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Abstract: Creating environmentally sustainable oral healthcare culture requires embedding contents in dental curriculum. This study aimed to explore the current knowledge and drivers among dental students and educators regarding environmentally sustainable dentistry (ESD) in the United Arab Emirates (UAE) and identify barriers and enablers to embrace it. A cross-sectional survey using online questionnaire was carried out in undergraduate dental educational institutes. Data analysis included descriptive statistics and thematic analysis. Most students and educators were not aware of ESD content in their curriculum. However, the majority of educators were familiar with ESD concept, while students were mostly unfamiliar. Nonetheless, students largely agreed on its importance and their interest in learning it, as they view it relevant to their future practice. Educators agreed that the dental profession has a responsibility to be environmentally friendly and expressed desire in introducing ESD content into the curricula. Several barriers were reported such as lack of knowledge, curriculum space, educational resources, and time. Meanwhile, enablers included providing training and resources. There is no explicit presence of ESD content in the dental curricula. Regardless of the lack of in-depth knowledge among educators and more so with students, they both have positive views toward incorporating ESD into dental curricula.

Keywords: Sustainability; dentistry; students; faculty; dental education; curriculum; environment

1. Introduction

Climate change has an impact on human health and is expected to have a greater effect in the future. Years of research, negotiations, and panel meetings by the United Nations (UN), World Health Organization (WHO) and Centers for Disease Control and Prevention (CDC) highlighted the importance of responding to climate change and fighting its global and health effects [1,2]. Some of which include extreme heat, air pollution, food and water-borne illnesses and infectious diseases that can have repercussions on human health such as the fast spread of viral infections which increases the incidence of pandemics and contributes to the difficulty of controlling them such as the recent COVID- 19 breakout [3,4]. Moreover, climate change currently takes hold of every advancement and development of multiple fields. Thus, several services and systems including the healthcare sector started to take into consideration their contributions to the climate crisis at each step of their businesses. As more people are becoming aware of the great threats that climate change imposes on the planet, it is important to comprehend the climate footprint of the healthcare system and carry the Hippocratic Oath of "Do No Harm" to a greater scope that includes the impact on the environment. The global expansion of the medical sector, combined with the increase in the use of disposable medical products, has contributed to the generation of massive amounts of medical waste [5].

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According to the World Economic Forum (WEF), the healthcare systems account for over 4% of global carbon dioxide (CO2) emission, which is considered more than that of the aviation and shipping sectors combined. Hospitals have the highest energy intensity of all publicly funded buildings and emit 2.5 times more greenhouse gasses than commercial buildings [3]. The global health climate footprint is equivalent to the annual greenhouse gas emissions from 514 coal-fired power plants [6].

The oral healthcare field is also a demanding and resource intensive sector that relies on large supplies of energy, water, and fuel for various clinical activities. This resource consumption inevitably contributes to greenhouse gas emissions and environmental pollution [7,8]. In dentistry, there is an impact on the environment along the timeline of the practice, starting from resourcing the materials, manufacturing them, the transport of patients to and from the clinic, the energy consumption of the practice, and disposal of waste [9]. For instance, Duane et al. identified aspects of dental practice that have the highest impact on environmental emissions. After categorizing them into core emissions, community emissions, and supply chain emissions, they found that the highest CO2 emission comes from the community. Travel is the most concerning as it directly contributes to CO2 emissions and has an impact on health and quality adjusted life years (QALYs). When all aspects were analyzed for their footprints, it was observed that more environmentally friendly approaches can be followed to ameliorate the deleterious impacts; and once a vision for change is achieved, the barriers are overcome through educating and motivating dental staff to move the practice into a sustainable route. However, to achieve this goal there is a need to identify external areas outside of the dentist's control that can have an influence on the adoption of sustainable dentistry practices such as policy makers, professional educators, and researchers [10,11].

The attention towards planetary sustainability led to various international policy agreements such as the Paris agreement and the Sustainable Development Goals (SDG) [12]. Such policies allow the globalization of shared understanding in relation to the importance of sustainability within the dental practice. The main hurdle to switch from the established conventional dental practice into a more sustainable one is the lack of awareness among the profession. Early in March 2003, the 5th European Dental Students' Association Congress of Belgrade introduced the term "Green Dentistry" which refers to the concept of environmental sustainability in dentistry (ESD) and recommended several regulations and policies that are compatible with sustainable development strategies. It further encouraged some countries to adopt this project such as Croatia, Sweden, the Netherlands, the United Kingdom (UK), and Greece [13]. More recently, there is notable growing interest in ESD in the education sector that is evident from conferences and contributions from student committees and dental organizations worldwide, such as Association for Dental Education in Europe (ADEE), European Dental Students Association (EDSA), Saudi Green initiative Youth Green Summit, Eco-Dentistry Association (EDA) and Canadian Dental Association (CDA) [12-15].

Although ESD started to gain popularity in recent years, related research started worldwide more than a decade ago [16-18]. Sustainability-related research can only have a prominent positive effect globally if it is metastasized throughout the world. Fortunately, pioneers in ESD are emerging around the globe, from Europe and Asia; however, if we view the topic from a wider scope, knowledge and awareness about ESD are still mundanely deficient, and more research is warranted for better understanding on the current situation and broadly disseminating related information. A study from the Dental School at the University of Manchester demonstrated that despite students' familiarity with environmental aspects of sustainability, additional efforts are needed to foster understanding of sustainability within the dental curriculum [19]. Similarly, a more recent study conducted to explore ESD in dental curricula at the Institute of Dentistry of Queen Mary University of London and Harvard School of Dental Medicine in the UK and the United States of America (USA), respectively, highlighted the interest of students and educators in the topic of ESD despite the lack of formal presence of the topic in their dental curricula [20]. The students and educators at both institutes showed positive attitudes to adopt ESD into the curricula, yet there are obstacles and barriers such as lack of knowledge and educational materials about ESD and time constraints to prepare related contents. The study further elaborated that enablers to incorporate ESD into the curricula include offering training courses to educators, providing ESD-related learning outcomes,

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creating capacity for educators to work on embedding ESD, providing institutional backing and carrying out relevant policy reforms [20]. The deficiency in ESD knowledge among practitioners, educators and students stems from the absence of education about ESD in the dental curriculum around the world. Thus, professional educators' and students' knowledge and awareness about ESD can enable the introduction of ESD within modern dental curricula worldwide. According to Martin et al. education plays a paramount role in raising proper awareness and promoting positive behavior and attitude changes for the adoption of policies related to ESD, and the starting point can be at an undergraduate university degree program and further through continuing professional development programs. These measures would ensure establishing a normalized attitudinal change amongst the next generation of professionals to provide oral health care in a sustainable manner [9].

The United Arab Emirates (UAE) is pioneer in creating sustainable environment in the region, in line with the pillars of the National Agenda of Vision 2021. The UAE hosts around 134 institutions of higher education and the largest concentration of International Branch Campuses. Recognizing that knowledge institutions are key partners in the implementation of SDG, the government aims to ensure that principles of sustainable development are reflected in the curricula at all levels of education [21]. Nonetheless, regardless of the country's tremendous efforts towards environmental sustainability, there is a lack of contribution to these endeavors in the dental field. New research about ESD and laying down the groundwork of knowledge will pave the way for incorporating the subject in the dental curricula. We believe that embedding environmental sustainability in the dental curricula starts with exploring the current outlook. Thus, this study aimed to explore the current knowledge and drivers among dental students and educators regarding ESD in the UAE and identify barriers and enablers to embrace it in dental education in the region.

2. Materials and Methods

The present study was approved by the University of Sharjah research ethics committee under IRB no: REC-22-09-23-03-S. To assess the perspective and attitude of the academic community of dental students and educators around the UAE towards ESD, a cross-sectional survey using online questionnaire was circulated and carried out at the undergraduate dental educational institutes within the UAE. Invitations to participate were sent to all full-time dental educators (faculty) (n=140), as well as all dental students at the undergraduate level of education (n=1,900) in the UAE.

The questionnaire was adapted from Joury et al study that was conducted in 2021 [20]. Only a few modifications were made to the questions, to ensure that they are appropriate for the study population and enhance questionnaire completion. Some were removed for congruence with the study community and others were rephrased for clarity and comprehensiveness. The questionnaire begins with a brief definition of the topic and introduction to avoid biased, inaccurate and unreliable responses and receive informed answers. To ensure that the questionnaire's content was epitomized in terms of exploring current ESD teaching, assessment, and practice; further research of the recent literature was executed prior to reviewing and finalizing the survey. Both versions of the questionnaire for students and educators were used in this study.

Separate invitation emails were sent to the faculty and students of each institution separately. A reminder was sent by email twice between the period of November 2022 and March 2023. Data analysis included generation of summaries of the data samples by descriptive statistics and closely identifying and interpreting patterns of meaning within our qualitative data by thematic analysis.

3. Results

In this study, 8% of students and 37.8% of educators responded, with a total number of 153 students and 53 educators. Students' ages ranged between 17 and 24 years, which included a percentage of 32% males, and 68% females. As for the age of the educators, it ranged from 28 to 64 years, which included 58.5% and 41.5% of males and females, respectively. Most educator participants were moderately (26.4% 14/53), somewhat (28.3% 15/53) or slightly familiar (28.3% 15/53) with the concept of ESD, while only 9.4% (5/53) were extremely familiar and 7.5% (4/53) were not familiar at all (Table 1). However, 26.8% (41/153) of students were not familiar with the concept and

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only 3.3% (5/153) were extremely familiar (Table 1). Students largely agreed on the importance of ESD and their interest in learning it, as they view it relevant to their future practice (Tables 1 and 2). Educators also agreed on the importance of ESD and teaching it and expressed desire in introducing it into the dental curricula (Tables 1 and 2).

Table 1. Students' and educators' familiarity with ESD and their opinions about the importance and professional responsibility for ESD.

Component	Overall	
	Students N (%153)	Educators N (%53)
Familiarity with ESD		
Not at all familiar	41 (26.8)	4 (7.5)
Slightly familiar	45 (29.4)	15 (28.3)
Somewhat familiar	37 (24.2)	15 (28.3)
Moderately familiar	25 (16.3)	14 (26.4)
Extremely familiar	5 (3.3)	5 (9.4)
ESD is important		
Strongly disagree	2 (1.3)	1 (1.9)
Disagree	2 (1.3)	Nil
Neutral	30 (19.6)	2 (3.8)
Agree	77 (50.3)	28 (52)
Strongly agree	42 (27.5)	22 (41.5)
Profession's responsibility for ESD		
Strongly disagree	5 (3.3)	3 (5.7)
Disagree	1 (0.7)	Nil
Neutral	19 (12.4)	2 (3.8)
Agree	77 (50.3)	26 (49.1)
Strongly agree	51 (33.3)	22 (41.5)
ESD teaching is important		
Strongly disagree	5 (3.3)	1 (1.9)
Disagree	1 (0.7)	Nil
Neutral	30 (19.6)	2 (3.8)
Agree	69 (45.1)	22 (41.5)
Strongly agree	48 (31.4)	28 (52.8)
Awareness of any ESD content being included in their dental curriculum		
Yes	39 (25.5)	11 (20.8)

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No	114 (74.5)	42 (79.2)

Table 2. Students' and educators' interest in ESD teaching and learning.

Component	Overall	
	Students N (%153)	Educators N (%/53)
ESD relevance for future dental practice		
Strongly disagree	3 (2)	-
Disagree	2 (1.3)	-
Neutral	35 (22.9)	-
Agree	68 (44.4)	-
Strongly agree	45 (29.4)	-
Interested in learning ESD		
Strongly disagree	3 (2)	-
Disagree	3 (2)	-
Neutral	39 (25.5)	-
Agree	75 (49)	-
Strongly agree	33 (21.6)	-
Interested in introducing ESD into the dental curriculum		
Strongly disagree	-	1 (1.9)
Disagree	-	Nil
Neutral	-	10 (18.9)
Agree	-	23 (43.4)
Strongly agree	-	19 (35.8)

Participants were asked about their awareness of any ESD content being included in the dental curriculum and it was found that 20.8% (11/53) of educators and 25.5% (39/153) of students think that ESD content is present at their institution (Table 1). Those who reported the presence of ESD in the curriculum were also asked about the ESD-related topics covered. Measuring and embedding sustainability into current dental practice and waste management got 8 out of 11 educator responses as examples of the covered topics, while sustainable equipment and supplies and energy saving were reported by 6 and 5 educators; respectively. Meanwhile, biodiversity and green space, travel and digital radiograph got the least responses; 3, 2, and 1 educator; respectively. As for students, 23 out of 39 reported that energy conservation measures, such as turning off lights, monitors, and chairs when not in use were covered, while 22 students mentioned the presence of sustainable equipment and supplies topics. Meanwhile 18, 16, and 14 students indicated for waste management, measuring and embedding sustainability into current dental practice and travel; respectively. The least frequently mentioned topic was biodiversity and green space, with 9 students selecting this answer. Educators and students who reported the presence of ESD-related topics in the curriculum were further inquired about the format of content delivery, time devoted, assessment of student's knowledge, and individuals responsible for the teaching ESD content, and the results came as the

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following. According to the 11 educators, the most common forms of ESD-content delivery are lectures, seminars, project and tutorials in a descending order. The most selected devoted time is 2-4 hours (6 out of 8), followed by less than 2 hours (3 out of 8), and more than 4 hours (1 out of 8). One educator stated that there was no devoted individual for ESD teaching despite its presence in the curriculum. The mostly used format of assessment according to educators were multiple-choice questions, presentation and clinical evaluation, and written essay in a descending order. One educator reported that students are taught but not assessed and another reported that students are neither taught nor assessed despite the presence of ESD-content in the curriculum. Regarding the responsibility of teaching ESD content, all answers were not explicit and only indicated that dental faculty of the different courses are involved in the teaching. According to the 39 students, the most common forms of ESD-content delivery are lectures, tutorials, projects, and seminars in a descending order. The most selected devoted time is less than 2 hours (16 out of 39), followed by 2-4 hours (14 out of 39), and more than 4 hours (5 out of 39). Four students responded to 0 time devoted for ESD teaching despite its presence in the curriculum. The mostly used format of assessment according to students were multiple-choice questions, clinical evaluation, presentation and written essay in a descending order. Six students reported that they are taught but not assessed and three of them reported that they are neither taught nor assessed despite the presence of ESD-content in the curriculum. Regarding the responsibility of teaching ESD content, most of the answers indicated that dental faculty of the different courses are involved; however, 8 students indicated that they did not know the answer for this question.

Tables 3 and 4 summarize the identified barriers and enablers by all educators for integrating ESD in the dental curricula. According to the educators, the most reported barrier is lack of knowledge about ESD, followed by insufficient curriculum space and resources for ESD educational materials. Other limitations included lack of time for preparing ESD content and not prioritizing ESD in the dental curriculum. The most reported factor that could help enable the integration of ESD into the dental curricula was the provision of training courses for educators and teaching staff on ESD. Additionally, other important factors that enable the embedding of ESD in dental curricula include setting ESD-related learning goals and providing educators with time and resources to work on integrating ESD.

Table 3. Educators' barriers to embedding ESD in the dental curricula.

Barrier	Educators N (%/53)
Lack of knowledge	39 (73.6)
Lack of capacity/time	18 (34)
Lack of educational resources	20 (37.7)
Lack of Priority	15 (28.3)
Lack of curriculum space	31 (58.5)

Table 4. Educators' enablers to embedding ESD in the dental curricula.

Enabler	Educator N (%/53)
Learning outcome	30 (56.6)
Training courses	45 (84.9)
Capacity/time	36 (67.9)
Presentation for students and staff	1 (1.9)

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More than half of all students (54.9%) and a significant majority of all educators (75.5%) emphasized the importance of incorporating ESD teaching in both classroom and clinical settings. One of the students stated: 'I hope students and staff, people in general, will be more aware of ESD. They should know and be reminded of the importance of our environment. I hope our feedback will help you proceed with this goal'.

4. Discussion

Regardless of the lack of knowledge among students and educators in the UAE and the paucity of official and clear inclusion of ESD in the current dental curricula demonstrated in this study, positive attitudes exist among most students and educators to adopt and integrate ESD into the curriculum. These findings concur with previous research in the literature on medical education [22-24]. There is an evident awareness towards practical environmental protection within the young student generation, such as initiatives related to environmental sustainability like cycling and public transportation schemes. However, significant barriers need to be addressed to integrate ESD in dental curricula including the lack of knowledge about ESD among students and educators, insufficient curriculum space and resources, lack of time for preparing the needed contents, and the tendency to not prioritize ESD learning outcomes. To overcome these barriers, this study recommends providing training courses for educators and teaching staff on ESD "educate the educators", integrating the subject in both classroom and clinical settings and focusing on setting ESD-related program objectives. This list of recommendations does not necessarily require a complete overhaul of the educational program but rather incorporating ESD content into existing dental curricula. The barriers and enablers identified in this study share large similarities between sustainability-related barriers and enablers reported in medical education. In addition, it is worth mentioning that the results of our study are in consonance with those obtained in Joury et al in 2021 that explored ESD in dental schools in the US and UK [20].

The efforts towards incorporating ESD in the dental curricula in the UAE can be facilitated by easing the way for educators to become competent in delivering ESD material through teaching techniques that students appreciate such as Socratic seminars, reciprocal teaching and interdisciplinary learning. Moreover, laying the groundwork to achieve this goal require identifying steps to make ESD related topic available as a resource at different educational facilities. However, providing adequate resources can be an impediment that should be overcome. Most resources are medical based and do not fully encompass dentistry or are outdated hence the need for adapted, modified and updated contents that are applicable to the dental field. Another innovative and practical method to educate dental faculty on the topic is encouraging them to be part of associations and attend international conferences that are attempting to embed UNESCO's SDGs into higher education, in addition to increasing the awareness of the faculty on the country's recent efforts for sustainable development, mainly in the healthcare sector such as Abu Dhabi's healthcare sustainability goals which aim to reduce carbon emissions [25-27].

It cannot be stressed enough that the focus should be also on dental students who will be the main players to develop enduring sustainability related attitudes among future dental clinicians, and the starting point should be from their undergraduate dental education to instill these values. Hence, this study acknowledges the importance of students' role as initiators for promotion of environmental education. The students' interests in learning ESD, their agreement that ESD is relevant to their future practice and the younger generations' inherent feeling of responsibility towards the environment indicate that their involvement in initiating ESD activities and collaborations can lead to successful implementation of ESD in the current curricula and later in the dental practice. Clinicians and students developing partnership in the learning process in this continuously developing field might be for the greatest interest. The different institutes that provide dental education can open the door to a shared collaboration to introduce ESD within their curricula, such agreement is a driver to accelerate the progress of ESD incorporation on a larger scope. Notwithstanding, funding, organizational factors and property challenges hinder such innovative measures that must take place in a wide spectrum, thus legislative authorities must address these challenges.

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Despite the interest towards ESD, having ESD legitimately embedded in the dental curriculum in the UAE requires regulatory bodies including the Ministry of Education (MOE), Commission for Academic Accreditation (CAA), Ministry of Health and Prevention (MoHAP) and MOE National Qualification Centre (NQC) to agree on incorporating sustainable dental practices into the learning outcomes, placing thereby an obligation on dental education providers to embed sustainability in their dental curricula. A structured Delphi approach could be ventured to identify a consensus view among dental students, educators, and other key allies about environmental sustainability learning outcomes in dental education and the possibility of making it a part of the professional competency standards [28].

Despite the intriguing findings of the current study, several limitations are present that need to be addressed. The low response rate might make it difficult to generalize the current findings to include all the students and educators at the various dental institutes in the UAE. It is also plausible that the present questionnaire mainly included participants that were interested in ESD. The participants' limited exposure to ESD, however, actively works against this possibility. Lack of in-depth qualitative data due to the type of questions in the survey might have been another limitation. Yet, by allowing for free text responses, the current study was able to compile enough qualitative data to meet its objectives. To advance environmental sustainability agenda in dental education and practice, more research is required on several aspects including the availability of materials, tools and equipment within the dental industry that comply with sustainability-related goals.

5. Conclusions

There is no explicit ESD-related content in the undergraduate dental curricula at the dental education institutions in the UAE. Regardless of the lack of adequate knowledge on the ESD topic among educators and more so within students, they both have/share highly positive views towards incorporating ESD into the curriculum. This requires implementing strategies to remove the stated barriers and provide enablers, and this goal can be achieved by incorporating ESD into UAE dental education requirements, changing certain laws based on crucial findings, and receiving institutional endorsement and assistance in the form of incentives, training, and academic resources. Overall, this study highlights the importance of promoting ESD in dental programs, as it can have significant benefits for both the environment and the future of dental profession in the UAE. The findings provide valuable insights for educators, policymakers, and stakeholders on the potential barriers and enablers for integrating ESD into UAE dental curricula and can inform the development of strategies and initiatives to promote sustainability in UAE dental education.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The authors confirm that the data supporting the findings of this study are available within the article.

Conflicts of Interest: The authors declare no conflict of interest.

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