to report their injury to the quality and compliance officer at the UMN SOD. However, students are busy and may not follow through with the reporting process particularly if no one else has been informed of their injury.

Students and other DHCPs should be made aware that psych-ological effects may occur after experiencing a sharps injury. Individuals reporting a sharps injury at the UMN SOD are provided with mental health resources at the UMN. In the current study, most (82%) of those who reported their injury felt as though they received adequate support after reporting. Non-reporting of a sharps injury may leave the individual without any access to the support and resources available to them. Results from this study also demonstrated the need to educate faculty and staff regarding how to appropriately respond to students reporting a sharps injury. Being treated poorly or in a punitive manner may have a detrimental impact and lead to non-reporting in the future. If the sharps injury can be considered a learning experience, the possibility of a second injury may be reduced. Also, if students do not report their sharps injuries, this behavior may be carried over into clinical practice as licensed providers. Enhancing the education provided to DHCPs regarding sharps injuries may increase health promotion and disease prevention.

This study had limitations. A significant limitation was that the surveys were not coded to identify and eliminate duplicate responses, potentially impacting the validity of the response rate and results. Some duplicates were only incidentally identified by respondents who completed both the paper and electronic surveys. Second, there was a low response rate, which may have impacted the representativeness of the study sample and the generalizability of the results. The low-response rate also impacted

the statistical power of the study, which may have been why there was no statistically significant difference in stress and depression scores between the groups of participants. This was a retrospective study which is subject to recall bias. There were also confounding variables that could not be controlled for such as stressors related to work and/or family. Lastly, using scales that ask about stress and depression symptoms in the past month may not have been the best way to identify symptoms that occurred greater than one month ago. Further research is needed with larger sample sizes to assess the psychological effects of sharps injuries over a longer period of time. Interviews and use of surveys with qualitative questions may produce more insightful information in this area.

Conclusion

Sharps injuries, common occupational hazards for DHCPs, have been shown to have psychological effects among health care workers. Results of this study of DHCPs and students demonstrated increased stress and anxiety levels during the month following a sharps injury. Further research in larger populations is needed to assess the extent of the psychological effects of sharps injuries.

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Dental Magnification Loupes and Head Tilt Angles among Dental Hygiene Students and Faculty: A comparative study

Catherine Wilson, RDH, MS; Tara Johnson, RDH, PhD; Cindy Seiger, PT, PhD

Abstract

Purpose: Evidence suggests that musculoskeletal disorders are a significant health issue for dental health care professionals. The purpose of this study was to compare head tilt angles among dental hygiene students and faculty members when wearing through-the-lens (TTL) as compared to vertically-adjustable-front-lens-mounted (VAFLM) magnification loupes while simulating dental hygiene scaling procedures (DHSP) on a manikin. A secondary purpose was to compare head tilt angles when wearing TTL and VAFLM loupes, to safety glasses while simulating DHSPs.

Methods: A within-subjects, crossover design was used with a convenience sample of dental hygiene students and clinical faculty (n=29). Head tilt angles were measured while participants simulated DHSP wearing TTL and VAFLM magnification loupes. Additionally, head tilt angles were calculated in a subgroup of ten participants while performing DHSP with safety glasses and with TTL and VAFLM loupes. Static photographic images were taken at three time points for each lens type while working in the maxillary and mandibular arches. A video analysis software program was used to calculate calculate head tilt measurements at each time point for each lens types. Data were analyzed using repeated measures ANOVA and Cohen's d.

Results: Mean head tilt angles were significantly lower when the VAFLM loupes were used in both maxillary and mandibular arches (p = 0.000). Cohen's effect size value suggested a high practical significance for VAFLM loupes with the mandibular arch (d = 1.21) and a medium to high significance for the maxillary arch (d = 0.70).

Conclusion: Participants demonstrated greatly reduced head tilt angles when using VAFLM loupes as compared to TTL. The magnitude of effect size suggests VAFLM loupes may have a positive impact on in reducing excessive head tilt angles, a known risk factor for musculoskeletal disorders among dental health care professionals.

Keywords: magnification loupes, ergonomics, dental hygienists, dental hygiene students, musculoskeletal disorders

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Introduction

Musculoskeletal disorders (MSDs) represent conditions affecting muscles, nerves, tendons, ligaments, joints, cartilage, or spinal discs. Disorders that worsen in severity and/or duration by specific work conditions are referred to as work-related MSDs.[1,2] According to the Occupational Safety and Health Administration (OSHA), work-related MSDs are the leading cause of pain, suffering and disability among American workers.[3] The development of work-related MSDs increases significantly when individuals maintain a fixed, awkward posture or perform repetitive routines in the workplace. The maintenance of a fixed, awkward posture while performing a repetitive work routine are common during the provision of dental and dental hygiene care.[4,5] The prevalence of work-related MSDs among dentists and dental hygienists has been reported to be between 64 - 93% for all body regions, with the neck, shoulder, wrists/hands, and lower back sustaining the highest percentage of injuries.[4-6] Further, evidence suggests MSDs are also a significant health issue for dental and dental hygiene students, developing at higher rates compared to cohorts in other health science programs.[7-10]

Recommendations for preventing or reducing MSDs include correcting static or awkward posture and minimizing repetitive movements for prolonged periods of time. These recommendations encompass maintenance of a neutral

working posture by positioning of patient and operator chairs, using magnification and optimal illumination, taking micro-breaks between patients, and practicing daily preventive exercises.[11] Forward bending and repeated rotation of the head, neck, and trunk to one side are frequent upper body positions sustained by dental hygienists during clinical practice. Any type of sustained forward head position is considered detrimental, but a forward head posture of >20° for an extended time is a high risk for clinicians to experience upper extremity pain and discomfort.[12]

Magnification loupes are considered a principal apparatus in the prevention of excessive forward bending of the head and neck. A body of research supports the use of magnification as an important factor in improved ergonomic posture for both students and practitioners.[13-17] However, a systematic review verifying the various aspects studied regarding the influence of magnification on work posture of dentists, reported that the advantages related to ergonomics were based primarily on daily clinical experiences, expert opinions, case reports and data obtained from self-administered questionnaires.[14] While there is extensive evidence suggesting a positive impact of magnification loupes (versus no loupes) on posture and work-related MSDs, comparisons between different loupe design features and their ergonomic benefits are limited.

There is a paucity of evidence in the literature demonstrating an association between magnification loupe design, declination angle and ergonomic posture. The most popular design is through-the-lens (TTL) in which the oculars (telescopes) are permanently mounted into the frame's carrier lens. A randomized controlled intervention with dentists and dental hygienists examined the difference in head and neck flexion angles between TTL loupes (intervention) and safety glasses (control) and identified that TTL loupes decreased head and neck flexion angles by 8.7° and 8.2° respectively, as compared to the control. While it was concluded that magnification loupes can decrease forward head tilt, declination angles were not identified.[18]

Another design commonly used in dentistry is the front-lens-mounted (FLM) loupes featuring a fixed ocular position on the frame itself. Maillet et al. investigated FLM loupes compared to safety glasses for improvements in working posture. Dental hygiene students were videotaped during clinical procedures while using FLM loupes and safety glasses and their postures were assessed with Branson et al.'s Posture Assessment Instrument (PAI). Results demonstrated that participants using FLM loupes scored significantly closer to ideal posture as compared to using safety glasses alone.[16] However, Hayes et al. surveyed practicing dental hygienists to determine their opinions regarding the use of loupes. Only half of respondents indicated that there was a positive change in their posture. While nearly all respondents indicated loupes were a benefit to identification of calculus deposits, only half self-identified a positive change in their posture while wearing loupes.[9]

Neither the TTL nor FLM loupe design allows for adjustment of the oculars to increase the declination angle (the angle that the clinician's eyes are inclined downward toward the work area). The declination angle should be steep enough (40° – 50°) to maintain a minimal forward head posture.[19] The recent development of a vertically-adjustable-front-lens-mounted (VAFLM) loupe design incorporates a vertical adjustment of the oculars allowing for a steeper declination angle (40° – 45°) and the potential for a decreased head tilt angle. Through the lens and VAFLM loupes are shown in Figure 1.

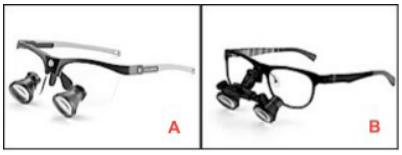

Figure 1. Through-the-lens (A) and vertically-adjustable front-lens-mounted (B) magnification loupes

To date, no objective studies have compared the traditional TTL or FLM loupes, routinely used in dentistry, to those with vertical adjustability for declination angle differences relative to forward head tilt. The purpose of this study was to compare head tilt angles among senior dental hygiene students and clinical faculty while wearing TTL loupes and VAFLM loupes during simulation of dental hygiene scaling procedures (DHSP) on a manikin. A secondary purpose was to compare the head tilt angles of a subset of participants while wearing the TTL and VAFLM loupes as compared to safety glasses during the simulated DHSP procedures.

Methods

The study protocol was reviewed and approved by the Institutional Review Board at Idaho State University. A within-subjects, crossover design was employed to identify head tilt angles under two lens types, through-the-lens (TTL) and vertically-adjustable-front-lens-mounted (VAFLM) loupes, during simulation of DHSP on a manikin. A nonprobability, purposive sample of second-year dental hygiene students (n=20) and clinical faculty (n=9) were recruited for this simulation study. A subgroup of participants (n=10) performed DHSP while wearing the TTL loupes, VAFLM loupes, and safety glasses. This subgroup of participants completed the same DHSP procedure with the safety glasses to allow for comparison of results with previous research studies. Only 10 study participants completed the third lens type (safety glasses) due to the overall amount of time needed to complete the

simulated procedures and availability of participants. Inclusion criteria required that volunteers only used TTL loupes with 2.5x magnification for training procedures and provision of patient care and previous working distance measurements were on file with the manufacturer (Orascoptic; Madison, WI). Volunteers requiring prescription lenses were excluded from the study; co-axial illumination (head lamp) was not used during any simulation procedures. Written consent was obtained from all participants prior to the simulation exercise. To counterbalance for order, practice, fatigue, and sequence effects, all participants were randomly assigned a sequence for loupe type and alveolar arch order for performing the DHSP.

Two weeks prior to the simulation exercise, student and faculty participant names were forwarded to the manufacturer for referencing the previously recorded measurements on file, and fifteen sets of VAFLM loupes with custom working distance ranges were provided for use in this study. Participants signed up for one of three scheduled sessions and two operatories were set up in the dental hygiene clinic for simulation procedures and data collection. Prior to each data collection session, the declination angle and inter-pupillary setting for the VAFLM loupes were adjusted for each participant by the principal investigator (PI) according to the manufacturer's online tutorial. Participants were allotted two minutes per arch (four minutes total for each loupe type) and asked to complete the simulated DHSP on the lingual surfaces of the upper and lower anterior teeth (canine to canine) of a manikin. Each participant sat at the 12 o'clock working position and used a universal curette and dental mouth mirror for the DHSP simulation. A one-minute rest interval was given to each participant before data was collected for the next loupe type. To capture head tilt angles for each loupe type, two camcorders on tripods, placed to the side and front of participants, were used to record the DHSP. Static photos from the three time points were extracted from the recordings and 2D motion analysis software was used to measure head tilt angles for each lens condition for all time points. Head-tilt angles for each variable are shown in Figure 2.

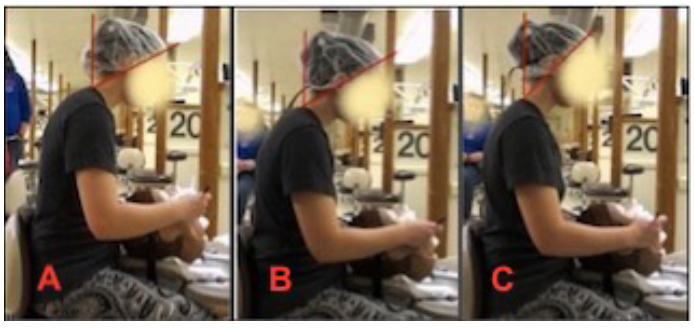

Figure 2. Head tilt angles during simulated dental hygiene scaling procedures using safety glasses (A), through-the-lens magnification loupes (B), and vertically adjustable front-lens-mounted magnification loupes (C)

Statistical Analysis

Static video images at 50-, 80- and 105-seconds were obtained from the video recordings and analyzed to determine head tilt angle measurements (measured in degrees). Analysis of the static video images was completed using a free, open access 2D motion analysis software program (Kinovea, 0.8.15 version 2). Data were compared for means and standard error of head tilt angles for type of loupe and time when simulating DHSP for anterior teeth of mandibular and maxillary arches on a manikin. Separate repeated measures ANOVA procedures were used to analyze the maxillary and mandibular data. Bonferroni adjusted dependent t-tests and a family-wise error rate of FWE=.05 were used for post-hoc mean comparisons. Cohen's *d* (*d*) was used to identify the magnitude of effect size between the conditions. The effect size interpretation was set at small=0.2, medium=0.5, and large=0.8. All data were analyzed using SPSS version 24 (IBM, Armonk, NY, USA). Significance level for all statistical tests was set at $\alpha=0.05$.

When analyzing the data for all three conditions, the preliminary statistical analyses indicated the statistical assumption of sphericity for repeated measures of ANOVA was violated for the loupe type and the data of the examination of the maxillary arch, but not of the examination of the mandibular arch. Therefore, the result of the lower-bound conservative test was reported for the maxillary arch data. All other statistical assumptions were met for the statistical analysis. Results for means, standard error, and confidence intervals were reported in degrees.

Results

At total of participants, including dental hygiene students (n=20) and clinical faculty members (n=9) met the inclusion criteria. All participants were female, and the student participants ranged in age from 21 -36 years while the faculty participants ranged in age from 42-61 years. Three fixed time intervals (50-, 80-, and 105-seconds) were examined while performing simulated DHSP on the mandibular and maxillary arches while wearing TTL and VAFLM magnification loupes.

Mandibular arch effects

The main effect on the neck flexion angle for each loupe type was statistically significant ($F(1, 28)=63.97$, $MSE=26.58$, $p=.000$, partial $\eta^2=.70$) in the mandibular arch. The proportion of variance by the loupe type was 70%, indicating a moderate effect. Flexion angles were significantly lower when participants were working on the mandibular arch while wearing VAFLM loupes ($M=49.19$, $SE=1.28$, 95% CI=46.56 – 51.82) than when wearing the TTL loupe ($M=55.44$, $SE=1.13$,

95% CI=53.12 – 57.76). The effect size for the difference was large (*d=1.21)*. The main effect for time was significant (F (2, 56)=4.25, *MSE*=2.67, *p*=.019, partial η^2=.13). There was a slight decrease in the neck flexion angle at the 80-second measurement when compared to the 50-second measurement. However, it was less than a 1° decrease, which is a small effect on the overall neck flexion experienced. While neck flexion increased at the 105-second measurement as compared to the 80-second measurement, this was not significant. The interaction of the loupe type with time was not significant for the mandibular arch (Table I).

Maxillary arch effects

The main effect on the neck flexion angle for each loupe type was statistically significant (F (1, 28)=21.55, *MSE*=37.81, *p*=.000, partial η^2=.44) in the maxillary arch. The proportion of variance by the loupe type was 44%, indicating a small to moderate effect. Flexion angles were significantly lower when participants were working in the maxillary arch while wearing VAFLM magnification loupes (*M*=41.71, *SE*=1.18, 95%CI=39.30 – 44.12) as compared to the TTL loupes (*M*=45.80, SE=1.03, 95% CI=43.92 – 48.15). Effect sizes for the differences were moderate (*d*=0.70). The main effect for time was not significant (F (2, 56)=1.47, *MSE*=3.14, *p*=.24, partial η^2=.05). The interaction of loupe type with time was not significant for the maxillary arch (Table I).

Magnification loupes versus safety glasses

A subset of the participants (students, n=7; faculty, n=3) performed the DHSP procedures while wearing safety glasses in addition to the two types of magnification loupes. When comparing the head tilt angles while using TTL and VAFLM magnification loupes, repeated measures ANOVA indicated head tilt angles during instrumentation procedures for both arches were significantly lower when wearing the VAFLM loupes as compared to wearing either the TTL loupes or safety glasses alone. Moderate to large effect sizes of decreased head tilt angles were found when wearing the VAFLM loupes type during simulated procedures performed in both arches while seated in the 12 o'clock position (Table I).

Discussion

To the authors' knowledge, research comparing the effects of magnification loupes with vertical adjustment on forward head posture (head tilt angle), working posture or upper extremity pain and discomfort has not been reported in the literature. Results of this study indicated head tilt angles when using VAFLM magnification loupes as compared to TTL were significantly decreased during simulated DHSP performed on a manikin. Findings were similar in a subset of the sample when with the added variable of safety glasses. While the use of TTL loupes showed a slight decrease in head tilt angle (<2°) as compared to safety glasses alone, VAFLM loupes displayed the greatest reduction in head tilt angle. The VAFLM loupes allowed the participants to maintain a decreased head tilt angle when viewing either arch in the manikin's oral cavity. This decrease in head tilt angle may be related to the adjustability feature of the VAFLM lenses for full coaxial alignment.[18] Through the lens and FLM magnification loupes have a higher likelihood of coaxial misalignment, which may result in increased head tilt angles.

Perhaps the most remarkable finding arising from this study was the magnitude of effect size exhibited by use of

Table I. Decreased flexion angle of the (vertically-adjustable-front-lens-mounted) VAFLM and the through-the-lens (TTL) loupes and safety glasses (SG) for all participants (n=29) and the subset (n=10)

Arch	n	VAFLM < TTL*	VAFLM < SG*	TTL < SG*
Mandibular	29	6.25° ± .78° 95% CI = 4.65° – 7.85° *p* = .000	—	—
	10	8.52° ± 1.15° 95% CI = 5.15° – 11.89° *p* = .000	10.18° ± 2.07° 95% CI = 4.12° – 16.24° *p* = .002	1.66° ± 1.82° 95% CI = (-)3.71° – 7.03° *p* = 1.00
Maxillary	29	4.33° ± .93° 95% CI = 2.42° – 6.24° *p* < .001	—	—
	10	7.03° ± 1.46° 95% CI = 2.75° – 11.32° *p* = .003	8.92° ± 2.03° 95% CI = 2.96° – 14.87° *p* = .005	1.88° ± 1.12° 95% CI = (-)1.40° – 5.17° *p* = .381

* Mean change ± standard error in degrees

VAFLM loupes compared to both TTL loupes and safety glasses. The effect size of the VAFLM on head tilt angle was large for all conditions in both arches, indicating that the VAFLM has a clinically significant effect on head tilt angles during a simulated DHSP. Effect size provides a truer measure of the magnitude of effect between variables over statistical significance alone because the influence of sample size is minimal.[20,21] Similarly to other studies, VAFLM magnification loupes were associated with clinically relevant improvements in head tilt angle as compared to TTL loupes and safety glasses.[22]

The amount of decrease in head tilt angle was dependent on which arch was being assessed. Thus, the declination angle required to maintain a neutral head tilt may be different when assessing the mandibular arch than the declination angle required for the maxillary arch. Additional research is needed to determine the optimal declination angle for each arch. This study was carried out on manikins from a 12 o'clock position. The declination angle required for performing dental hygiene procedures may differ depending on the position where the procedures are performed. Future research is needed to provide optimal declination angles for both arches at different seating positions.

The findings demonstrating no difference in head-tilt between using the TTL and safety glasses are consistent with those of Ludwig et al.[23] on the effects of magnification loupes on posture. However, other studies have demonstrated that magnification loupes improve posture.[15,16] While neck pain was not analyzed in this study, research has shown that magnification loupes may have a positive effect in decreasing neck pain.[19] Additional research is needed to determine the effect of VAFLM loupes on neck pain.

Due to the amount of time to complete the simulated procedures and the availability of the participants, only 10 study participants completed the safety glasses portion of this study, limiting the findings. The small number of participants may have affected the ability to detect true differences in head- tilt positions. During analysis of the data for all three conditions (VAFLM, TLT, safety glasses), the statistical assumption of sphericity for repeated measures of ANOVA was violated for the DHSP performed in the maxillary arch. This violation likely occurred due to the small number of participants (n=10) who completed all three conditions. Additional research is needed with a larger sample to further determine the differences between the head tilt angles when conducting objective measurements while performing simulated DHSP.

This study has other limitations. A convenience sample of students and clinical faculty was used for recruitment of participants and results may not be representative of the entire population. Participants were video recorded during DHSP and may have modified aspects of their posture in response to being recorded. Several extraneous variables may have influenced outcomes as well. The lever to open and close the manikin's mouth protruded two inches beyond the dental chair headrest, making it difficult for participants to get close enough to the dental chair for optimal intraoral visualization. Participants may have already adapted a less than optimal working posture from previous clinical experiences, or the established TTL loupe working distances may not have been accurate. All instrumentation procedures were performed from the 12 o'clock position, and some participants may have been trained to approach anterior teeth from different clock positions. Future studies should include a broad sample of practitioners and students with varying levels of experience. Further studies should examine effects of magnification loupes on overall posture during instrumentation in all six sextants of the mouth in patients.

Conclusion

Vertically adjustable, front-lens-mounted magnification loupes demonstrated greater reductions in head tilt angles as compared to TTL loupes and safety glasses among dental hygiene students and clinical faculty participants. The large scale of effect size for VAFLM loupes resulted in a clinically relevant improvement in head tilt angles which may translate into enhanced overall posture and ultimately, a reduction of upper extremity MSDs among dental health care providers. More research is needed to compare the various types of magnification loupes in a larger population. Further study is needed to identify the ergonomic benefits of improved posture over time, to the reduction of pain and prevention of work-related MSDs.

Disclosure

Orascoptic™ (Madison, WI) provided the vertically-adjustable-front-lens-mounted magnification loupes for the study. The company had no role in the design, conducting of the study or in reporting of the results.

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Active Shooter Preparedness among Dental Hygiene Students

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Abstract

Purpose: Active shooter incidents (ASIs) occurring in dental hygiene academic settings present unique challenges and research examining institutional preparation of dental hygiene students for such incidents is lacking. The purpose of this pilot project was to examine the perceived preparedness, confidence, and awareness of dental hygiene students regarding ASIs.

Methods: A validated 24-item electronic survey was distributed to dental hygiene students (n=68) at one institution to measure their preparedness, confidence, and awareness regarding ASIs. Descriptive statistics and Pearson correlations were used for data analysis.

Results: Fifty-seven dental hygiene students completed the survey for a response rate of 84%. Many participants felt slightly prepared (n=26, 45.6%) or not prepared (n=15, 26.3%) to respond to an ASI in the classroom. Most were slightly confident (n=26, 45.6%) or not confident (n=16, 26.3%) in helping to control the classroom during an ASI. Over half (n=32, 56.1%) were not certain if their institution provided active shooter trainings and were not certain if drills occurred (n=25,43.8%). Perceived preparedness was positively correlated with confidence in helping to control an ASI in the classroom (r(56)=.616, p=.000). Positive correlations were also identified with perceived preparedness to respond in a lab or clinic with the assumption that ASIs are taken seriously at their institution (r(56)=.375, p=.004).

Conclusion: A general lack of preparedness and confidence for responding to ASIs may exist among dental hygiene students along with a lack of awareness regarding trainings and drills. Educational institutions should implement best practices for preparing dental hygiene students for ASIs.

Keywords: dental hygiene students, active shooter, education, disaster preparedness, workplace safety, workplace wellness

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Introduction

Active Shooter incidents (ASIs) occurring health care settings, including dental hygiene clinics and classrooms, present unique challenges. Dental hygiene on-campus clinics include potentially large gatherings of people and complex building structures with several floors, or a multi-building facility spread over a large area. Additionally, there may be secured and unsecured departments, multiple entryways, potentially confusing hallways, and additional factors including biological waste or other hazardous materials. The unique nature of on-campus clinic facilities and limitations due to size, location, rural versus urban, presence of students, security and modes of communication with individuals on and off campus, law enforcement availability and response times, are some of the many challenges campus health care clinics may face during an ASI.[1]

During an ASI, dental hygiene faculty and student providers at on campus clinics, may also be faced with decisions about leaving patients; and patients may have difficulty evacuating due to age, physical disability, and/or language barriers. Regardless of complexity, the greater the familiarity with campus facilities, security personnel, and action plans, the more prepared faculty and students will be for an ASI.[2] Dental hygiene students, faculty, and staff in educational institutions, community, and clinical practice settings are not immune to shooting violence. An "active shooter" has been defined as "an individual actively engaged in killing or attempting to kill people in a confined and populated area."[3] Authorities use the term "active" to indicate a shooting is currently taking place and is in a susceptible state in which responding law enforcement and targeted

victims have the potential to alter the final result of the event through their actions.[3]

From 2000 to 2018, a total of 277 ASIs were reportedly carried out by 282 shooters among residential locations, worship centers, healthcare facilities, government/military facilities, educational institutions, commercial locations, and other locations in the United States (US).[4] Of those incidents, twelve occurred at health care facilities, killing 25 and wounding 30.[4] Additionally, 57 of those incidents occurred in educational settings, of which fifteen were in higher education institutions with 171 persons killed and another 220 wounded.[4] According to a study by the Federal Bureau of Investigation (FBI), workplace ASIs increased from an annual average of 6.4 to 16.4 during the years of 2000 to 2013.[3] In a study of hospital-based shootings from 2000 to 2011, there was a similar uptick with the average number of annual shootings increasing from nine to seventeen.[5] These findings are of concern for health care professions and for the educational institutions in which the members of the workforce are prepared, and supports the need to examine prevention strategies so that best practices can be learned.

According to the FBI, most violence in health care settings is a result of encounters with patients,[6] which is of concern for dental hygiene care facilities on college campuses and private practice dental settings, considering that patients typically pay for services at a front desk or with a cashier. Settings with money exchange via cashiers accounted for 54 of the homicides reported in 2016, an increase of 65% from 2015.[7] According to Weber et al., preparedness experience can influence disaster readiness and impact behaviors during an actual incident.[8] Preparedness and guidance on how to appropriately assist patients in clinical care settings and classroom peers during an ASI may be a prudent addition to program orientation sessions.

Preparation for active shooters on college campuses should be part of an overarching disaster preparedness culture, and expectations should be well communicated campus-wide so that resilience can be strengthened.[8,9] Communicating campus emergency management efforts to students, faculty, staff, and visitors, aids to build, sustain, and improve a comprehensive emergency management plan promoting institutional resilience, departmental and individual preparedness.[10,11] Research also shows that when campus preparedness training is lacking, concern among students arises and gives the overall perception that their institution's administration is not concerned with student safety.[11] Clear communication from the institution that safety is valued for all forms of campus violence, including ASIs, is important, especially for dental hygiene programs due to their on-campus clinical facilities, although this aspect has yet to be explored in the literature.

Increased communication and preparedness measures implemented by institutions may have a positive correlation with increasing one's ability to appropriately respond during an ASI.[12] However, a survey of 161 US colleges during the 2008-2009 academic year found only half of those surveyed agreed that prevention curriculum was regularly disseminated among their campus communities.[13] However, while those same institutions had emergency preparation protocols in place, only 25% agreed their students understood the procedures and 30% agreed employees understood.[13] Similar results among students were identified by Lovekamp et al., regarding a general lack of awareness of the systems their institution had in place for emergencies.[14] In addition, students may have had a false sense of security regarding their institution's preparedness to protect them in the event of an emergency.[14] Higher education institutions should communicate campus emergency management policies and resources, response protocol, and training opportunities to students, faculty, and staff.[15] Furthermore, communication of policies, protocol, training, and drills should occur at all levels of the institution and be tailored to individual programs and be applicable to clinical and laboratory facilities both on and off campus.

According to the Federal Emergency Management Agency (FEMA), educational institutions are responsible for providing preparedness curricula for students, faculty, and staff, including information regarding lock down procedures and expectations for response protocol;[9] however, regular implementation of such curricula with training seems to be lacking among US institutions of higher education.[9,12,13,16] Despite this curricular omission, research shows preparation in the form of trainings and drills can be effective.[16,17] Peterson et al. found feelings of perceived preparedness significantly increased after watching a 20-minute training video when compared to students who watched a control video.[17] Additionally, Skurka et al., found that even showing a short 2-minute training video can have immediate and lasting psychosocial effects, so students are able to react appropriately when faced with an ASI.[16]

Despite efforts to plan and train, the response of most targeted victims varies due to their initial shock and instinctual reaction.[1] It has been suggested that understanding perceived preparedness is important since perception may influence how the student responds during an actual emergency event.[11] Victims are more likely to recall at least a portion of the training and drills they have participated in. Chances of

survival are increased through the ability to regain self-control and apply what was learned to circumstances surrounding the incident.[1] Adopted and implemented training protocol should be made known to all civilians and potential responders for coordination of efforts and a general understanding of recommended behaviors.

Dental hygiene programs utilize large classrooms, labs, and clinics with rotating schedules throughout the day. Since these facilities are unique in size, layout, and resources, it is important for institutions to investigate how to effectively apply best practices for disaster preparedness.[15] This should be a consideration when conducting drills[18] since one study showed that 26% of the ASIs which occurred between 1900 to 2008 took place in buildings with classrooms and laboratories within college settings.[19] In prior ASIs, researchers have learned that some victims who hid in closed rooms were shot through thin doors/walls.[2] Adequate cover or protection should be sought as far away from doors as possible and behind solid objects including concrete walls, thick desks, and filing cabinets.[1] It is recommended for facilities to be evaluated for pre-planned assembly areas of refuge for sheltering-in-place to protect potential victims.[1] Dental hygiene program facilities should be evaluated by trained authorities so the safest options for evacuation and concealment can be known, and/or recommendations be made for facility improvements.

Literature exists exploring active shooter preparedness in higher education or specific programs within institutions,[8,9,11,15,20,21] however this topic has yet to be researched in dental hygiene programs, although they may be especially vulnerable. The purpose of this pilot study was to examine the perceived preparedness, confidence, and awareness of dental hygiene students regarding ASIs at their educational institution.

Methods

This study received exempt status from the College of Health Sciences Institutional Review Board Committee at Old Dominion University.

A convenience sample of first- and second-year dental hygiene students enrolled at Old Dominion University (n=68) were invited to participate. Degree completion and graduate dental hygiene students were excluded since their distance learning programs do not take place on campus. A previously validated survey instrument (Cronbach alpha score of .831 for internal consistency), designed to measure preparedness and confidence of students as related to ASI, was used for the study.[20] The survey instrument consisted of 23 multiple choice and demographic items and included one response option that allowed participants to share final thoughts on active shooter preparedness.

The survey was sent via e-mail invitation over an eight-week period (Qualtrics; Provo, UT) and included general instructions, the purpose of the survey, implied consent, and the survey link. Within the introductory statement, key terms were defined including "active shooter", "prepared", "slightly", "moderately", and "extremely." Voluntary consent was understood upon completion of the survey and participants who completed the entire survey were invited to enter a random drawing for a $50 Amazon gift card. Personal data for the random drawing was not linked to the survey data to protect participant anonymity. Descriptive statistics and Pearson product moment correlations were used to analyze the data (IBM SPSS 25; Armonk, NY).

Results

A total of 57 dental hygiene students completed the survey for a response rate of 84%. All participants were female (n=57) and the majority self-reported as Caucasian (n=37, 64.9%) and were 18-29 years of age (n=50, 87.72%). Sample demographics are shown in Table I.

Table I. Demographics (n=57)

Gender	**n (%)**
Male	--
Female	57 (100.0)
Prefer not to answer	--
Ethnicity	**n (%)**
Caucasian	37 (64.91)
Asian	9 (15.79)
African American	7 (12.28)
Hispanic	2 (3.51)
Other	2 (3.51)
Age	**n (%)**
18-29	50 (87.72)
30-44	6 (10.53)
45-59	1 (1.75)

Most participants indicated that they felt "slightly prepared" or "not prepared at all" to respond to an ASI in the classroom (n=26, 45.61%; n=15, 26.32%) respectively. In regard to preparedness for an ASI in a laboratory or clinical setting, a little more than one quarter (28.07%, n=16) felt "slightly prepared" and 43.86% (n=25) felt "not prepared at

all.". When asked about confidence level in helping to control the classroom in the event of an ASI, almost half felt "slightly confident" (45.61%, n=26). Additionally, when asked about confidence level in helping to protect fellow classmates during an ASI, most felt either "slightly confident" (38.60%, n=22) or "moderately confident" (36.84%, n=21). Participants' preparedness and confidence respond to an ASI are shown in Table II.

Pearson's correlations showed significant, positive correlations between participants' perceived preparedness and confidence levels. Perceived preparedness by the participants to appropriately respond to an ASI in the classroom was significantly, positively correlated with confidence in helping to control the classroom during an ASI ($r(56)=.616$, $p=.000$); and the effect was large. Additionally, perceived preparedness to respond to an ASI in a lab or clinic setting was significantly, positively correlated with confidence in helping to protect fellow classmates during an ASI ($r(56)=.538$, $p=.000$). There was a large effect, indicating strength between the variables. Finally, the assumption that the institution takes ASIs seriously was significantly, negatively correlated with whether or not the student was aware if the institution had a policy for ASIs in place ($r(56)= -.334$, $p=.011$). Pearson correlations are shown in Table III.

Participant awareness of campus policies and trainings were measured and reported by expressed certainty in response to survey questions. Frequencies of responses to questions assessing participants' awareness about ASIs, policies, trainings, and drills at the institution are shown in Table IV. More than half of the participants (56.14%, n=32) were "not certain" if an ASI had occurred on campus since the year 2000 and one-half (50.88%, n=29) were "not certain" of the institution's campus carry policy regarding possession of firearms on campus. When asked if the institution provided training for students to respond to an ASI, over half (56.14%, n=32) were "not certain" and most were either "not certain" (43.86%, n=25) or stated "no" (35.09%, n=20) to the provision of active shooter drills on campus.

If participants responded "yes" to the institution providing training or drills, follow-up questions were asked regarding whether it was mandatory, the frequency of occurrence, and if faculty were involved in the trainings or drills. Seventeen participants (29.82%) responded "yes" to the question about whether their institution provided training to students for ASIs. Of those, more than half (52.94%, n=9) responded that it was not mandatory. Of those that answered "yes" to mandatory trainings, all participants stated that it was required once a year and that the trainings included faculty. Twelve participants (21.05%) responded "yes" to the question about whether their institution provided active shooter drills. Of those respondents, the majority (41.67%, n=5) were "not sure" how often drills occurred, whereas the remainder of the participants answered that the drills occurred every six months (n=3), annually (n=3), and monthly (n=1). Additionally, most of these participants responded "yes" to the inclusion of the faculty in active shooter drills on campus (n=9, 75%). When participants were asked for final comments, some (n=3) mentioned that they felt safer in the classroom when the door

Table II. Responses to preparedness and confidence items (n=57)

	Not prepared at all n (%)	**Slightly prepared n (%)**	**Moderately prepared n (%)**	**Extremely preparedn (%)**
How prepared are you to respond to an active shooter event in one or more of your classrooms?	15 (26.32)	26 (45.61)	15 (26.32)	1 (1.75)
How prepared are you to respond appropriately to an active shooter event in one of your labs or clinics on campus?	25 (43.86)	16 (28.07)	14 (24.56)	2 (3.51)
	Not confident at all n (%)	Slightly confident n (%)	Moderately confident n (%)	Extremely confident n (%)
In the event of an active shooter incident, how confident are you that you could help control the classroom if needed?	15 (26.32)	26 (45.61)	16 (28.07)	--
In the event of an active shooter incident, how confident are you that you could help protect fellow classmates if needed?	11 (19.30)	22 (38.60)	21 (36.84)	3 (5.26)

Table III. Pearson correlations between self-reported preparedness and confidence levels (n=57)

	Perceived preparedness to respond in classroom	Perceived preparedness to respond in lab or clinic	Perceived confidence in helping control classroom	Perceived confidence in protecting classmates	Assumption that ASIs are taken seriously at institution	Institution has policy on ASIs
Perceived preparedness to respond in classroom	1	.739**	.616**	.476**	.277*	-.202
Perceived preparedness to respond in lab or clinic	--	1	.532**	.538**	.375**	-.224
Perceived confidence in helping control classroom	--	--	1	.592**	.264*	-.118
Perceived confidence in protecting fellow classmates	--	--	--	1	.409**	-.155
Assumption that ASIs are taken seriously at institution	--	--	--	--	1	-.334*
Institution has policy on ASIs	--	--	--	--	--	1

* Correlation is at the 0.05 significance level (p≤ 0.05)
**Correlation is at the 0.01 significance level (p≤ 0.01)

Table IV. Awareness of campus active shooter incidences, policies, trainings, and drills (n=57)

	Not certain n (%)	No n (%)	Yes n (%)
Has your institution experienced an active shooter event since the year 2000?	32 (56.14)	20 (35.09)	5 (8.77)
Does your institution have a policy in place for active shooter events?	23 (40.35)	1 (1.75)	33 (57.89)
Does your institution provide active shooter training to teach students how to respond appropriately?	32 (56.14)	8 (14.04)	17 (29.82)
Does your institution run active shooter drills?	25 (43.86)	20 (35.09)	12 (21.05)

	Not certain n (%)	Not permitted n (%)	Concealed carry n (%)	Open carry n (%)
Which of the following best describes your institution's campus carry policy? Campus carry refers to the possession of firearms on college or university campuses in the United States.	29 (50.88)	28 (49.12)	--	--

	Strongly disagree n (%)	Disagree n (%)	Neither agree nor disagree n (%)	Agree n (%)	Strongly Agree n (%)
The possibility of an active shooter incident is taken seriously at my institution.	--	3 (5.26)	13 (22.81)	20 (35.09)	21 (36.84)

was locked (n=3) and felt that more training and drills would be beneficial (n=4).

Discussion

All health care facilities, including campus dental and dental hygiene clinics, must be prepared to mitigate injury and death from ASIs. Local and campus law enforcement officials and emergency management departments can actively assist departments and college administrators in planning and guidance to deal with an ASI. Incorporating an ASI plan into emergency management policies should be standard for dental and dental hygiene clinics located on college campuses.

Dental hygiene programs with on-campus clinical facilities may be especially vulnerable due to daily interactions with patients, as well as the collection of fees for service. Due to the nature of clinical care facility operations, it may be best practices for dental hygiene programs to have their own ASI policies, training, and drills in addition to those offered by their respective institutions. This practice would be in alignment with the recommendation by Lovekamp et al., that the institutional disaster curriculum should be student-specific.[14] This should also be considered in ASI policies and training for private dental clinics as they tend to maintain open areas with no doors for the operatories, front office, sterilization, and laboratory areas. Typically, in dental clinics, the only rooms with a door are the entrance to the reception area, restrooms, personal offices, and storage closets. Finding a safe room with a door to lock or barricade would be difficult, especially if several staff members and patients needed the safe space at the same time. Considering these challenges, it would be advantageous to have local law enforcement personnel visit dental hygiene programs and private practice clinics and consult regarding areas for possible concealment in the event of an ASI.

Disaster preparedness and response literature have placed an emphasis on the importance of training and drills for potential ASIs. While the conversation of what to do in the event of such tragedies may be uncomfortable, some individuals may find it reassuring knowing that their institution is prepared and ready to keep them safe. Most respondents in this study indicated believing that their institution takes active shootings seriously, yet results showed that most were unaware of measures being taken to prepare for active shooters. It is unclear why the participants concluded that the institution takes ASI seriously when a majority were uncertain regarding the campus firearm carry policy, trainings, and drills related to ASIs. Based on these findings, the communication of active shooter policies and trainings for students may be lacking at the institution.

It should be mentioned that the institution which served as the basis for the study population, has a policy forbidding firearms and has adopted an active shooter policy based on the principles of the FBI protocol "Run, Hide, Fight."[4] The university also offers trainings by campus police, and holds drills on campus that include students. Though not directly associated with this study, it should be noted that within the previous year, the dental hygiene students and faculty completed an online active shooter training course designed by Vector Solution's Safe Colleges Training program[22] and the dental hygiene care facility had a panic button installed at the reception desk. Faculty and students in the department were also appraised of the location of the button and given directions for use. In addition, the students in this study have been required to participate in evacuation drills, for example fire drills, while in their clinic sessions. Though these policies can be easily found on the website and in policy manuals at the institution, it is likely students need more direct communication regarding active shooter policies and preparedness. It has been suggested that communication with students could be facilitated by posters, fliers, emails, phone calls, text messages, and/or Twitter to announce trainings and drills.[15] Additionally, dental hygiene students specifically may benefit from clearer policies, training, and drills in the designated clinical facilities associated with their program, due to the increased vulnerability of these settings.

Previous literature has identified significant, positive correlations between perceived preparedness and the institution having an active shooter policy in place;[23-27] however this correlation was not found in the current study. In this study, very few students reported being prepared or confident in their ability to help during ASIs. Of those who reported perceived confidence, there was a significant, positive correlation of perceived preparedness with a large effect size, indicating that participants' confidence may have given them a perception of readiness for ASIs.

Responses on this survey, indicated that despite having policies, drills, and trainings on campus, in general, dental hygiene students did not feel prepared or confident to handle ASIs in classroom, laboratory, and clinic settings. Only one third of the students reported feeling prepared to respond in the classroom and laboratory or in being confident in helping control the classroom and protect classmates. Because the students were seemingly unaware of policies and trainings available on campus, it is possible that their general lack of preparedness and confidence is a result of

ineffective communication from the university regarding available campus trainings and drills. Findings from this study regarding a general lack of preparedness among dental hygiene students aligns with previous research[13-15] further reinforcing the need for clear communications to students regarding policies and training related to ASIs. These findings also reiterate the need for dental hygiene programs to adopt policies and training in their own unique settings to increase confidence and preparedness of students should an ASI occur in one of their classes, laboratories, or clinics. It may be beneficial to require mandatory training for students, faculty, and staff and track participation through documentation. Considering the manner that a targeted victim reacts can alter the end results of an ASI, it would be best for these reactions to be influenced by practice and learned skills, not panic and hasty decisions. Policies, curriculum, communication, trainings, and drills must be well thought out, updated, implemented and documented regularly.

Participants provided open-ended comments related to active shooter preparedness. A small number of respondents indicated that they would feel safer if the doors stayed locked during classroom instruction and several felt more trainings and drills would be beneficial. One student indicated that primary schools provide active shooter trainings and drills to students and would like to see the same occur at institutions of higher education. These comments further demonstrate that students were unaware of drills and trainings already occurring on campus and that they would benefit from these activities occurring specifically in their classrooms and clinics.

This pilot study had several limitations. The convenience sample of dental hygiene students from one institution, in one geographic location limits the generalizability of the findings. Demographic information regarding college attendance rates, or previous degrees, to compare responses between first- and second-year students, was not included. The demographic differences between students who have attended higher education campuses for longer periods of time may have influenced perceived ASI preparedness and awareness. Additionally, the questionnaire required self-reporting of preparedness, confidence, and awareness, which may have impacted results.

Future research should focus on samples that expand the geographic location to include a cross section of dental hygiene students. Since all dental hygiene programs include clinical facilities that may be vulnerable to ASIs, it would be beneficial for a multidisciplinary threat assessment team to study such facilities for vulnerabilities. Trainings and drills, specifically in dental hygiene clinical facilities and classrooms, should be evaluated to determine best practices. Finally, it may be beneficial to include dental hygiene faculty and staff perceptions of active shooter policies and preparedness in their respective programs.

Conclusion

A general lack of preparedness and confidence for responding to ASIs may exist among dental hygiene students along with a lack of awareness regarding trainings and drills. Dental hygiene students' confidence regarding their ability to help control a classroom setting or protect their classmates was correlated with the assumption that the institution took ASIs seriously. Active shooter policies, trainings, and drills may not be easily applied to dental hygiene programs and their unique clinical settings. Planning to counter an ASI requires an interprofessional team and an approach that includes multiple scenarios and practice routines to strengthen preparedness efforts. Educational institutions should implement best practices for preparing dental hyigene students for ASIs.

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