

Innovations in Dental Hygiene Education

Implementing Environmental Sustainability Educational Intervention in Dental Hygiene Instruction

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Purpose: The planet faces a climate crisis threatening public health. Dentistry contributes to a large portion of the waste output in the United States. The purpose of this study was to assess dental hygiene (DH) students' perceptions and knowledge on environmentally sustainable dentistry (ESD) prior to and following an educational intervention.

Methods: A convenience sample of second-year DH students (n=34) at the University of North Carolina at Chapel Hill (UNC-CH) was recruited for this pilot study consisting of a pre-survey, an online educational module and immediate post-survey, and a final assignment followed by another post-survey. The educational module followed a funnel approach to educate learners on the topic of sustainability before narrowing down to how sustainability can be applied to dentistry. Paired t-tests compared pre- and post-module survey scores on changes in knowledge and attitudes. Univariate and qualitative analyses were conducted on the post-assignment component.

Results: Twenty-five participants had qualifying responses for the pre- and post-module survey (71.4% response rate); 22 participants completed the post-assignment survey (62.7% response rate). There was a statistically significant increase from pre- to post-module knowledge scores ($p < 0.0005$). Most respondents (>90%) indicated that the follow-up assignment strengthened their learning experience. Qualitative analysis revealed that the assignment helped participants apply module concepts in the real world and adopt less wasteful behaviors in clinic.

Conclusion: Instructional interventions on ESD in DH education may improve students' knowledge of environmentally sustainable habits and encourage behavioral changes. Study findings can help introduce an environmental sustainability component to the DH educational curriculum.

Keywords: dental hygiene education, environmental sustainability, environmentally sustainable dentistry, climate change

This manuscript supports the NDHRA priority area **Professional development: Education** (evaluation).

Submitted for publication: 4/11/21; accepted: 1/26/22

Introduction

The United States (US) healthcare system is one of the largest waste emitters on the planet,¹ contributing to climate change and creating threats to human and environmental health.² Climate change is one of the biggest challenges facing the current and future generations by threatening the food, water, home, and health security of millions of people worldwide.³ Considering that dentistry is a major component of the US health care system, it is logical to assume that dentistry, by extension, also contributes a significant portion of the national waste output. However, the exact scope of the impact dentistry in the US has on the environment is still unknown.

Dental care professionals have an ethical obligation and responsibility to understand and minimize the profession's environmental and public health impact.⁴ In 2017, the

Fédération Dentaire Internationale (FDI) World Dental Federation, the leading organization representing dentistry in the world, issued the following statement: "Dentistry as a profession should integrate sustainable development goals into daily practice and support a shift to a green economy in the pursuit of healthy lives and well-being for all through all stages of life."⁵ In alignment with this statement, the United Kingdom's (UK) Centre for Sustainable Healthcare (CSH) established the Sustainable Healthcare Education (SHE) network, an interprofessional coalition of over 900 clinicians, academics, and students aiming to incorporate sustainable healthcare education into the health profession curriculum and general education.⁶ Presently, there is no US-based equivalent of CSH. Existing organizations, such as The

Medical Society Consortium on Climate and Health, are focused on internal medicine with no mention of dentistry, despite dentistry being a billion-dollar medical industry within the US.^{7,8}

Dental hygienists are essential in promoting community and individual well-being as front-line healthcare workers and advocates for preventive oral health. Further education on the impact of climate change and environmental sustainability for DH students is essential in preventing adverse health outcomes related to the environment and promoting healthier communities. Equipped with the knowledge and mechanisms behind ESD, dental hygiene students can be a catalyst towards a more environmentally conscious dental workforce. However, resources for the education of environmentally sustainable dentistry (ESD) in the US-based dental and dental hygiene curriculum are sparse, and their effectiveness has not been reported in the literature. Survey research indicates interest in implementing ESD into dental education;⁹ however, there is a lack of educational materials and knowledge on ESD.⁹ To overcome these challenges, Joury et al. proposed the creation of ESD-related learning outcomes and capacity for educators to embed ESD in dental education.⁹

Recognizing these same barriers to implementation of ESD in DH education, an educational intervention on ESD was created in the undergraduate DH education program at the University of North Carolina at Chapel Hill (UNC-CH) Adams School of Dentistry. The purpose of this study was to determine the baseline for DH students' attitudes and perceptions towards environmentally ESD and determine the usefulness of an educational intervention in the dental hygiene curriculum on ESD.

Methods

Study Design

Recruitment for this study included a convenience sample of second-year DH students (n=34) enrolled in the Bachelor of Science DH program at the UNC-CH Adams School of Dentistry during the fall semester of 2020. Second-year DH students were the target population because they have completed at least one year of clinical work with patients and had likely witnessed the ways dentistry may impact the environment. The UNC-CH Institutional Review Board (IRB) determined this study exempt (#20-1313).

This study consisted of two phases: an educational module and a follow-up assignment. Phase One utilized an educational online module intervention paired with immediate pre- and post-online surveys (Qualtrics; Provo, UT, USA). Phase Two employed a follow-up assignment and a post-assignment

online survey. Completing the education module and post-module assignment was a mandatory requirement for second-year DH students, while completing the pre and post surveys was voluntary. Students choosing not to participate in the surveys were not considered part of the study sample.

Pre- and Post- Module Surveys

The pre- and post-surveys contained items on attitudes and knowledge towards climate change and ESD practices. The surveys were designed to take no more than three minutes to complete and were administered immediately before and after completing the online educational asynchronous module. The surveys were pilot tested for face validity by three dental hygienists and three dentists who had graduated within the past three years. Pilot testers provided feedback on the time needed to complete the surveys, comprehension, and clarity of survey questions.

Participants were assigned a random ID number in the pre-survey to track changes in knowledge and attitudes from pre- and post-survey responses. The random ID also ensured that survey responses remained anonymous. Survey responses and module participation were kept separate with no linkages. The pre-survey consisted of six items focused on knowledge regarding environmental issues and seven items on attitudes and beliefs regarding climate change and its relationship to dentistry. Question difficulty was developed according to what an average person who had completed high school would know and then increased in difficulty for individuals who were up-to-date with current environmental news. Questions utilized a mixture of multiple-choice knowledge-based and Likert-style questions ranging from strongly disagree to strongly agree. For example, question 11 in the pre-survey asked, "Please indicate your level of agreement with this statement: Environmental sustainability is important." The post-module survey had an additional optional free response section to allow participants an opportunity to share additional general feedback at their own discretion.

Module Design

The educational module embedded the post-survey link at the end of the module; participants could not access the link until the module was completed. The post-survey consisted of six knowledge questions and seven attitude questions that mimicked those of the pre-survey. However, there was an addition of two Likert-style questions asking participants for their opinion of the module and a free-response option for any other miscellaneous feedback. At the end of the post-survey, participants had the choice to opt-in for an equal chance to receive a \$15 gift card by providing their name and email address.

The asynchronous online educational module was titled “Environmental Sustainability and Dentistry” (Table I). The same pilot testers for the pre- and post-surveys pilot also tested the educational module for ease of use, completion time, and accessibility. It was hosted on the UNC-CH Learning Management System (Sakai) and consisted of six sections: 1) Environmental Sustainability, 2) Climate Change Impacts, 3) Healthcare & Dentistry, 4) Sustainable Laws and Policies, 5) Applications, and 6) References. A series of papers by Duane et al. focused on guiding dental practices to implement more environmentally friendly practices informed the module content.¹⁰ Module information was presented in short video format through PowerPoint slides and a voiceover.

Table I. Education module section objectives

Section Title	Objectives
Environmental Sustainability	Define “Environmental Sustainability” Define “Climate Change” Describe connection between climate change and environmental sustainability Identify sources of greenhouse gases (GHG)
Climate Change Impacts	Outline three environmental impacts of climate change
Healthcare and Dentistry	Identify energy intensive healthcare processes Compare US healthcare waste output to rest of world Identify common types of dental waste Discuss environmental danger of dental amalgam
Sustainable Laws and Policies	Identify key legislation and initiatives relevant to environmental sustainability, especially in healthcare Discuss politicization and instability of environmental issues in US
Applications	Provide examples on how to practice environmentally sustainable dentistry List manufacturers/suppliers at local dental institution that have recycling services/options for student’s reference Discuss how to pressure suppliers/manufacturers to provide environmentally friendly options for their products
Climate Change Impacts	Describe three environmental impacts of climate change

Sections 1 and 2 introduced students to environmental sustainability and its importance by highlighting climate change impacts sourced from human activities. Section 3 drew the connection between climate change and dentistry. Section 4 informed study participants on the current state of policies and current administration regarding environmentally sustainable dentistry and healthcare in the US. Section 5 educated students on utilizing sustainable dentistry and introduced methods that they could employ in private practice. Section Six included all references used for the creation of the module and its material. Content-based questions were embedded throughout the module to promote participant engagement and information retention. Completion of all embedded questions was required to ensure that participants completed the module before accessing the post-survey. The embedded questions and responses were not recorded.

Follow Up Assignment

Three weeks following the module, students engaged in a short assignment to reinforce the module content. Students identified an area of dentistry that may or may not benefit from a sustainable approach. Once identified, they evaluated the pros and cons of the approach, described any challenges towards implementing the change, and identified alternative sustainable products if applicable.

Students reported their findings via VoiceThread,¹¹ a collaborative online tool that allows users to present virtually with slides/images on the Learning Management System and commented on at least two of their classmates’ presentations. Following the assignment, students were given the opportunity to provide further feedback on the assignment through a post-assignment survey. While completion of the assignment was required of all students, participation in the survey and study was not. Survey responses were anonymous, and participants could indicate consent for the assignment and feedback for inclusion in the study.

Post-Assignment Survey

The post-assignment survey was administered online (Qualtrics; Provo, UT, USA) and pilot-tested for face validity by dental hygienists who had graduated within three years. The pilot testers provided feedback on survey completion time, readability, and question comprehension. The post-assignment survey took no more than eight minutes to complete. Questions utilized

a combination of Likert-style and open-ended questions to gauge student impressions toward the value of the post-module assignment. For example, question 2 asked, “This assignment helped me apply concepts learned in the module in the real world.” Likert-style response options ranged from “disagree” to “agree.” Four qualitative questions in the post-assignment survey were organized into the following categories: enrichment, change, and continuity. These questions helped determine what students thought should be discontinued, continued, or added to improve their learning experience. For example, question 7 asked, “What part(s) of this assignment should be stopped/changed to improve the learner experience?”

Data Analysis

Quantitative statistical analysis using statistical software (SAS 9.4; SAS Institute Inc., Cary, NC, USA) included paired t-tests to compare participant knowledge and attitude responses from pre- and post-surveys. Survey responses were grouped into the following subgroups: pre-knowledge, pre-attitude, post-knowledge, post-attitude, and self-perceived module effectiveness. All tests were conducted at the 95% confidence interval, and significance was set at $p < 0.05$. Univariate and bivariate analyses were also performed on pre- and post-module surveys and post-assessment survey.

Open-ended responses were analyzed using descriptive coding. The codes were then categorized to create themes. Quotes, representative of these themes, were used to present the data. Inter-coder reliability (ICR) between two separate coders was used to minimize potential bias. There was an ICR of 80% agreement out of twenty-five total measures.

Results

Out of the thirty-four students, 25 completed the pre- and post-surveys for phase one (71.4% response rate). Responses that were incomplete or lacked matching pre-/post-surveys were omitted from the analysis. Of these participants ($n=25$), twenty-four had matching pre-/post-survey responses (68.6% response rate). The pre-survey data revealed that most (74.0%, $n = 20$) participants supported implementing environmentally friendly dentistry. However, a majority (89.0%, $n = 24$) also self-reported possessing little to moderate knowledge on environmental sustainability, and a third (33.0%, $n=9$) felt that they had little to no knowledge of climate change.

There was a statistically significant ($p < 0.0001$) difference between pre-survey and post-survey knowledge scores (Figure 1). Study participants scored an average of 1.987 out of 6 (standard deviation (SD) ± 0.651) possible points on

knowledge in the pre-survey. In the post-survey, knowledge scores increased 0.9167 points to an average of 2.917 out of 6 points (SD) ± 0.496).

Figure 1. Agreement between pre-knowledge and post-knowledge scores after completion of education module



There was a statistically significant ($p < 0.0001$) positive difference between pre-survey and post-survey attitude scores. (Figure 2). Participants scored an average of 6.085 points out of 7 (SD) ± 0.852 total possible points on attitude in the pre-survey. Attitude scores increased by 0.708 points to an average of 6.744 points out of 7 (SD) ± 0.541 total possible points in the post-survey. In the pre-survey, 26.0% ($n=7$) strongly agreed that environmentally sustainable dentistry did not compromise current standards of care. However, post-survey results showed that 41.0% ($n=11$) strongly agreed, and even more participants had increased their results to a more positive stance. Comparisons of the average pre- and post-survey knowledge and attitude scores are shown in Figure 3.

Responses to free-response questions in the immediate post-module survey aligned with two major themes: module format and module content. Study responses regarding module content revealed an unanimously positive response. One such response was, “It was very informative and eye opener to help the environment as part of the dental professionals.” Responses about module format were evenly divided between positive and critical responses. One study respondent expressed appreciation for the format, “I really liked

Figure 2. Agreement between pre- and post-attitude scores after completion of education module

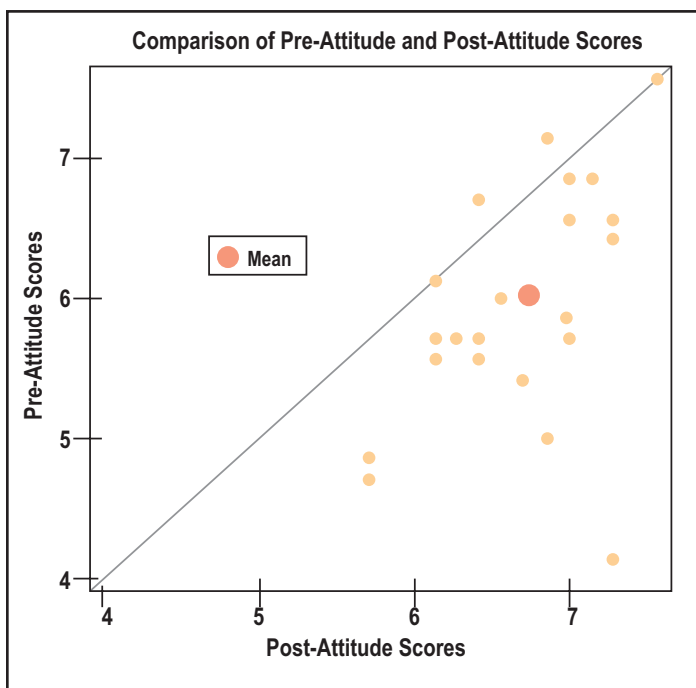
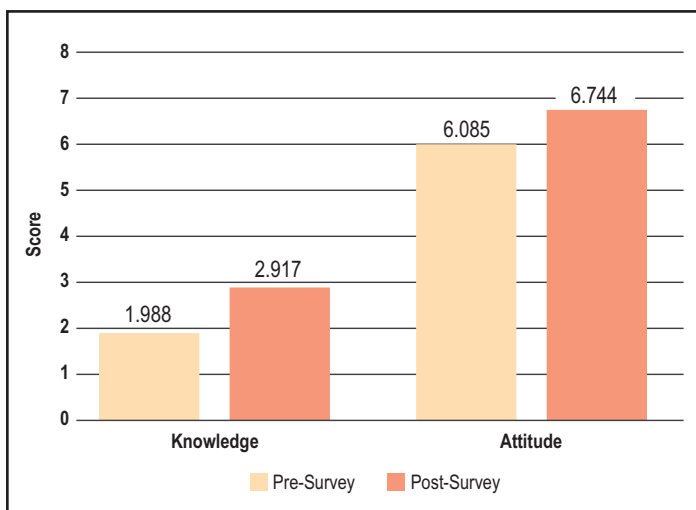


Figure 3. Comparison of average pre-survey and post-survey knowledge and attitude scores



the short video format.” While another voiced dissatisfaction with the pacing of the module, “Talked way too fast to keep up while taking notes.”

In the follow-up assignment three weeks after the education module, participants presented topics including autoclavable patient napkins, biodegradable gloves, reusable glass syringes, bamboo charcoal floss, and high-technology dry vacuum for water conservation. The students discussed the benefits and challenges of implementing these types of measures in dental practice.

Twenty-two students agreed to participate in the follow-up assignment survey (64.7% response rate). Univariate analysis revealed 100.0% of the participants expressed that the reflective assignment was at least “somewhat helpful” and a valuable supplement to the module intervention. Additionally, nearly all (90.0%, n=20) of the respondents felt that the reflective assignment helped students apply module concepts in the real world, and that they had learned about a dental product they were unaware of previously (95.0%, n = 21). Most respondents (90%, n=20) felt that the follow-up assignment helped them think at least somewhat creatively or critically on environmental sustainability and dentistry.

Open-ended responses to the post-module assignment survey revealed the following themes: reinforcement, critical thinking, behavioral change, satisfaction, external factors, design, content, and non-applicable (Table II). Most respondents indicated that the follow-up assignment was useful in helping to apply concepts introduced in the module to the real world and clinic. A few respondents (9.0%, n=2) stated that the assignment pushed them to think critically about reducing dental waste and conducting their own research. One participant stated, “Continue to encourage independent research. I thought that was the most interesting part of the project, learning about all the efforts to make dentistry more sustainable.” While others expressed a need for improvement due to external factors such as, “This project came along in the same week when all of our (other) projects were due” (18.0%, n = 4).

Discussion

Environmental sustainability is vital to improving patient and public health outcomes. Duane et al. recognized healthcare’s contribution to environmental waste and the need to shift to sustainable delivery of healthcare.¹² Dentistry, in particular, has been slow to adapt to the growing need for sustainable practices.¹² Environmental sustainability should be implemented across all sectors, yet oral health professionals know very little about environmental sustainability and dentistry.⁹ Results from this pilot study help fill this gap. The study determined the baseline level of knowledge and attitudes of DH students at one dental hygiene program, implemented an educational intervention, and assessed its helpfulness in improving DH students’ perceptions of environmentally sustainable practices in dentistry. Participants displayed statistically significant increases in their knowledge ($p < 0.0001$) and attitude scores ($p < 0.0001$) after the study interventions. Analysis of the study results determined that the most significant area of change in DH student attitudes was the belief regarding whether environmentally sustainable dentistry is achievable without compromising current standards of care.

Table II. Themes and examples for post module assignment survey

Code	Frequency	Example(s)
Reinforcement	6	“I learned about how we use a lot of stuff that has a better alternative.” “It opened my eyes to the amount of waste that comes from practicing dentistry.”
Critical Thinking	3	“...gave ideas on how to reduce waste.” “I thought that (doing independent research) was the most interesting part of the project, learning about all the efforts to make dentistry more sustainable.”
Behavioral Change	2	“I’ve tried to be less wasteful in clinic because of the environmental lesson.” “Allowed me to think about how to contribute to a more sustainable environment.”
Satisfactory	8	“Lesson is great as is!” “The videos were helpful and served as a memorable way to express content.” “Continue breakdown of material, well organized and easy to understand.”
External Factors	4	“Don’t wait until almost final weeks to ask us to do the project.”
Design	2	“Printable/downloadable version for notes/reference.” “When engaging in the content and clicking through each section, it’s easy to miss questions. Therefore, would prefer them all in one place.”
Content	3	“More examples on how to cut down unnecessary waste.” “More information on how the dental office can reduce carbon footprint and alternatives to materials and barriers.”

Regarding potential shifts towards ESD, participant responses in the pre-survey indicate that while DH students may be receptive to any future shifts towards ESD, they lack the knowledge and means to push and advocate for that change. Results from this study correspond to research by Joury et al. on barriers to implementing ESD in dental and dental hygiene education that included a lack of knowledge and awareness on ESD.⁹ The causes behind the absence of knowledge and awareness of ESD in both dental and DH students is due, in part, to the lack of educational material on ESD.⁹ The provision of ESD educational materials similar to the online module and follow-up assignment in this study could be used in other DH programs or as a CE course to help overcome the knowledge and awareness barriers.

The educational materials created for this study can be reproduced or serve as a model for future educational interventions related to ESD. Implementation of a follow-up assignment following any educational interventions is also recommended to reinforce the educational material. Based on post-assignment survey responses, most participants felt that the follow-up assignment was beneficial to their learning about environmentally sustainable dentistry. Participants also thought that the assignment pushed them to make behavioral changes in the clinic to limit waste.

Practical Implications

The inclusion of environmental sustainability in the DH curriculum is a valuable component of the public health aspect of DH education. Teaching environmental sustainability and its role in public health will help encourage dental hygiene students to look beyond the obvious when evaluating variables that affect their patient’s oral health.

The topic of nutrition can illustrate this point well. In school, DH students learn about the connection between diet and oral health. For example, patients with imbalanced diets high in sugar and carbs are at elevated risk of caries development.¹³ However, it is not as simple as telling a patient to eat more nutritious foods and factors such as social inequities must be considered. Though social inequities are a more abstract variable to consider for oral health factors, they are no less important. Similarly, ESD is also an abstract but important variable of oral health. For example, environmental sustainability is crucial in developing equitable food security policies that push for better diets for the public and promote oral health. Environmental sustainability and its principles are utilized for managing variables such as water use, minimizing food waste, and effective use of resources.¹⁴⁻¹⁵ There is an undeniable tie between environmental sustainability and oral health.

Integrating environmental sustainability into the DH curriculum may also create opportunities for interprofessional education (IPE) and collaboration. For example, ESD can be further strengthened by including sustainability into the curriculum of dental and dental assisting students. In clinical practice settings, as well as in dental education, dentists and dental assistants are often responsible for procuring, managing, and disposing of supplies.

IPE collaboration can also extend beyond dental education students. Outside of the SHE network, the CSH also has a Fellows and Scholars program where healthcare professionals of various backgrounds learn about environmental sustainability and are trained to incorporate strategies into their practice settings.¹⁶ Health care professionals in the US can consider adopting a similar approach. Students of various healthcare backgrounds (dental, medical, social work etc.) could learn together and identify areas of practice within their respective professions that would benefit from a sustainable approach. Not only would they be able to learn more from each other and about their respective health care fields, but students would also learn from experts that they may not have been exposed to otherwise such as environmentalists, scientists, and public health experts. The feasibility of IPE on environmentally sustainable healthcare is especially promising in educational settings where there are already student groups from varied fields of study dedicated to the topic.¹⁷

Limitations and Future Research

Although the educational module intervention supported the study hypothesis, there were limitations. One limitation was the small sample size from one institution and this study should be considered a pilot study to provide insight into what one may expect to see on a similar study at a larger scale. Participant recruitment and response rate were also limited due to the COVID-19 pandemic. Opportunities to recruit a larger pool of participants outside of the UNC-CH second-year DH class had to occur virtually. Recruitment and data gathering also occurred at the beginning of the COVID pandemic, when participants found themselves in volatile and likely overwhelming situations.

Initially, the study intervention was planned to be an in-person seminar with active learning opportunities such as group discussions to enforce learner engagement and information retention. Due to the COVID-19 pandemic, students could not attend an in-person seminar, and the intervention occurred online. While there were concerns that the quality of education may decline due to online format, participants indicated that they appreciated the module for its novel content and design featuring short video presentations

with accompanying questions. The virtual intervention did not appear to affect the quality and effectiveness of education. These findings were supported by a meta-analysis on the evaluation of distance learning by Allen et al. which demonstrated no significant decline in the effectiveness of online education compared to traditional in-person learning.¹⁸ While the quality of education did not diminish, future research may also consider implementing alternative educational interventions that incorporate more face-to-face interactions. Comparisons between live, virtual-only, and hybrid educational interventions could also be implemented to determine which educational delivery method may be the most effective.

Conclusion

Results from this study indicate that the topic of environmental sustainability be considered for inclusion in the DH curriculum. The environmental impact of dental waste is closely connected to the overall health of patients and the public. Dental hygiene students in this study were receptive to ESD educational material, became familiar with new and alternative products, and found the learning experience fulfilling. Results of this study can advocate for the widespread implementation of ESD in dental and dental hygiene education, but also in other health care professions creating both intra- and interprofessional education opportunities. Future research should include testing this ESD education module on a larger sample size and include follow-up studies on the retention of environmentally sustainable interventions in clinical practice.

Acknowledgments

The authors would like to extend a special thank you to Dr. Ceib Phillips and Miss Pooja Saha for their guidance with the statistical analysis of this study.

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