Exploring environmental sustainability in UK and US dental curricula and related barriers and enablers: a cross-sectional survey in two dental schools

Easter Joury,*[1] Jennifer Lee,[2] Ashwini Parchure,[2] Frances Mortimer,[3] Sang Park,[2] Cynthia Pine,[1] Darshini Ramasubbu[4] and Linda Hillman[5]

Key points

While environmental sustainability in dentistry (ESD) does not exist formally in dental curricula, students and educators are greatly interested in it.

Major barriers to embracing ESD in dental curricula include lack of knowledge about ESD, lack of time for preparing ESD content, lack of ESD educational materials and current infection control regulations.

Main enablers include offering 'teach the teacher' training courses to educators, providing ESD-related learning outcomes, creating capacity for educators to work on embedding ESD, lobbying regulators to include ESD as a mandate in dental education, providing institutional backing and carrying out relevant policy reforms.

Abstract

Introduction Very little is known about the knowledge and attitudes of dental students and educators regarding environmental sustainability in dentistry (ESD), the presence of ESD in dental curricula, and barriers and enablers to embracing ESD in dental education.

Methods A cross-sectional survey using piloted online questionnaires for students and educators was carried out at the Institute of Dentistry, Queen Mary University of London and at Harvard School of Dental Medicine. Data analysis included descriptive statistics and thematic analysis.

Results ESD does not exist formally in the dental curricula at either institution. Despite poor knowledge, students and educators had very positive attitudes to embracing ESD in the curricula. The most noted barriers were lack of knowledge about ESD, lack of time for preparing ESD content, lack of ESD educational materials and infection control regulations. Enablers included embedding ESD in UK and US dental education standards, having institutional backing and support in terms of providing training, educational materials, capacity and incentives, as well as adopting a critical evidence-informed approach in reforming current infection control regulations.

Conclusions Dental education and infection control regulatory bodies, as well as dental institutions, can embed ESD in UK and US dental curricula by supporting the implementation of identified enablers.

Introduction

Climate change is the greatest threat to global health of the twenty-first century.[1] Healthcare systems, which were developed to protect and promote health, make a major contribution to the climate crisis and consequently result in health harm. The climate footprint of healthcare systems is equivalent to 4.4% of global net emissions. If the health sector were a country, it would be the fifth-largest carbon emitter on the planet.[2] In the United Kingdom (UK), the National Health Service (NHS) in England produces 5% of England's carbon footprint,[3] with equivalent services in the United States (US) accounting for 10%.[4] Dental services, as part of the wider healthcare system, contribute to the climate impact. Travel (including patient and staff travel), building energy use, procurement, waste, water and use of nitrous oxide are all responsible for the dental carbon footprint.[5]

The World Health Organisation has underscored the paramount importance of working towards environmental sustainability to protect public health.[6] To this end, healthcare systems and professionals should consider environmental sustainability as an integral part of their good practice to improve patient and population health through mitigation and adaptation measures. Sustainability actions may additionally benefit the healthcare system by saving money and improving patient care.[7]

With the increasing awareness of the importance and urgency of responding effectively to the climate crisis,[8] the international drive to equip healthcare professionals with sustainable healthcare-related knowledge, skills and attitudes has gained momentum.[9,10] The UK has taken the lead in integrating environmental sustainability measures into healthcare, as demonstrated by the General Medical Council, which published the *Outcomes for graduates 2018* document. The

[1]Centre for Dental Public Health and Primary Care, Institute of Dentistry, Queen Mary University of London, Turner Street, London, E1 2AD, UK; [2]Harvard School of Dental Medicine, 188 Longwood Avenue, Boston, MA 02115, USA; [3]Centre for Sustainable Healthcare, Cranbrook House, 287–291 Banbury Road, Oxford, OX2 7JQ, UK; [4]Dublin Dental University Hospital, Trinity College Dublin, Lincoln Place, Dublin 2, Ireland; [5]East of England Centre, Public Health England, Victoria House, Capital Park Fulbourn, Cambridge, CB21 5XB, UK.
*Correspondence to: Easter Joury
Email address: e.joury@qmul.ac.uk

Refereed Paper.
Accepted 4 October 2020
https://doi.org/10.1038/s41415-021-2942-y

latter places new requirements for medical education.[11] Doctors qualifying or registering in the UK should understand and apply the principles of sustainable healthcare to their medical practice. The document references the following environmental sustainability priority learning outcomes (PLOs): i) describe how the environment and human health interact at different levels; ii) show the knowledge and skills needed to improve the environmental sustainability of health systems; and iii) discuss how the duty of a doctor to protect and promote health is affected by the dependence of human health on the local and global environment.[12] These PLOs were further elaborated in the US.[13] Subsequently, medical curricula have started embracing sustainable healthcare. The goal of the latter is to provide high-quality healthcare now without compromising the ability to provide healthcare in the future.[9] This may be achieved by focusing on the improvement of health and better delivery of healthcare, rather than late intervention in disease, with resulting co-benefits to patients and to the environment on which human health depends. In other words, making healthcare more sustainable means adapting current service provision to emphasise disease prevention, patient empowerment, lean service delivery and utilising treatment options with a lower environmental impact.[14]

Dental education is lagging behind this shift in medical education. The World Dental Federation (FDI) issued a policy statement on 'Sustainability in dentistry' (2017), stating that: '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 wellbeing for all through all stages of life'.[15] However, at the 2018 European Dental Students' Association meeting, students expressed concern that sustainability was not part of the curriculum across European dental schools. Within the General Dental Council's *Preparing for practice* document, there is no requirement for sustainability to be delivered in undergraduate curricula.[16]

Advocacy to embed environmental sustainability in dental curricula should start by exploring the current landscape. Thus, this study aimed to: i) explore current knowledge and drivers among dental students and educators regarding environmental sustainability in dentistry (ESD) at the Institute of Dentistry of Queen Mary University of London (IoD QMUL) and Harvard School of Dental Medicine (HSDM); and ii) explore the presence of ESD in the dental curricula at both schools and identify barriers and enablers to embracing it in dental education.

Materials and methods

A cross-sectional survey using online questionnaires was carried out at IoD QMUL and HSDM between May 2019 and December 2020.

Ethical approval was obtained from Queen Mary Ethics of Research Committee and Harvard Faculty of Medicine Office of Human Research Administration. Consent was obtained from all participants.

Invitations to participate were sent to all educators (n = 175 and 298) as well as all undergraduate or pre-doctoral dental students (n = 343 and 138) at IoD QMUL and HSDM, respectively. Additionally, invitations were sent to all dental hygiene and therapy students at IoD QMUL (n = 20).

The development of the questionnaire was partially based on a survey questionnaire for European dental schools, to explore current understanding and teaching practice regarding sustainable healthcare.[16] To improve the validity and reliability of selected questions and enhance questionnaire completion, a number of amendments were carried out. Questions were rephrased to improve clarity. Instead of using free text or 'yes/no' response styles only, a mix of five-point Likert scales and multiple-choice questions were used in addition to free text and 'yes/no' response styles. Response options for Likert scales were ordered from negative (for example, strongly disagree) to positive (for example, strongly agree) to avoid bias related to the higher likelihood of selecting options placed on the left-hand side and hence exaggerating positive responses. Examples of sustainable dental healthcare elements were provided to ensure clarity and response accuracy. Additional questions were added, based on a review of relevant literature, to ensure that the questionnaire's content was comprehensive in terms of exploring current ESD teaching, assessment and practice. Questions were also added to explore educators' and students' familiarity with and drivers for ESD, barriers and enablers to embedding ESD in the dental curricula, and socio-demographic background. Separate versions of the questionnaire were developed for educators and students, with common elements (for example, ESD-related familiarity and interest) and different elements (for example, barriers and enablers in the educators' questionnaire only).

Questionnaires were piloted on a small number of educators and students at each institution to check content clarity, accuracy and comprehensiveness, as well as questionnaire structure and format.

Six email reminders were sent. The first reminder was sent after one week from the invitation email, the second reminder after four weeks and the third reminder after seven weeks. Due to the summer break and starting a new academic year, the rest of the reminders were sent after a four-month hiatus, at intervals of two weeks. A video invitation was added to the last three reminders to increase response rate. New dental students starting their first academic year in 2019/2020 were not included in this survey.

Data analysis included descriptive statistics and thematic analysis.

Results

The response rates were 37% and 20% for students and educators, respectively. A total of 184 students (117 [63.6%] from IoD QMUL and 67 [36.4%] from HSDM) and 93 educators (44 [47.3%] from IoD QMUL and 49 [52.7%] from HSDM) took part in this study. Students from across all dental programme years as well as educators with varying degrees of responsibility for the curriculum, seniority and speciality participated. Among students, the mean age was 22.9 (± SD = 3.8), ranging between 18 and 46 years, and 34.2% were male, 64.7% were female and 1.1% preferred not to say their gender. Among educators, the majority were aged between 25 and 54 years, and 37.6% were male, 60.2% were female and 2.2% preferred not to say their gender.

The vast majority of students and educators were unfamiliar or slightly familiar with ESD (Table 1). Among students, there was nearly a complete consensus on the importance of ESD and teaching ESD, as well as on students' interest in learning ESD, which they saw as relevant to their future practice (Table 2). Although the majority of educators agreed or strongly agreed on the importance of ESD and teaching ESD, less than half expressed their interest in introducing ESD into the dental curricula (Table 2).

Only seven students and eight educators were aware of any ESD content within the curricula. Nonetheless, they provided very little information on such ESD content

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

Component	Overall		IoD QMUL		HSDM	
	Students N (%)	Educators N (%)	Students N (%)	Educators N (%)	Students N (%)	Educators N (%)
Familiarity with ESD						
Not at all	98 (53.3)	29 (31.2)	67 (57.3)	14 (31.8)	31 (46.3)	15 (30.6)
Slightly	50 (27.2)	18 (19.4)	30 (25.6)	11 (25.0)	20 (29.9)	7 (14.3)
Somewhat	27 (14.7)	23 (24.7)	17 (14.5)	9 (20.5)	10 (14.9)	14 (28.6)
Moderately	8 (4.3)	20 (21.5)	3 (2.6)	9 (20.5)	5 (7.5)	11 (22.4)
Extremely	1 (0.5)	3 (3.2)	0	1 (2.3)	1 (1.5)	2 (4.1)
Missing	0	0	0	0	0	0
Profession's responsibility for ESD						
Strongly agree	115 (62.5)	90 (96.8)	79 (67.5)	20 (45.5)	36 (53.7)	24 (49.0)
Agree	57 (31.0)	44 (47.3)	31 (26.5)	23 (52.3)	26 (38.8)	21 (42.9)
Neither agree nor disagree	7 (3.8)	44 (47.3)	3 (2.6)	0	4 (6.0)	0
Disagree	2 (1.1)	1 (1.1)	1 (0.9)	0	1 (1.5)	1 (2.0)
Strongly disagree	3 (1.6)	1 (1.1)	3 (2.9)	0	0	1 (2.0)
Missing	0	3 (3.2)	0	1 (2.3)	0	2 (4.1)
ESD is important						
Strongly agree	98 (53.3)	40 (43)	56 (55.6)	18 (40.9)	33 (49.3)	22 (44.9)
Agree	61 (33.2)	40 (43)	34 (29.1)	22 (50)	27 (40.3)	18 (36.7)
Neither agree nor disagree	22 (12.0)	10 (18.8)	15 (12.8)	3 (6.8)	7 (10.4)	7 (14.3)
Disagree	1 (0.5)	1 (1.1)	1 (0.9)	0	0	1 (2.0)
Strongly disagree	2 (1.1)	2 (2.2)	2 (1.7)	1 (2.3)	0	1 (2.0)
Missing	0	0	0	0	0	0
ESD teaching is important						
Strongly agree	77 (41.8)	34 (36.6)	46 (39.3)	17 (38.6)	31 (46.3)	17 (34.7)
Agree	68 (37.0)	32 (34.4)	48 (41.0)	14 (31.8)	20 (29.9)	18 (36.7)
Neither agree nor disagree	32 (17.4)	9 (9.7)	20 (17.1)	6 (13.6)	12 (17.9)	3 (6.1)
Disagree	2 (1.1)	2 (2.2)	1 (0.9)	1 (2.3)	1 (1.5)	1 (2.0)
Strongly disagree	2 (1.1)	16 (17.2)	2 (1.7)	6 (13.6)	0	0
Missing	3 (1.6)	0	0	0	3 (4.5)	10 (20.4)

and related learning pedagogies in the curriculum. By triangulating data from students and educators, it seems that there is a very small amount of ESD content in the HSDM curriculum (mainly related to energy) and it is delivered through a lecture with no assessment. In terms of ESD policies and measures, mainly educators highlighted some ESD initiatives such as the cycling scheme at IoD QMUL, as well as the subsidised public transportation scheme, turning off energy (for example, dental chairs, appliances and lights) and motion-sensing lights at HSDM.

Barriers and enablers to embedding ESD in the dental curricula are summarised in Tables 3 and 4. The most noted barrier was lack of knowledge about ESD, followed by lack of time for preparing ESD content and lack of ESD educational materials. Other reported barriers included infection control regulations and resources needed for purchasing and sterilising reusable instruments and equipment, ESD not being part of the learning outcomes set out by dental education regulatory bodies, as well as lack of recycling schemes. Lack of curriculum space was not identified as a barrier by the vast majority of educators at both dental schools. The most frequently reported enabler was offering 'teach the teacher' training courses to educators. One of the educators stated: 'Online training on ESD may be helpful'. Furthermore, providing ESD-related learning outcomes and creating time and capacity for educators to work on embedding ESD were identified as important enablers too. Other reported enablers were grouped under the following themes: policy reforms and institutional backing; lobbying regulators to include ESD as a mandate in dental education; creating

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

Component	Overall		IoD QMUL		HSDM	
	Students N (%)	Educators N (%)	Students N (%)	Educators N (%)	Students N (%)	Educators N (%)
ESD relevance for future dental practice						
Strongly agree	80 (43.5)	-	49 (41.9)	-	31 (46.3)	-
Agree	72 (39.1)	-	51 (43.6)	-	21 (31.3)	-
Neither agree nor disagree	24 (13.0)	-	12 (10.3)	-	12 (17.9)	-
Disagree	4 (2.2)	-	4 (3.4)	-	0	-
Strongly disagree	1 (0.5)	-	1 (0.9)	-	0	-
Missing	3 (1.6)	-	0	-	3 (4.5)	-
Interested in learning ESD						
Strongly agree	76 (41.3)	-	42 (35.9)	-	34 (50.7)	-
Agree	72 (39.1)	-	48 (41)	-	24 (35.8)	-
Neither agree nor disagree	22 (12)	-	19 (16.2)	-	3 (4.5)	-
Disagree	6 (3.3)	-	4 (3.4)	-	2 (3.0)	-
Strongly disagree	5 (2.7)	-	4 (3.4)	-	1 (1.5)	-
Missing	3 (1.6)	-	0	-	3 (4.5)	-
Interested in introducing ESD into the dental curriculum						
Strongly agree	-	11 (11.8)	-	3 (6.8)	-	8 (16.3)
Agree	-	34 (36.6)	-	18 (40.9)	-	16 (32.7)
Neither agree nor disagree	-	19 (20.4)	-	11 (25.0)	-	8 (16.3)
Disagree	-	12 (12.9)	-	6 (13.6)	-	6 (12.2)
Strongly disagree	-	1 (1.1)	-	0	-	1 (2.0)
Missing	-	16 (17.2)	-	6 (13.6)	-	10 (20.4)

recycling schemes; providing funding and incentives for staff willing to work on teaching ESD; and a tax levy on reusable instruments and equipment. The majority of students (56%) and educators (64.5%) stressed the need to teach ESD in both the classroom and clinical setting. A special emphasis on embedding ESD in clinical teaching was noted. One of the educators stated: 'I don't think this really should be an individual module or component to teach as such, more that our clinicians should emphasise being environmentally friendly in clinics'.

Discussion

The current study has shown that there is no explicit inclusion of ESD in the dental curricula at either IoD QMUL or HSDM. Despite poor ESD knowledge, very positive attitudes to adopt ESD in the curricula exist among students and educators. These findings are not surprising and are in alignment with the medical education literature.[9] Students are increasingly demanding that sustainable healthcare is embraced in their education and future careers.[17]

Educators identified specific barriers and enablers to embracing ESD in the dental curricula, which are mainly related to providing resources (for example, training, educational materials, incentives and freeing capacity) and policy initiatives and reforms (for example, mandating ESD by regulatory bodies and reforming infection control regulations using a critical evidence-informed approach). It was interesting to find large similarities between sustainability-related barriers and enablers identified in dental education and those reported in medical education.[9,18]

The current study identifies support for a bottom-up approach to facilitate embedding ESD in UK and US dental curricula. This bottom-up approach needs to be complemented by a top-down approach to support implementation. This would imply embedding ESD in UK and US dental education standards in order to create a new legitimacy and lead to a significant change. The General Dental Council in the UK and the Commission on Dental Accreditation in the US, as regulatory bodies, should incorporate sustainable health into learning outcomes, placing thereby an obligation on dental education providers to embed sustainability in all dental curricula. To facilitate this step, a UK- and US-wide consultation using Delphi approach could be undertaken to garner the opinion of dental students, educators and other key stakeholders about environmental sustainability learning outcomes in dental education. Learning outcomes could be drafted based on review of relevant literature and adaptation of current learning outcomes in medical education, and might include:

1. Describe concepts and definitions of climate change, carbon footprint and sustainability
2. Discuss the importance of environmental sustainability for the health of patients
3. Discuss the carbon hotspots of dentistry and how these can be modified
4. Evaluate the overall environmental impact of clinical dentistry and how this can be improved through innovation
5. Appraise how future healthcare professionals can help shape a sustainable healthcare system, and the knowledge and skills (such as leadership), change management and co-production that they will require
6. Evaluate current literature and participate in research on sustainability in dentistry.

Next, the drafted learning outcomes could be revised iteratively to reach consensus through rounds of consultations using a variety of methods such as online questionnaire, telephone interview, face-to-face seminar and email consultation. Learning outcomes could be illustrated by case studies on sustainable dental healthcare education.

Providing training and educational resources are crucial to support educators in embracing environmental sustainability in the curriculum. Although many resources to support sustainable healthcare learning are available (for example, learning resources from the Centre for Sustainable Healthcare, postgraduate medical Royal Colleges, World Health Organisation and international Massive Open Online Courses), they were developed for medical schools and training, and hence adaptation would be needed for dentistry. Health Education England has developed an online resource on environmental sustainability in dentistry. However, this concise resource lacks simplicity and contextualisation in most parts and is now quite dated.

As a starting point towards embedding ESD in the dental curricula, Tun's practical recommendations for implementing sustainable healthcare in medical schools could be used and tested in the dental education context. These recommendations include: 1) teaching sustainability as a spiral cross-cutting theme rather than a standalone topic; 2) clinicians and students should develop partnership and learn from each other in this developing field; 3) contextualising learning and linking it to clinical practice; and 4) using multiple pedagogies and embedding sustainability in the assessment of the wider

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

Barrier	Overall	IoD QMUL	HSDM
	N (%)	N (%)	N (%)
Lack of knowledge			
Yes	52 (55.9)	26 (59.1)	26 (53.1)
No	16 (17.2)	9 (20.5)	7 (14.3)
Missing	25 (26.9)	9 (20.5)	16 (32.7)
Lack of capacity/time			
Yes	37 (39.8)	18 (40.9)	19 (38.8)
No	31 (33.3)	17 (38.6)	14 (28.6)
Missing	25 (26.9)	9 (20.5)	16 (32.7)
Lack of educational resources			
Yes	37 (39.8)	18 (40.9)	19 (38.8)
No	31 (33.3)	17 (38.6)	14 (28.6)
Missing	25 (26.9)	9 (20.5)	16 (32.7)
Lack of priority			
Yes	31 (33.3)	16 (36.4)	15 (30.6)
No	36 (38.7)	18 (40.9)	18 (36.7)
Missing	26 (28.0)	10 (22.7)	16 (32.7)
Lack of curriculum space			
Yes	1 (1.1)	0	1 (2.0)
No	67 (72.0)	35 (79.5)	32 (65.3)
Missing	25 (26.9)	9 (20.5)	16 (32.7)
Other			
Yes	10 (10.8)	7 (15.9)	3 (6.1)
No	57 (61.3)	27 (61.4)	30 (61.2)
Missing	26 (28)	10 (22.7)	16 (32.7)

determinants of diseases. Additionally, learning from emerging courses on ESD that are still 'work in progress' led by Plymouth, Manchester and Dublin universities could inform the way forward.[5] Competition and collaborative innovation among dental schools in the UK and US could be main drivers to accelerate progress towards ESD education. For example, there has been a call to develop pooled resources to be used by all medical schools in the UK. Yet, funding and intellectual property challenges hinder such innovative measures.[9] Therefore, system leadership and effective collaboration between relevant stakeholders and dental schools must occur to address these challenges.

This study is not without limitations. The low response rate could affect the generalisability of the current findings to the total number of students and educators at both schools. It might be that only those who are interested in ESD participated in the current survey. However, the low ESD familiarity of participants argues against such possibility. Another limitation might be the lack of in-depth qualitative data collected via semi-structured interviews. Nonetheless, ensuring free text response options allowed the current study to collate sufficient qualitative data to serve its aims.

The present study is a 'first look' survey, providing some original preliminary work in ESD. Further research is needed to push the environmental sustainability agenda in dental education and practice. Three research pillars are key: i) creating infection control evidence on the safety of single-use versus reusable instruments and equipment, as well as the presence of environmentally friendly

alternatives of essential single-use instruments and equipment; ii) identifying lean dental care pathways; and iii) identifying effective prevention and treatment options with lower environmental impact. Setting research priorities for each pillar should follow the principles of participatory approach involving key relevant stakeholders from different statutory and non-statutory sectors and bodies, as well as service users and the public.

Conclusions

ESD does not exist formally in the dental curricula at IoD QMUL and HSDM. Despite poor knowledge, very positive attitudes to embrace ESD in the curricula exist among students and educators. Enablers include providing resources and policy reforms. A top-down approach is needed to support the current bottom-up approach to embed ESD in UK and US dental curricula. This includes embedding ESD in UK and US dental education standards, adopting a critical evidence-informed approach in revising infection control regulations, and having institutional backing and support in terms of training, educational materials, capacity and incentives.

Conflict of interest

The authors declare that they have no competing interests. This survey was not funded.

Acknowledgements

The authors express their gratitude to all students and educators who participated and facilitated this survey at both institutions. Also, the authors thank administrative staff who supported circulating invitation and reminder emails. Jennifer Lee and Ashwini Parchure contributed equally to this paper.

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

Enabler	Overall	IoD QMUL	HSDM
	N (%)	N (%)	N (%)
Learning outcomes			
Yes	47 (50.5)	23 (52.3)	24 (49.0)
No	30 (32.3)	15 (34.1)	15 (30.6)
Missing	16 (17.2)	6 (13.6)	10 (20.4)
Training courses			
Yes	60 (64.5)	27 (61.4)	33 (67.3)
No	17 (18.3)	11 (25.0)	6 (12.2)
Missing	16 (17.2)	6 (13.6)	10 (20.4)
Capacity/time			
Yes	54 (58.1)	24 (54.5)	30 (61.2)
No	23 (24.7)	14 (31.8)	9 (18.4)
Missing	16 (17.2)	6 (13.6)	10 (20.4)
Other			
Yes	11 (11.8)	8 (18.2)	3 (6.1)
No	66 (71.0)	30 (68.2)	36 (73.5)
Missing	16 (17.2)	6 (13.6)	10 (20.4)

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