Environmental Impact of Waste in Dental Care: Educational Strategies to Promote Environmental Sustainability

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Abstract. **Dental practice generates significant waste with significant environmental impact, but the lack of awareness and education about sustainability in dental waste management postulates challenges for public health and professional training, so effective educational strategies are needed to promote sustainable practices and environmentally responsible dental care. The study used a mixed longitudinal approach to evaluate changes in dental students. Data were collected from 15 students through surveys, interviews as well as documentary analysis. Educational strategies were designed and implemented, followed by rigorous statistical and qualitative analysis, ensuring validity and research ethics. After the course, a significant increase in knowledge was observed, with more than 80% of the students acquiring basic knowledge about the types of pollutants and their environmental impact. In addition, there was a positive change in attitudes, with more than 70% expressing greater awareness and two willingness to adopt sustainable practices in disposal management. Students also recognized the importance of caring for the environment, with more than 80% showing a greater willingness to implement sustainable practices in their future professional practice. Environmental education is fundamental to the promotion of sustainable practices in dental care. Educational strategies can generate significant changes in students' knowledge, attitudes and perceptions, influencing the adoption of more sustainable practices in clinical practice.**

Keywords: Dental practice, Environmental education, Environmental sustainability, Ethical responsibility, Waste management.

INTRODUCTION

Dental practice, although essential for oral health care, carries a significant environmental impact due to the generation of various wastes, such as amalgams, resins and chemicals [1]. In the context of the National University Toribio Rodriguez de Mendoza of Amazonas, the lack of investigators and low awareness of environmental sustainability in dental waste management represent a major concern. This situation postulates challenges both in terms of public health, due to possible contamination of the local environment, and in the training of future dental professionals, who may lack the necessary education on sustainable practices [2]. Therefore, the need to address this issue through effective research and educational strategies becomes imperative to promote environmentally responsible and sustainable dental care.

The importance of implementing educational strategies to foster environmental awareness and promote sustainable practices in dental clinic disposal management lies in several fundamental aspects that converge in both environmental, public heath, and professional ethics [3]. First, dental practice generates a significant amount of waste that can have a negative impact on the environment if not properly managed. These disposals include mercury-containing dental amalgams [4], composite resins, radiographic relay chemicals, and other biological and chemical materials. Improper management of these wastes can result in soil, water, and air contamination, which in turn can affect the health of local ecosystems and surrounding communities [5].

In addition, the adoption of sustainable practices in dental clinic waste management can significantly contribute to the reduction of the environmental footprint of the dental practice [6]. By implementing measures to reduce, recycle, and reuse materials, as well as to minimize the generation of disposals, dental clinics can decrease their

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environmental impact. From a public health perspective, proper management of dental waste is essential to prevent the spread of infectious diseases and protect the health of patients, clinical staff, and the general public [7]. Biological and chemical wastes generated in otologic practice may contain pathogens and toxins [8] that pose a health risk if not handled properly. Therefore, educating dental professionals on best practices for waste management is crucial to ensure a safe and healthy clinical environment. As healthcare professionals, dentists have a responsibility to protect the health and well-being of their patients, as well as to contribute to the well-being of society at large [9]. This includes an ethical responsibility to minimize the environmental impact of their practice and to act ethically and environmental responsibility.

Students' knowledge of the environmental impact of dental waste, their attitudes toward waste management and their willingness to adopt more sustainable practices [10], as well as their perceptions of the importance of caring for the environment in the context of dental care, are key aspects that can have a significant impact on clinical practice and overall environmental sustainability. By being informed about the different types of disposals generated in dental practice, as well as their potential impacts on the environment and public health, students are better equipped to make informed decisions and adopt sustainable practices in their future professional practice [11].

Students' attitudes toward environmental waste management play an important role in promoting sustainable practices [12]. If students show a positive attitude and a willingness to adopt sustainable practices, they are more likely to be motivated to implement changes in their clinical practice and work toward reducing their environmental footprint [13]. On the other hand, negative or indifferent attitudes may hinder efforts to promote environmental sustainability in dental practice.

Students' perceptions of the importance of caring for the environment in the context of dental care can influence their behavior and adoption of sustainable practices [14]. If students perceive that caring for the environment is an integral part of their role as health care professionals, they are more likely to consider environmental sustainability as a priority in their clinical practice and actively seek ways to minimize environmental impact [15].

From an internal perspective, they may indeed face barriers related to lack of awareness of the importance of environmental sustainability, resistance to change, lack of resources and adequate training, as well as concerns about the cost and feasibility of implementing sustainable practices in clinical practice [16]. In addition, trainees' personal attitudes and values toward the environment and sustainability may also influence their willingness to adopt more sustainable practices. Externally, barriers may be faced related to lack of institutional support, lack of clear policies and guidelines on sustainable practice in dental [17], as well as limitations in the infrastructure and resources available in dental clinics. In addition, factors such as time pressure, clinical workload and patient demands may also hinder the implementation of sustainable practices in daily practice.

Changes in students' knowledge, attitudes, and behaviors after implementation of educational strategies demonstrate a significant increase in knowledge about environmental impact, as well as a positive change in attitudes toward waste management and adoption of more sustainable practices [18]. Previous studies have shown that education and awareness about effective tools to promote changes in knowledge, attitudes, and behaviors related to environmental sustainability in different contexts, including medical and dental care [19]. By providing students with a comprehensive education on the importance of environmental sustainability in ontological practice and fostering more sustainable attitudes and behaviors, we can work toward a more environmentally conscious and responsible dental practice and society as a whole [20].

The purpose of the study was to contribute to the development of more sustainable practices in dental care by evaluating the effectiveness of educational strategies designed to promote environmental awareness and the adoption of sustainable practices among dental students. By addressing the lack of previous research in this area and recognizing the need for environmental awareness and action in dental practice, the study sought to provide empirical evidence on the effectiveness of educational interventions to improve students' knowledge, attitudes, and behaviors related to waste management and environmental sustainability. With this purpose in mind, it was hoped that the results of the study would help inform future educational policies and programs at the Universidad Nacional Toribio Rodriguez de Mendoza de Amazonas and other similar educational institutions, as well as promote a more environmentally conscious and responsible ontological practice.

MATERIAL AND METHODS

Study design:

A mixed approach was chosen, combining qualitative and quantitative methods to obtain a complete and in-depth understanding of the phenomenon studied. A longitudinal study design was employed to collect data two points in time and assess changes in students' knowledge, attitudes, and behavior over time [21].

Population and Sample:

The target population of the study was the 15 students enrolled in the clinical course of the Faculty of Stomatology of the National University Toribio Rodriguez de Mendoza of Amazonas. Since this population constitutes the totality of students in the clinical courses, sampling was not applied, since all available students were evaluated. This guaranteed the total representativeness of the students in the study. The sample size was considered adequate to allow for rigorous statistical analysis of the data, while maintaining a pre-established level of confidence and precision.

Data Collection:

A combination of data collection methods was used, including surveys, semi-structured interviews, and documentary analysis. A structured questionnaire was designed to assess students' knowledge, attitudes toward environmental sustainability, and practices related to waste management in dental care. Semi-structured interviews were conducted to delve deeper into specific topics and

capture more detailed perceptions of the participants. In addition, existing educational materials and institutional documents related to teaching environmental sustainability at the University were analyzed.

Implementation of educational strategies:

Educational strategies were designed and implemented based on the findings of the literature review and the needs identified in the student population. These strategies included workshops, seminars, printed educational materials and online resources designed to promote environmental awareness and encourage sustainable practices in dental care.

Data Analysis:

Descriptive and inferential statistical analysis of quantitative data collected through surveys was conducted using techniques such as frequency, correlation, and regression analysis. The qualitative data obtained from the interviews and documentary analysis were analyzed using thematic content analysis to identify patterns, emerging themes and relationships between the data.

Validation and Reliability:

Steps were taken to ensure the validity and reliability of the data, including triangulation of methods, peer review, and verification of the consistency of findings across different sources and data collection techniques.

Ethical Considerations:

Ethical approval was obtained prior to conducting the study. The informed consent of the participants was guaranteed and the principles of confidentiality and anonymity were respected in the handling of the data.

RESULTS

Knowledge of environmental pollutants:

Prior to the competition, an initial assessment of students' knowledge of environmental pollutants was carried out using a questionnaire designed to assess understanding of the different types of pollutants generated in dental practice and their impact on the environment. The results revealed that 0% of the students had knowledge on this topic before receiving the specific education.

After the course, a second evaluation was performed to measure the change in the students' knowledge. A significant increase in knowledge was found, with more than 80% of students gaining basic knowledge about the types of contaminants, including biological, chemical, and radioactive disposals, generated in the dental practice and how they can affect the environment. Students demonstrated an understanding of the risks associated with improper management of these wastes and the importance of proper management to minimize environmental impact.

Attitudes towards waste management and environmental sustainability:

Prior to the course, student attitudes toward waste management and environmental sustainability were assessed through surveys designed to measure student perceptions of the importance of adopting sustainable practices in clinical practice. The results indicated that 0% of the students had positive attitudes toward this topic prior to receiving the specific education.

Subsequent to the course, a second evaluation was conducted to determine if there had been a change in the students' attitudes. A significant positive change was observed, with more than 70% of students expressing an increased awareness and willingness to adopt sustainable practices in waste management in clinical practice. Students showed a renewed commitment to the importance of environmental sustainability in their future professional practice.

Perceptions of the importance of caring for the environment:

Prior to the course, students' perceptions of the importance of caring for the environment in the context of dental practice were assessed using surveys designed to measure students' perceptions of the ethical responsibility to protect the environment. The results indicated that 0% of the students considered this topic important prior to receiving the specific education.

After the course, a second evaluation was conducted to determine if there had been a change in the students' perceptions. A significant change was found, with over 80% of students recognizing the importance of caring for the environment and the need to adopt sustainable practices in their future professional practice. Students demonstrated a deeper understanding of their ethical responsibility to protect the environment and a greater willingness to implement sustainable practices in their clinical practice.

DISCUSSION

The present investigation focused on evaluating the impact of educational strategies to promote environmental sustainability in dental practice among university students. With the aim of addressing the lack of awareness about the disposals derived from dental care and their environmental impact, a course was designed to provide specific education on the subject. The results obtained revealed significant changes in students' knowledge, attitudes and perceptions, indicating the potential of environmental education to promote more sustainable practices in dental care.

First, there was a notable increase in students' knowledge of environmental pollutants associated with dental practice. Prior to the course, no students had basic knowledge about the types of pollutants generated in the dental practice and how they can affect the environment. This finding suggests that targeted education can be effective in closing the knowledge gap and sensitizing students to environmental challenges in their future professional practice [22].

In terms of attitudes towards disposal management and environmental sustainability, the results also showed a positive change. Before the course, none of the students had positive attitudes towards waste management and environmental sustainability. However, after the course, more than 70% of the students expressed an increased awareness of the importance of adopting sustainable practices in waste management and showed a willingness to implement them in their clinical practice. This suggests that environmental education can significantly influence students' attitudes [23], and foster a greater commitment to

sustainability in dental practice. In line with previous research highlighting the importance of environmental education in the healthcare setting, our study aligns with the findings of Al-Qarni [24], who demonstrated that the implementation of educational interventions increased knowledge about eco-friendly dentistry among dental professionals and students. Likewise, Lopez-Medina et al. [25] emphasized the need for comprehensive training in sustainable health care, evidencing student demands for more training in low environmental impact practices. This supports the importance of our educational intervention to address the lack of knowledge and awareness of waste management in dentistry.

Our findings also agree with the results of Revankar et al. [12], who found a high level of knowledge among dental students about biological waste management, suggesting that students may be receptive to environmental education in this field. However, it is crucial to note that, although students may have prior knowledge, our educational intervention achieved a significant increase in knowledge about environmental contaminants associated with dental practice. This underscores the effectiveness of targeted educational strategies to close the knowledge gap and sensitize students to environmental challenges in their future professional practice.

Regarding perceptions of the importance of caring for the environment, the results were also encouraging. Before the course, none of the students considered it important to care for the environment in the context of dental practice. However, after the course, more than 80% of the students recognized the importance of caring for the environment and the need to adopt sustainable practices in their future professional practice. This finding emphasizes the importance of environmental education in dental education and its ability to influence students' perceptions of the ethical responsibility to protect the environment [26].

These results are consistent with the findings of Mayta-Tovalino et al. [15], who showed that dental students in Peru have a high level of knowledge and awareness of the need for proper management and/or recycling of biomedical waste from dental products. Although no significant variables were found to be associated with this relationship, this suggests that the students are well informed about waste management, which reinforces the importance of environmental education in the training of health professionals. Likewise, the results of Gershber et al. [20] indicate that dental students in the United States recognize the importance of environmental sustainability in dental practice, although most reported limited knowledge in this field. This highlights the need to integrate content related to environmental sustainability into dental educational programs to ensure that future professionals are prepared to address environmental challenges in their clinical practice. On the other hand, Chen et al. [27] found that pharmacy students in Australia lack knowledge of sustainable environmental pharmacy practices and have limited standing to content related to this topic in their curricula. These findings underscore the importance of including environmental sustainability content in healthcare educational programs, not only in dentistry, but also in other healthcare-related disciplines. Taken together, these studies support the importance of environmental education in the training of health care professionals and highlight the need to integrate content related to environmental sustainability into dental and pharmacy education programs to promote more sustainable practices in health care.

Despite the encouraging results, it is important to recognize the challenges and limitations associated with implementing sustainable practices in dental care [28]. barriers identified by students included lack of awareness or education about sustainable practices, costs associated with implementing more sustainable technology, and resistance to change by clinical staff. These challenges underscore the need to address not only the education of students, but also the ongoing training of clinical staff and the creation of an enabling environment for the adoption of sustainable practices.

CONCLUSION

The results of this study emphasize the crucial role of environmental education in promoting more sustainable practices in dental care. The implementation of specific educational strategies can lead to significant changes in students' knowledge, attitudes, and perceptions, which in turn can influence the adoption of more sustainable practices in clinical practice. However, continued efforts are needed to address the challenges and limitations associated with implementing sustainable practices and to ensure lasting commitment to environmental sustainability in dentistry.

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