

Journal Pre-proof

Curriculum Content for Environmental Sustainability in Dentistry

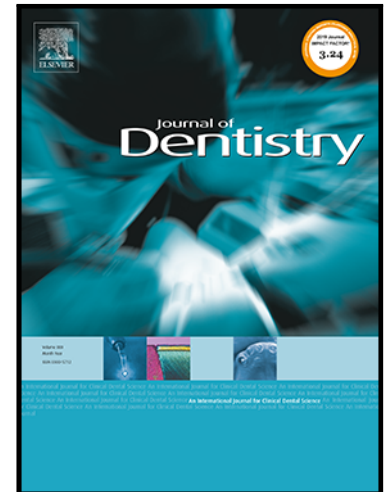
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Highlights

- There is an urgent need to embed Environmental Sustainability in dental education.
- A comprehensive strategy to embed Environmental Sustainability in the curriculum.
- A novel method to define and map curriculum content has been explored and validated.
- Defined a list of educational content statements for Environmental Sustainability.
- Statements mapped to all curriculum subjects to facilitate teaching and assessment.

Journal Pre-proof

Curriculum Content for Environmental Sustainability in Dentistry

Short Title: Curriculum Content for Environmental Sustainability in Dentistry

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Keywords: Environmental Sustainability, Dental Education, Curriculum Content, Oral Health Professionals, Dental Hygienists

Abstract

Objectives: (i) Identify suitable strategies and opportunities to embed Environmental Sustainability (ES) within an existing Oral Health Professional (OHP) curriculum through a series of focus groups with students and academic staff and (ii) Create high-level evidence-based and subject-specific ES content through an approach grounded in evidence and collaboration with key stakeholders in OHP education.

Methods: Focus groups were used to explore academic staff and student views on appropriate teaching and assessment methods for ES. Content statements were developed from an extensive literature search, mapped to curriculum subjects, and validated through consultation with students, discipline-experts and education-experts.

Results: Five themes were identified from the focus groups: Environmental Sustainability transcends all disciplines of dentistry and oral healthcare; Baseline knowledge transmission with relevant practical application; Viewing and modifying existing teaching and assessment events through a different lens; Normalising the topic of Environmental Sustainability to support attitude and behaviour change and Safeguarding against misinformation and disinformation. Forty-four content statements were developed and mapped to nineteen curriculum subjects.

Conclusions: This study identifies for the first time a comprehensive strategy for the inclusion and delivery of ES (method and content) in the curriculum. A novel method to define and map curriculum content has been explored and validated using a range of complementary methodologies. A comprehensive and robust list of evidence-based and subject-specific educational content statements have been defined in the field of Environmental Sustainability in dentistry and oral healthcare.

Clinical Significance: Oral healthcare has a significant environmental impact, the key to all mitigation strategies is by educating the profession at all levels.

Keywords: Environmental Sustainability, Dental Education, Curriculum Content, Oral Health Professionals, Dental Hygienists

Introduction

Oral Health Professional (OHP) curricula must be responsive to the changing societal and educational landscape to ensure graduates can meet the demands of the profession for the present and the future. As a regular quality assurance measure, a curriculum should have in-built sustainability achieved through a development process to allow appropriate periodic review of material content and delivery [1, 2]. Curricula typically develop over time in response to three principal drivers: new developments in the discipline (dentistry and oral healthcare), changing educational rationales and innovation and pressures from wider stakeholders [3-8].

Environmental Sustainability (ES) and climate change are challenges that transcend all sectors. The United Nations Brundtland Commission defined Sustainability as: "*Meeting the needs of the present without compromising the ability of future generations to meet their own needs*" [9]. The significant environmental impact of oral healthcare, particularly in relation to carbon dioxide equivalent emissions, pollution and waste generation has been highlighted and quantified in the literature [10-12]. These impacts principally relate to staff commute, patient travel, procurement, energy and water consumption and waste generation.

Introducing ES into OHP education

The need to embed ES within OHP education at all levels (undergraduate, postgraduate, and continuing professional development) has been established [13-16]. The Association for Dental Education in Europe (ADEE) has been at the forefront of this drive with the 'Sustainability in Dentistry' Special Interest Group activities reported in two published consensus reports [13, 14]. These reports (i) identify the need to embed ES within the OHP curriculum and (ii) recommend learning outcomes and methods of learning, teaching, and assessment of ES. Similarly, the FDI World Dental Federation is actively promoting ES through education in all settings with a wide range of impactful resources and publications [16-19]. Staff and student support for introduction of the topic into undergraduate education has been demonstrated in multiple surveys [20-23].

An example of implementation at a national level is the General Dental Council in the United Kingdom (UK). The regulator has adopted some learning outcomes from the ADEE European consensus report in the recent Safe Practitioner Framework publication [24]. This mandates that ES is taught and assessed in UK dental schools from September 2025 and that all graduates must demonstrate that they meet the learning outcomes from 2030.

The challenges with introducing ES

Higher Education Institutions across the world are cognisant of the need to embed ES education across all their departments, including dental schools. This task presents a number of real challenges in OHP education, and it appears that many schools are not currently teaching or assessing ES, as identified in a recent pan-European survey [25]. The profession has sought to address this deficit with the publication of guidance and recommendations that address the conceptual implementation challenges [13, 14]. The ADEE consensus statements remain the only guidance for educators in OHP education with respect to ES. The documents promote ES and establish a need, as well as proposing learning outcomes to be taught and assessed. Notwithstanding, several practical barriers remain to embed and implement ES in the undergraduate dental curriculum [21, 22, 26], that include:

- A perceived lack of knowledge to teach ES.
- Time constraints due to the overloaded nature of existing curricula.
- A lack of practical guidance and resources for educators and students.

The aims of this research are two-fold:

- Identify suitable strategies and opportunities to embed ES within an existing curriculum through a series of focus groups with OHP students and academic staff.
- Create high-level evidence-based and subject-specific ES content through an approach grounded in collaboration with key stakeholders in OHP education.

The objectives to meet these aims are:

- To explore the opinions of academic staff and students on strategies to teach and assess selected ES learning outcomes within undergraduate OHP curricula.
- To create, categorise and map evidence-based and subject-specific content statements.
- To undertake a stakeholder consultation to ensure that the content statements are fit for purpose.

Materials and Methods

The aims and objectives were achieved through two exploratory investigations:

- Workstream 1: Explore the Views of Academic Staff and Students to Embedding Environmental Sustainability in the Curriculum - A Qualitative Approach
- Workstream 2: Develop and Map Content Statements for Environmental Sustainability to Subjects within the Dental Curriculum - A Multi-Stakeholder Consultation

Explore the Views of Academic Staff and Students to Embedding Environmental Sustainability in the Curriculum - A Qualitative Approach

This intervention received approval from the Dentistry Ethics Committee at the lead author's affiliated institution (application number 056582). Focus groups were used to achieve the aims of this research.

Recruitment

Academic teaching staff (clinical and non-clinical) across all departments of the authors' academic institutions and students registered on undergraduate clinical programmes (Bachelor's Degree in Dentistry Surgery and Diploma in Dental Hygiene and Dental Therapy) were invited to participate in the study. The email invitation provided an overview of the project, proposed focus group dates and a more detailed participant information sheet. Interested participants were asked to respond by email to confirm their interest and availability. Additional recruitment measures were considered with provision to extend the focus group study if data saturation was not accomplished. All participants gave consent and clarity was provided regarding withdrawal of consent.

Structure of the intervention

Forty-five-minute focus group meetings were undertaken across multiple days between December 2023 and January 2024. Participants were grouped either as academic staff or students, there was no mixing amongst cohorts. Focus group sizes were limited to four and five participants. One experienced focus group facilitator (JD) chaired all the sessions having completed the required training. The focus groups were semi-structured, with a prepared script used to guide the facilitator to ensure reproducibility across all interventions. The script was developed from published research relating to curriculum development in OHP education [14, 27, 28]. The discussion centred around three learning outcomes taken from the ADEE learning outcomes publication, with participants asked to propose methods to teach and assess or observe each statement [14].

The three learning outcomes used were:

- Explain the importance of practising sustainable oral health care.
- Apply the scientific knowledge base in relation to the environmental impacts of common treatment methods, and common approaches to the delivery of care.
- Develop effective patient-specific strategies for preventive oral health, reducing the need for recall, operative intervention, and material use.

Data collection

The focus group discussion content was transcribed live by a trained researcher (EG) using Google Docs (<https://www.google.co.uk/docs/about/#overview>). Each focus group discussion was also audio-recorded and used to supplement the transcriptions where appropriate. The interactive presentation platform 'Woo Clap' (<https://www.wooclap.com/>) was used to gather independent thoughts that served as points of discussion for all attendees. During the discussions, participants were given codes that conferred anonymity and enabled effective matching and collation of statements.

Data analysis

Independent responses to the questions and the written transcriptions were analysed by two independent and trained assessors (JD, EG) using thematic analysis as described by Braun and Clarke [29]. The preliminary steps were completed independently and included data familiarisation, coding, and theme development. The two assessors then met to reach consensus through discussion and if needed, re-evaluation of the transcripts. In this analytical approach, themes are created according to perceived relevance to the research question and not necessarily the prevalence of topics. Data saturation was determined when no new themes were identified in the transcripts.

Develop and Map Content Statements for Environmental Sustainability to Subjects within the Dental Curriculum - A Multi-Stakeholder Consultation.

Prior to development, the conceptualisation of this project was shared with academic staff and students to identify any early issues with feasibility and acceptability. The development and refinement of content statements followed five steps.

1. Identification of core sources

The evidence base for ES in oral healthcare was gathered through an extensive literature search that ran continuously from August 2021 to January 2024 to ensure all contemporaneous literature (English language) was included in the research. The search strategy was dynamic and evolved depending on the area of interest. The MEDLINE database was used to identify relevant sources and MeSH keywords were used. The core search terms used were:

- [Title]: sustain* AND dent*
- [Title]: sustain* AND oral
- [Title]: environ* AND dent*
- [Title]: environ* AND oral
- [Title]: eco* AND dent*
- [Title]: eco* AND oral
- [Title]: green AND dent*
- [Title]: green AND oral
- [Title/Abstract]: climate AND dent*
- [Title/Abstract]: climate AND oral
- [Title/Abstract]: life cycle AND dent*
- [Title/Abstract]: life cycle AND oral

- [Title/Abstract]: planet* AND dent*
- [Title/Abstract]: planet* AND oral
- [Title/Abstract]: waste AND environ* AND dent*
- [Title/Abstract]: waste AND environ* AND oral

There were no date limitations to the search strategy and all published articles that were relevant to the subject area were included.

2. Theme generation and organisation

Themes relevant to ES in oral healthcare were identified from the literature search. This process allowed the researchers to organise the subject area prior to writing the evidence-based statements.

3. Content statement development

The content statements were written and refined by three researchers (JD, NM, JF) who were led by the evidence base, and the themes generated from the previous steps. The researchers used their expert opinion in relation to ES and curriculum development to devise the statements with a pedagogic structure. This was an iterative process whereby researchers developed and refined multiple drafts through discussion until consensus was reached.

4. Identification of curriculum subjects/disciplines and mapping the content statements

A list of curriculum subjects was developed from the EU directive 2005/36/EC and national specialty bodies [30]; these were: Basic Sciences, Cariology, Periodontology, Endodontology, Paediatric Dentistry, Preventive Dentistry, Conservative Dentistry, Prosthetic Dentistry, Orthodontics, Oral and Maxillofacial Surgery, Oral Medicine and Pathology, Oral and Maxillofacial Radiology and Imaging, Oral Implantology, Special Care Dentistry, Dental Public Health and Community Dentistry, Dental Biomaterials, Dental Technology, Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences, Dental Practice Management.

Each content statement was mapped to the relevant curriculum subjects by two independent researchers (JD, NM) through multiple rounds of discussion. Any disagreements were resolved through consultation with an additional researcher (JF).

5. Consultation process

To ensure the evidence-based and subject-specific statements were fit for purpose across relevant stakeholders in OHP education, three separate consultation processes were undertaken with three different cohorts: students, discipline-experts, and education-experts.

The student consultation process was developed to review the clarity of language and ease-of understanding of the content statements. Clinical students from two dental schools in the UK were invited to comment. A Google Forms (<https://docs.google.com/forms>) survey link was created that included all content statements and a dichotomous answer of 'clear' and 'not clear' for each statement. All questions were mandatory with a further free-text option to comment on the 'not clear' responses.

The discipline-expert consultation process aimed to validate the mapping of content statements carried out by the researchers previously. Discipline experts from participating dental schools in the UK were invited to contribute to this process. Academics who teach these disciplines were invited to comment on the statements that were mapped to their area of expertise.

The final consultation process was disseminated through ADEE with the aim of acquiring the views of educationalists from across Europe. A consultation page was created on the ADEE website whereby the content statements and subject mapping were presented. Respondents were asked to provide their comments via a free-text box. The consultation process was shared in ADEE's monthly newsletter and via social media.

Comments from all three consultation processes were used to refine the content statements to ensure clarity of language and educational validity.

Results

Explore the Views of Academic Staff and Students to Embedding Environmental Sustainability in the Curriculum - A Qualitative Approach

A total of forty participants attended the focus groups, with a split of twenty-two academic staff and eighteen students from 8th December 2023 to 19th January 2024. Academic staff participants included academics from nine different curriculum subjects and ranged from clinical teachers (part-time clinicians) to professors. Students from both the undergraduate dental surgery and dental hygiene and dental therapy clinical programmes participated in the research, ranging from first year to final year students. Data saturation was reached in the sixth focus group and after twenty-eight participants, obviating the need to extend the study beyond the planned interventions. All planned and scheduled focus groups were conducted, even after data saturation had been achieved; to ensure inclusivity of all views.

Thematic analysis of the transcriptions from the focus groups resulted in the generation of five themes. The themes and supporting quotes are presented in Table 1.

Table 1: Themes identified through thematic analysis and supporting quote(s) from the focus group sessions.

| Theme | Supporting Quote(s) |
|---|---|
| Normalising the topic of Environmental Sustainability to support attitude and behaviour change. | <i>"It should be mentioned in most lectures, so students automatically think about Environmental Sustainability." "It must be seen as a normal part of their practice on a daily basis and not a separate thing."</i> |
| Baseline knowledge transmission with relevant practical application. | <i>"It should be reinforced practically, and I think it should be embedded as you go through your course, not just a lecture on Environmental Sustainability and you are expected to know it."</i> |
| Viewing and modifying existing teaching and assessment events through a different lens. | <i>"It is a lens issue, we need to change our language." "It could be something as simple as modifying the patient management marking scheme to include Environmental Sustainability."</i> |
| Environmental Sustainability transcends all disciplines of dentistry and oral healthcare. | <i>"Students need to see the importance of Environmental Sustainability in every area of dentistry. Every educator needs to be thinking about Sustainability in their teaching."</i> |
| Safeguarding against misinformation and disinformation. | <i>"It is important that students know about life-cycle assessments (LCA's) to provide evidence-based facts and avoid disinformation."</i> |

Develop and Map Content Statements for Environmental Sustainability to Subjects within the Dental Curriculum - A Multi-Stakeholder Consultation

The literature search generated eleven themes which were principally derived from previous carbon modelling and scoping reviews on ES in oral healthcare [10, 11, 15, 31]. These were: Raise Awareness, Behaviour Change, Reduce, Reuse, Recycle, Rethink, Good Quality Oral Healthcare, Knowledge Exchange and Research, Policy and Regulations, Environmental Impact – Travel, Environmental Impact – Procurement, Environmental Impact - Energy and Water Consumption, Environmental Impact - Waste Management, Dental Materials.

Fifty-one content statements were developed prior to the consultation processes. The student consultation process received nine responses. Thirty-nine statements were rated as 'clear' by all students, whilst twelve statements were rated as 'not clear' by at least one student. Seventeen educators across sixteen of the curriculum subjects responded to the 'discipline-expert' consultation process. Three educators responded to the ADEE consultation and provided some comments on language and mapping. Amendments were made considering all responses and forty-four content statements were finalised.

The content statements are presented in two tables. Table 2 presents the content statements with supporting content and the associated evidence base. Table 3 demonstrates the mapping process with the content statements aligned with the applicable curriculum subjects that were identified. During the mapping exercise it was identified that some statements are applicable to *all* clinical subjects in the OHP curriculum, whilst others were linked to *fewer* subjects. To aid reading, all statements that have been mapped to clinical subjects have a purple tag, whilst statements linked to a small number of subjects have an amber tag. The clinical subjects within this group are: Cariology, Periodontology, Endodontology, Paediatric Dentistry, Preventive Dentistry, Conservative Dentistry, Prosthetic Dentistry, Orthodontics, Oral and Maxillofacial Surgery, Oral Medicine and Pathology, Oral and Maxillofacial Radiology and Imaging, Oral Implantology, Special Care Dentistry, Dental Public Health and Community Dentistry.

Table 2: A list of the content statements grouped thematically with supporting content and evidence.

| | Content Statement | Supporting Content | Evidence |
|------------------------|--|---|---------------------------|
| <i>Raise Awareness</i> | | | |
| A1 | The delivery of oral healthcare is often environmentally unsustainable. We need to take responsibility as a profession to mitigate these impacts. | <ul style="list-style-type: none"> ○ Many patients travel to dental practices, mostly by car. ○ Oral healthcare provision is not centralised but spread throughout thousands of small dental practices. ○ Non-centralised care is not good from an ES perspective, as distribution of goods, staff commute, waste collection and disposal are multiplied many times. | [10, 11, 31-33] |
| A2 | The environmental impacts of oral healthcare cannot be eliminated but they can be significantly mitigated. | <ul style="list-style-type: none"> ○ A significant part of oral healthcare is interventive, with reparative treatment for the management of preventable disease. This requires many patient appointments, with an associated use of energy (electricity and water), materials, PPE and waste generation. ○ All equipment, sundries and materials are part of a wasteful linear economy with a significant carbon footprint. ○ Every human activity, whatsoever its nature, has an environmental impact. ○ The best way to mitigate the environmental impacts from oral healthcare is through a reduction of the 'need to treat'. A reduction of a need to treat, is achieved through the prevention of preventable diseases and the delivery of high-quality care. ○ A reduction of 'need to treat' results in a reduced need to use resources, energy and waste generation at all points of the oral healthcare supply chain. | [15, 16, 33-36] |
| A3 | The provision of <u>professionally delivered</u> oral healthcare results in significant environmental impacts from: (i) Staff commute and patient travel; (ii) the product supply chain and management of waste from the dental practice. | <ul style="list-style-type: none"> ○ These environmental impacts are inversely related to the oral health and disease risk status of the individual. ○ That is, good oral health equates to minimal environmental impacts. ○ Good oral health requires fewer operative interventions, with a consequential reduction of all environmental impacts (Staff commute and patient travel; as well as the manufacturing, distribution and waste management of materials and sundries used in the dental practice.) | [10-12, 15, 31-33, 37-43] |
| A4 | <u>Personal oral hygiene regimes</u> have inevitable 'baseline' environmental impacts. These impacts arise from | <ul style="list-style-type: none"> ○ Environmental impacts that arise from effective personal care preventive regimes are an inevitable consequence of maintaining good oral health. ○ The impacts from the use of personal products and devices (e.g. toothbrush, dentifrice, | [12, 44, 45] |

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| | the product supply chain and disposal of oral hygiene products and devices. | <p>interdental cleaning aids, mouthwashes) are much lower than that from the delivery of professional interventional care. Principally, because the patient is not travelling to a remote location (dental practice) and the number of these home-care products is significantly so much smaller than those used in a dental practice.</p> <ul style="list-style-type: none"> ○ The paradigm between the ES impacts from dental practice and home care is a good example of why the impacts cannot be eliminated and can only be mitigated. | |
| A5 | It is imperative to promote and maintain good oral health through the prevention of oral diseases. An effective preventive regime carries an environmental burden that is much smaller than a disease-driven interventional treatment approach. | <ul style="list-style-type: none"> ○ Prevention of preventable diseases and conditions including dental caries, periodontal disease, pulpal disease, tooth surface loss and oral cancers. ○ Follow evidence-based guidelines for professional delivery of oral healthcare and the promotion of personal oral health regimes. <p>UK and European examples include:</p> <ul style="list-style-type: none"> ○ NICE guidelines for recall intervals based on oral disease risk. ○ Delivering Better Oral Health: an evidence-based toolkit for prevention. ○ EFP guidelines on the clinical management of stage I-III periodontitis. | [12, 38-40, 42-48] |
| A6 | There is a need to influence and educate the profession and the public on strategies to mitigate the environmental impacts of oral healthcare. | <p>Staff and patient engagement through a series of proactive approaches that may include:</p> <ul style="list-style-type: none"> ○ A strong focus on patient engagement and ownership of own oral healthcare, with an emphasis on home-based personal preventive regimes. ○ The conduct, and promotion and delivery of quality care that is evidence driven. ○ In-house staff training on ES, as a part of normal professional development. ○ ES champions in the dental practice and local professional communities. ○ External continuing professional development activities. ○ Patient information leaflets, promotion through social media. ○ Integration of ES messages into all aspects of oral healthcare. ○ Emphasise that the provision and maintenance of good oral health is good for the patient, good for society and the single best way of mitigating environmental impacts from oral healthcare. | [13-15, 25, 49-57] |
| A7 | The single most effective strategy to improve environmental sustainability in oral healthcare is through disease prevention. This will | <ul style="list-style-type: none"> ○ Promote effective preventive strategies for all patients, tailored to their age and needs. ○ Reduce frequency and consumption of sugars and acidic drinks. ○ Promote toothbrushing and fluoridation. ○ Encourage dental attendance and risk-based maintenance schedules. | [12, 15, 34, 38, 42, 43, 49, 53, 58] |

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| | result in less travel, less use of resources and less waste generation. | <ul style="list-style-type: none"> ○ Promote a reduction in alcohol consumption and tobacco cessation. ○ Adopting a minimal intervention approach to oral healthcare. ○ Where appropriate and feasible, water fluoridation should be considered as a community approach for the prevention of caries. | |
| Behaviour Change | | | |
| B1 | Environmental sustainability requires a culture change across the profession and supply chain. | <ul style="list-style-type: none"> ○ Normalise the subject of ES. ○ Start with informal discussions to increase awareness and increasingly formalise into organisational/practice protocols and procedures (e.g. designate sustainability leads). ○ Translating personal, home-based attitudes and behaviours to the professional setting. ○ <i>Apprehension and resistance to ES behaviour changes, can be overcome by increasing awareness and identifying common ground and strength of feelings amongst colleagues.</i> | [15, 16, 31, 34, 55, 59-62] |
| B2 | Effective and evidence-based prevention will benefit patients' oral health and mitigate environmental impacts. | <ul style="list-style-type: none"> ○ Increase patient awareness on the impact that good oral health has on them, society and the environment. ○ Motivate patients to take greater ownership for their own oral health, with an emphasis on home-based personal preventive regimes. ○ Support patients to embed new oral health behaviours when they are ready to do so. ○ Patients as co-creators and co-managers of their oral health. ○ Increase patient awareness on the importance of preventive regimes that are tailored to their age and needs. | [15, 47, 53] |
| B3 | The formulation of action plans and policies will result in more environmentally sustainable practice. | <ul style="list-style-type: none"> ○ Designate a lead sustainability officer or dental practice champion or a sustainability working group. ○ Add sustainability to the practice agenda and ethos. ○ Foster an inclusive environment where staff can exchange ideas on ways to do things better. | [15, 53, 63] |
| B4 | Avoid waste: high-quality and efficient patient care will mitigate environmental impacts. | <ul style="list-style-type: none"> ○ Only use what is necessary by planning each patient encounter. ○ Focus on high-quality care by using fit for purpose materials and instruments that are grounded in evidence-based techniques. | [34, 64, 65] |
| 4 R's – Reduce, Reuse, Recycle, Rethink | | | |

| | | | |
|-------------------------------------|--|--|------------------------------|
| C1 | Delivering a prevention-focused, patient-centred high quality oral health care service will reduce treatment need and the resultant environmental impact. | <ul style="list-style-type: none"> ○ The best way to mitigate the environmental impacts from oral healthcare provision is through a reduction of the 'need to treat'. A reduction of a need to treat, is best achieved through the prevention of preventable diseases and the delivery of high-quality care. ○ A reduction of 'need to treat' results in a reduced need to use resources, energy and waste generation at all points of the oral healthcare supply chain. | [12, 34-36] |
| C2 | Consider using reusable options where appropriate. | <ul style="list-style-type: none"> ○ Use of cloth fabric alternatives to SUPs including clothes, barriers and cleaning items. ○ Reusable PPE: laboratory coats to replace aprons, reusable face shields, patient bibs. ○ Use of washable cups, dishes and cutlery. ○ Reusable instruments (impression trays, suction tips, matrix band retainers). | [15, 37, 39, 40, 51, 66-68] |
| C3 | A shift from a wasteful linear economy to a more sustainable circular economy in oral healthcare is possible by proactively seeking and implementing recycling opportunities. | <ul style="list-style-type: none"> ○ Educate staff about recycling in all areas of the dental practice. ○ Enable waste separation/segregation for ease of recovery for recycling. ○ Improve awareness and liaising with local authorities and support groups. ○ Identify and use pre-existing community recycling programmes to recycle separated paper and plastic parts of autoclavable bags and packaging. ○ Recycle office waste such as plastics, paper and medical shredding, printer cartridges. | [15, 35, 60, 65, 69-71] |
| C4 | Rethink - how can you optimise existing systems and processes to be more environmentally sustainable? | <ul style="list-style-type: none"> ○ Use of digital technology for patient appointments, records, electronic reminders. ○ Electronic credit card transfers and order forms. ○ Reduce paper use. ○ Engage with emerging scientific/technological changes to the profession. | [15, 31, 72] |
| Good Quality Oral Healthcare | | | |
| D1 | Good oral healthcare is good for the patient, good for the profession and good for the environment. | <ul style="list-style-type: none"> ○ Delivery and maintenance of good oral health, focused on prevention and with the provision of durable interventions, using high quality products materials and that will last longer and/or require fewer revisions. ○ Careful planning and execution of clinical procedures should lead to a reduction of materials and equipment use. | [12, 34] |
| D2 | A reduction in the need for professional-led interventions is achieved through disease | <ul style="list-style-type: none"> ○ The best way to mitigate the environmental impacts from oral healthcare provision is through a reduction of the 'need to treat'. A reduction of a need to treat, is best achieved through the prevention of preventable diseases and the delivery of high-quality care. | [12, 15, 18, 34, 35, 49, 58] |

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| | prevention. This is the single most environmentally sustainable measure. | <ul style="list-style-type: none"> ○ A reduction of 'need to treat' results in a reduced need to use resources, energy and waste generation at all points of the oral healthcare supply chain. ○ The provision of oral healthcare in all settings should focus on the fundamental messages of oral health promotion and disease prevention: <ul style="list-style-type: none"> ○ Effective preventive strategies for all patients, adapted to their age and needs. ○ Reduction in the frequency and consumption of sugars and acidic drinks. ○ Encourage toothbrushing and fluoridation. ○ Encourage dental attendance and risk-based maintenance schedules. ○ Promote a reduction in alcohol consumption and use of and cessation of tobacco products. | |
| D3 | High quality operative care reduces repair, replacement and waste. | <ul style="list-style-type: none"> ○ Adopting evidence-based practices to achieve high-quality and durable clinical outcomes. ○ Establish protocol-driven patient-care practices to drive reproducibility of high-quality and durable outcomes. ○ Careful selection and use of dental materials, instruments and equipment in accordance with the manufacturer's 'Directions for Use'. | [18, 34] |
| D4 | Integrated healthcare services with patients as co-managers of their care mitigates environmental impacts. | <ul style="list-style-type: none"> ○ Structured treatment plans that are professional led with joint 'patient-professional' responsibility for delivery. ○ Support patients to be co-managers of their oral healthcare: Active participation in decision-making, treatment and maintenance. ○ Smart treatment planning to reduce the number of appointments. ○ Integration with wider healthcare services to facilitate a multi-disciplinary approach to patient care. | [18, 34] |
| D5 | There is a need to take ownership of the care that you provide through lifelong learning to deliver high quality clinical outcomes. Evidence-based procedures provide environmentally sustainable care. | <ul style="list-style-type: none"> ○ A professional that maintains knowledge and skills to a high standard is well placed to provide good quality care. Good quality care is environmentally sustainable care. ○ Learn and develop best practice: pursue a tailored programme of continued professional development (CPD). ○ Lead by example: set high standards, engage with the profession, make a difference, inspire others. ○ Effective clinical governance: review, reflect and improve the quality of care you provide. ○ Engage with local networks, national organisations and practice-based research. | [18, 34] |

| <i>Knowledge Exchange - Research</i> | | | |
|--------------------------------------|--|---|-----------------|
| E1 | Developing a research curiosity will increase your levels of knowledge and awareness and may help to mitigate the environmental impacts of oral healthcare. | <ul style="list-style-type: none"> ○ Be aware and have knowledge of important environmental research methodologies including Life Cycle Assessments (LCA). | [14] |
| E2 | Evidence-based dentistry must consider the triple bottom line of clinical effectiveness, cost effectiveness and environmental sustainability. | <ul style="list-style-type: none"> ○ Identify and select high quality evidence that considers clinical effectiveness but also economic feasibility and environmental sustainability. ○ Use current and strong evidence-based knowledge to guide your decision making at all stages of care. | [38, 73] |
| E3 | It is important to guard against misinformation and disinformation that may influence the objectivity of your decision-making. | <ul style="list-style-type: none"> ○ There is confusion, misinformation and disinformation in environmental sustainability that is influenced by the media and individual opinion. ○ Adopt a critical approach to all literature to avoid nonfactual and harmful information and agendas. | [17] |
| <i>Policy and Regulations</i> | | | |
| F1 | Active engagement with environmental policies and regulations in oral healthcare will mitigate your environmental impact. | <ul style="list-style-type: none"> ○ Engage with effective Antibiotic Stewardship. ○ Follow current regulations to handle, manage and dispose of dental amalgam safely. ○ Adopt evidence-based clinical care guidelines to determine patient care pathways and follow up appointments. E.g. Delivering Better Oral Health, NICE guidelines on recall intervals, European Federation of Periodontology guidelines. | [46-48, 74, 75] |
| F2 | Active engagement and collaboration with policymakers will lead to the development of more environmentally sustainable oral healthcare policies. | <ul style="list-style-type: none"> ○ Promote innovative ways to maintain high quality care delivery whilst mitigating environmental impacts. ○ Engage with municipal waste management and collection services to further mitigate impacts. E.g. waste separation, recycling, energy recovery incineration. ○ Challenge the status quo at a local level, within the workplace e.g. laboratories, reception, common room, waste segregation. | [15, 76] |
| <i>Environmental Impact - Travel</i> | | | |

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| G1 | Adopting more sustainable travel options will mitigate your environmental impact. | <ul style="list-style-type: none"> ○ Promote and encourage active travel (such as walking and cycling) where possible. ○ Encourage the use of public transport and car sharing when active travel not feasible. ○ Encourage and facilitate electric vehicle use amongst colleagues. | [15, 56, 59, 64, 65] |
| G2 | Planning patient care to reduce the number of appointments will mitigate the environmental impact of the care you provide. | <ul style="list-style-type: none"> ○ Reduce the number of appointments by providing multiple procedures in one visit. ○ Engage with Tele-dentistry and Remote Clinical Consultations to reduce travel. ○ Combine family appointments wherever possible. ○ Using digital technologies (CAD-CAM, intra-oral scanning, 3D printing) will reduce the number of appointments and transport to dental laboratories. | [15, 53, 56, 59, 64, 65, 72] |
| G3 | Facilitating care delivery in multi-professional health centres will mitigate the environmental impact of the care you provide. | <ul style="list-style-type: none"> ○ Engage with oral health outreach programmes where only the OHP team travels. An example is <u>Childsmile</u> with reduced travel, carbon emissions and improved air quality. ○ Provision of on-site preventive care facilities in nursing and care homes. ○ Centralised resources, procurement, waste management and circularity. | [34, 38, 42, 43, 64] |
| G4 | Optimising dental practice administration will mitigate the environmental impact of the care you provide. | <ul style="list-style-type: none"> ○ Optimise efficiency of transport between the clinic and the dental laboratory. ○ Increased use of telecommunication for all administrative logistics (eg. SMS reminders, virtual post-op follow ups). ○ Effective scheduling to allow appointments with different OHPs on the same day. | [15, 59, 64, 72] |
| <i>Environmental Impact – Procurement</i> | | | |
| H1 | Procured goods have an inherent environmental impact that arises from the supply chain. This is additional to clinical or consumer use and includes: sourcing of raw materials - manufacturing - packaging - distribution - procurement - waste management. | <ul style="list-style-type: none"> ○ All procured oral health items reach the consumer or the dental practice with a large 'pre-loaded' environmental impact tag – Purchased goods accumulate environmental impacts in an incremental manner as the product moves from one stage to the next along the supply chain. ○ Purchase durable equipment that have long warranties and are easy to maintain. ○ During the procurement process, consider the energy use in the distribution/delivery of the product and the management of waste with special consideration to the product presentation and packaging used. ○ Optimise how products are sourced through effective stock management, waste auditing, purchasing bulk deliveries and selecting products with minimal packaging. | [15, 16, 31, 65, 76, 77] |
| H2 | Engaging and challenging | <ul style="list-style-type: none"> ○ Work and engage with suppliers to assess their sustainability practices. | [15, 16, |

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| | stakeholders across the supply chain will support environmentally sustainable practices. | <ul style="list-style-type: none"> ○ Apply pressure to suppliers to engage to act in an environmentally sustainable manner. ○ Request recycling information for medical equipment from manufacturers. ○ Identify locally produced items and coordinate with local suppliers to reduce travel. ○ Reducing and reusing packaging. | 53, 55] |
| H3 | Selecting fit for purpose dental materials, clinical items (PPE and products) and equipment will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Adopt a prevention-first approach to reduce oral healthcare interventions, material use and associated environmental impact. ○ Use high-quality materials and follow clinical guides to optimise restoration longevity. ○ Proactively reduce the use of amalgam in line with the Minamata Convention to phase down and phase out the use of amalgam in clinical dental practice. ○ Critically evaluate the environmental impact of all dental materials and incorporate this into decision-making at all levels. ○ Follow the Directions for Use (DFUs) very carefully for each material system for correct and optimum clinical outcomes. | [34, 77] |
| Environmental Impact – Energy and Water Consumption | | | |
| I1 | Reducing energy and water consumption at all levels of oral healthcare is key to mitigating the environmental impacts of oral healthcare. | <ul style="list-style-type: none"> ○ Use energy efficient appliances (e.g. LED, fluorescent bulbs, light sensors, dimmer switches). ○ Make use of natural lighting and turn off the lights when not in use. ○ Turn off the tap when brushing. ○ Use appliances when fully loaded. ○ Maintain and upgrade boilers and air conditioning units to ensure they are energy efficient. ○ Better use of windows and blinds to regulate temperature before using air conditioning. | [15, 36, 51, 55, 59, 65, 78, 79] |
| I2 | The use of energy from renewable sources will mitigate your environmental impacts. | <ul style="list-style-type: none"> ○ Produce your own renewable energy through use of solar panels, wind turbines, solar thermal systems, and heat pumps. ○ Engage with energy companies that use renewable energy. | [15, 36, 55, 65, 78-80] |
| Environmental Impact – Waste Management | | | |
| J1 | Developing and implementing a local environmentally sustainable waste management plan will mitigate your | <ul style="list-style-type: none"> ○ Implementation of the 4 Rs (reduce, reuse, recycle, rethink). ○ Identify and use effective waste disposal services that are close to the practice. ○ Incorporate the management of food waste, consider energy conversion or composting. | [15, 53, 68, 70] |

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| | environmental impacts. | <ul style="list-style-type: none"> ○ Waste segregation. ○ Use licensed handlers for off-site recycling of hazardous materials. ○ Use incineration facilities with energy recovery where possible. | |
| J2 | Engaging and challenging all stakeholders will result in more environmentally sustainable waste disposal procedures. | <ul style="list-style-type: none"> ○ Increase awareness of waste management and the associated costs. ○ Ensure effective waste segregation. ○ Ensure that waste contractors are complying with the appropriate local and national legislation at all levels, from collection to disposal. ○ Encourage contractors to diversify to include novel recycling opportunities. | [15, 53] |
| J3 | Reducing medicinal waste through evidence-based prescribing will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Only prescribe the required amount and dose. ○ Follow evidence-based national/international prescribing guidelines. ○ Adopt antibiotic stewardship to promote and monitor judicious use of antimicrobials. ○ Encourage patients to return unused medication to the pharmacy for safe disposal ○ Discourage disposal down sink or toilet as this has a huge impact on biodiversity and antibiotic resistance. | [15, 65, 68, 74, 75] |
| J4 | Reducing and recycling plastic waste will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Conduct environmental audits of the dental practice following the principles of the International Chamber of Commerce. ○ Minimise single use plastics as much as possible and replace with reusable items including matrix band retainers, anaesthetic syringes, aspiration tips, Dappen's pots. ○ Adopt reusables where possible to reduce single use plastic waste. | [33, 68, 81-83] |
| Dental Materials | | | |
| K1 | Managing amalgam waste through safe practices will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Use water-spray and high-volume aspiration when removing amalgam restorations. ○ Use effective chairside traps, vacuum filters, amalgam separators that meet ISO 11143. ○ Avoid the use of hypochlorite cleaners, as they increase dissolution of mercury. ○ Have an amalgam spill-kit for manage elemental mercury. ○ Recycle waste amalgam with effective collection, separation and recovery of mercury and silver through approved biological waste management companies. | [15, 51, 53, 68-71, 84, 85] |
| K2 | Reducing the use of nitrous oxide will mitigate the environmental | <ul style="list-style-type: none"> ○ Reduce the need for inhalation sedation through high-quality preventive oral healthcare thus avoiding operative interventions and other forms of sedation and anaesthesia. | [15, 59, 60] |

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| | impacts of the care you provide. | <ul style="list-style-type: none"> ○ Capture and neutralise the gas during use. ○ Use effective protocols and standard operating procedures to avoid atmospheric pollution. | |
| K3 | Reducing gypsum use for dental casts will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Employ intra-oral scanning to reduce impression material and gypsum waste. ○ Consider 3D printing and biodegradable resins to produce models. ○ Adopt biodegradable alternatives to gypsum. ○ Consider recycling options for gypsum. | [15, 56, 66, 69, 71] |
| K4 | Recovering and recycling dental materials, clinical items (PPE and products) and equipment will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Recycle waste amalgam, gypsum, lead foil, metal used in fixed/removable prosthodontics. ○ Segregate and recycle sterile packaging. ○ Use surgery zoning to separate contaminated and non-contaminated waste and facilitate recycling of these items where possible. | [15, 65, 70] |
| K5 | Using digital radiography will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Reduced use of harmful silver thiosulphate fixer. ○ Reduction of lead foil waste. ○ Improved image quality, reduced radiation exposure, editing abilities, facilitated storage & access. | [15, 51, 66, 69, 85] |
| K6 | Using environmentally sustainable disinfectant procedures will mitigate the environmental impacts of the care you provide. | <ul style="list-style-type: none"> ○ Use of ultrasonic, steam or dry heat for sterilisation instead of more toxic cleaning agents. ○ Avoid disposal of toxic pollutant solutions into the municipal wastewater sewerage system. | [39, 51, 59, 66, 86] |

Table 3: Content statements and curriculum subject mapping results

| Code | Content Statements | Subject Applicability |
|------------------------|--|---|
| <i>Raise Awareness</i> | | |
| A1 | The delivery of oral healthcare is currently environmentally unsustainable. We need to take responsibility as a profession to mitigate | Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |

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| | these impacts. | |
| A2 | The environmental impacts of oral healthcare cannot be eliminated but they can be mitigated. | Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |
| A3 | The provision of <u>professionally delivered</u> oral healthcare results in significant environmental impacts from: (i) Staff commute and patient travel; (ii) the product supply chain and management of waste from the dental practice. | <u>ALL clinical subjects</u> |
| A4 | <u>Personal oral hygiene regimes</u> have inevitable 'baseline' environmental impacts. These impacts arise from the product supply chain and disposal of oral hygiene products and devices. | <u>ALL clinical subjects</u> Less relevant to: Endodontology, Oral and Maxillofacial Radiology |
| A5 | It is imperative to promote and maintain good oral health through the prevention of oral diseases. An effective preventive regime carries an environmental burden that is much smaller than a disease-driven interventional treatment approach. | <u>ALL clinical subjects</u> Less relevant to: Oral and Maxillofacial Radiology |
| A6 | There is a need to influence and educate the profession and the public on strategies to mitigate environmental impacts of oral healthcare. | <u>ALL clinical subjects</u> and Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |
| A7 | The single most effective strategy to improve environmental sustainability in oral healthcare is through disease prevention. This will result in less travel, less use of resources and less waste generation. | <u>ALL clinical subjects</u> |
| Behaviour Change | | |
| B1 | Environmental sustainability requires a culture change across the profession and supply chain. | Dental Public Health & Community Dentistry, Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences, Dental Practice Management |
| B2 | Effective patient education will benefit their oral health and mitigate environmental impacts. | <u>ALL clinical subjects</u> and Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |
| B3 | The formulation of action plans and policies will result in more environmentally sustainable practice. | Dental Practice Management |
| B4 | Avoid waste: high-quality and efficient patient care will mitigate environmental impacts. | <u>ALL clinical subjects</u> and Dental Technology, Ethics, Professionalism, Information Literacy, Social Accountability and |

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| | | Behavioural Sciences, Dental Practice Management |
| 4 Rs – Reduce, Reuse, Recycle, Rethink | | |
| C1 | Delivering a prevention-focused, patient-centred high quality oral health care service will reduce treatment need and the resultant environmental impact. | <u>ALL clinical subjects</u> |
| C2 | Consider using reusable options where appropriate. | <u>ALL clinical subjects</u> and Basic Sciences, Dental Technology, Dental Practice Management |
| C3 | A shift from a wasteful linear economy to a more sustainable circular economy in oral healthcare is possible by proactively seeking and implementing recycling opportunities. | Basic Sciences, Dental Practice Management |
| C4 | Rethink - how can you optimise existing systems and processes to be more environmentally sustainable? | Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences, Dental Practice Management |
| Good Quality Oral Healthcare | | |
| D1 | Good oral healthcare is good for the patient, good for the profession and good for the environment. | <u>ALL clinical subjects</u> and Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |
| D2 | A reduction in the need for professional-led interventions is achieved through disease prevention. This is the single most environmentally sustainable measure. | <u>ALL clinical subjects</u> Less relevant to: Oral and Maxillofacial Radiology |
| D3 | High quality operative care reduces repair, replacement and waste. | <u>ALL clinical subjects</u> and Dental Technology |
| D4 | Integrated healthcare services with patients as co-managers of their care mitigates environmental impacts. | <u>ALL clinical subjects</u> and Dental Technology |
| D5 | There is a need to take ownership of the care that you provide through lifelong learning to deliver high quality clinical outcomes. Evidence-based procedures provide environmentally sustainable care. | <u>ALL clinical subjects</u> and Dental Technology, Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences, Dental Practice Management |
| Knowledge Exchange - Research | | |
| E1 | Developing a research curiosity will increase your levels of knowledge and awareness and may help to mitigate the environmental impacts of oral healthcare. | Basic Sciences, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |

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| E2 | Evidence-based dentistry must consider the triple bottom line of clinical effectiveness, cost effectiveness and environmental sustainability. | <i>ALL clinical subjects</i> and Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |
| E3 | It is important to guard against misinformation and disinformation that may influence the objectivity of your decision-making. | Basic Sciences, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences |
| Policy and Regulations | | |
| F1 | Active engagement with environmental policies and regulations in oral healthcare will mitigate your environmental impact. | <i>ALL clinical subjects</i> and Dental Biomaterials, Dental Technology, Ethics, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences, Dental Practice Management |
| F2 | Active engagement and collaboration with policymakers will lead to the development of more environmentally sustainable oral healthcare policies. | Dental Public Health and Community Dentistry, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences, Dental Practice Management |
| Environmental Impact - Travel | | |
| G1 | Adopting more sustainable travel options will mitigate your environmental impact. | Core Environmental Sustainability Learning and Teaching Events, Extra-curricular culture change. |
| G2 | Planning patient care to reduce the number of appointments will mitigate the environmental impact of the care you provide. | Dental Practice Management |
| G3 | Facilitating care delivery in multi-professional health centres will mitigate the environmental impact of the care you provide. | <i>ALL clinical subjects</i> and Dental Practice Management |
| G4 | Optimising dental practice administration will mitigate the environmental impact of the care you provide. | Dental Practice Management |
| Environmental Impact - Procurement | | |
| H1 | Procured goods have an inherent environmental impact that arises from the supply chain. This is additional to clinical or consumer use and includes: sourcing of raw materials - manufacturing - packaging - distribution - procurement - waste management. | Core Environmental Sustainability Learning and Teaching Events, Extra-curricular culture change. |
| H2 | Engaging and challenging stakeholders across the supply chain will support environmentally sustainable practices. | Basic Sciences, Dental Public Health and Community Dentistry, Professionalism, Information Literacy, Social Accountability and Behavioural Sciences, Dental Practice Management |

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| H3 | Selecting fit for purpose dental materials, clinical items (PPE and products) and equipment will mitigate the environmental impacts of the care you provide. | <u>ALL clinical subjects</u> and Dental Biomaterials, Dental Technology, Dental Practice Management |
| Environmental Impact – Energy and Water Consumption | | |
| I1 | Reducing energy and water consumption at all levels of oral healthcare is key to mitigating the environmental impacts of oral healthcare. | <u>ALL clinical subjects</u> and Basic Sciences, Dental Biomaterials, Dental Technology, Dental Practice Management |
| I2 | The use of energy from renewable sources will mitigate your environmental impacts. | Dental Practice Management |
| Environmental Impact – Waste Management | | |
| J1 | Developing and implementing a local environmentally sustainable waste management plan will mitigate your environmental impacts. | Basic Sciences, Dental Practice Management |
| J2 | Engaging and challenging all stakeholders will result in more environmentally sustainable waste disposal procedures. | Basic Sciences, Dental Public Health and Community Dentistry, Dental Practice Management |
| J3 | Reducing medicinal waste through evidence-based prescribing will mitigate the environmental impacts of the care you provide. | <u>ALL clinical subjects</u> and Basic Sciences (specifically Microbiology and Pharmacology) |
| J4 | Reducing and recycling plastic waste will mitigate the environmental impacts of the care you provide. | <u>ALL clinical subjects</u> and Basic Sciences, Dental Biomaterials, Dental Technology, Dental Practice Management |
| Dental Materials | | |
| K1 | Managing amalgam waste through safe practices will mitigate the environmental impacts of the care you provide. | Cariology, Conservative Dentistry, Prosthetic Dentistry, Special Care Dentistry, Dental Public Health and Community Dentistry, Dental Biomaterials, Dental Practice Management |
| K2 | Reducing the use of nitrous oxide will mitigate the environmental impacts of the care you provide. | <u>ALL clinical subjects</u> Less relevant to: Orthodontics, Oral and Maxillofacial Radiology |
| K3 | Reducing gypsum use for dental casts will mitigate the environmental impacts of the care you provide. | <u>ALL clinical subjects</u> and Dental Technology Less relevant to: Endodontology, Preventive Dentistry, Oral Medicine and Pathology, Oral and Maxillofacial Radiology |
| K4 | Recovering and recycling dental materials, clinical items (PPE and products) and equipment will mitigate the environmental impacts of the care you provide. | <u>ALL clinical subjects</u> and Dental Technology, Dental Practice Management |

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| K5 | Using digital radiography will mitigate the environmental impacts of the care you provide. | Oral and Maxillofacial Radiology and Imaging, Oral Medicine and Pathology, Dental Practice Management |
| K6 | Using environmentally sustainable disinfectant procedures will mitigate the environmental impacts of the care you provide. | Dental Practice Management |

Discussion

This research explores the strategies for embedding ES within an existing OHP curricula and the content that should be included – The 'how to do it' and 'what to include'. The output provides a complementary addition to previous reports that establish a need to embed ES in curricula and detail specific learning outcomes [13, 14]. The approaches used are grounded in the evidence-base and collaboration with key stakeholders within OHP education. Key themes have been developed from academic staff and student focus groups and evidence-based statements have been mapped to all curriculum subjects. These findings apply to OHP education at all levels, across all professions and extend from junior students to professional development of qualified clinicians. It is envisaged that the strategies, the evidence-based subject-specific statements and the supporting examples are to be applied directly as appropriate within local contexts.

Normalising the topic of Environmental Sustainability to support attitude and behaviour change

Academic staff and students perceived the topic of ES to be mostly unexplored within the curriculum, with limited discussion of the topic in their previous educational experiences. A key step outlined by the two cohorts was to discuss ES frequently and to 'normalise' the topic as a key part of OHP education. This is also a key strategy outlined in the literature [34, 61]. A change of mindsets is required (namely attitudes and behaviours) by all stakeholders to reinforce this key topic in all aspects of education. Students felt that there is a particular need for role models to demonstrate positive environmental attitudes and behaviours within the constraints of current clinical practice.

Environmental Sustainability transcends all disciplines of dentistry and oral healthcare

This research identified that climate change and ES are concerns that must be embedded across *all* subjects and disciplines of dentistry and oral healthcare. Previous guidelines have supported a move away from standalone ES courses delivered at a specific point in the curriculum, although it is not clear if this is a common approach [13, 14, 25]. Standalone ES courses do not typically extend across all curriculum subjects, do not reinforce longitudinal learning and may be more difficult to embed within an existing curriculum as it requires the creation of a new programme of study. Longitudinal interweaving of ES with horizontal and vertical integration allows for incremental learning of this challenging construct with increasing levels of sophistication and complexity and adequate coverage of all curriculum subjects [87-90]. Delivering ES education that is packaged and explored across multiple learning events and disciplines presents some important advantages. Firstly, the core learning concept will be captured and better understood if delivered in the actual context of the discipline (e.g. N₂O inhalation sedation in Paediatric Dentistry and the environmental impacts associated with this). The cumulative cognitive load will also be reduced, which may improve knowledge retention and facilitate reflection in action [28, 91, 92]. Whilst not specifically termed as 'cognitive load', students who participated in the focus groups raised concerns regarding additional content in an already demanding curriculum and suggested that new ES content is delivered as part of other topics. In addition to the educational benefits, it is likely this approach will reduce curriculum burden through incorporation within *existing* educational events.

Baseline knowledge transmission with relevant practical application

Academic staff and students were aligned in their opinions with regards to the need for early didactic and theoretical learning of the core issues relating to climate change, the environmental

impact of oral healthcare and the need to overcome existing barriers and strategies to achieve environmentally sustainable change. It was widely acknowledged that students come from diverse backgrounds and current pre-university education does not provide a standardised approach to environmental science. The delivery of 'baseline' didactic teaching through lectures or other feasible methods is valuable to achieve standardised learning prior to further subject (ES) exploration across the multiple disciplines within the OHP curriculum. The FDI World Dental Federation has recently published a Massive Open Online Course (MOOC) to help professionals and students to understand the importance of sustainable practices and their own role in championing environmental sustainability within oral healthcare [17]. The importance of relevant practical application of theoretical learning was discussed amongst both cohorts and this aligns with the need for both conceptual and experiential knowledge [93]. A disparity between these two knowledge systems results in a 'theory-practice' gap and a lack of practical emphasis may lead to a perception that ES is not importance or actionable [94].

Viewing and modifying existing teaching and assessment events through a different lens

It is extremely positive that academic staff and students identified multiple opportunities to modify existing teaching and assessments events by adapting the lens in which we view OHP education. Both cohorts raised suggestions regarding modifying existing teaching content, learning resources, clinical systems, and assessment rubrics. These relatively simple changes will convey several important benefits: normalise ES, incorporate ES across the full length of the curriculum and incorporate ES within assessments. Specific ideas include incorporating ES into current lectures, adapting clinical forms and awarding marks for ES in clinical and written assessments.

Safeguarding against misinformation and disinformation

Climate change and ES are emotive topics and academic staff and students must be conscious of the risk of eco-anxiety and the need to provide appropriate student support measures [95]. Such measures may include an open discussion staff-student forum where issues can be voiced and addressed in an objective, balanced and informed manner. Misinformation and disinformation can exacerbate levels of eco-anxiety, which must be avoided. Environmental sustainability is a pragmatic approach to the mitigation of environmental impacts that is grounded in an evidence-based approach. Awareness of emerging environmental research methods including life-cycle assessment (LCA) is essential.

ES is sometimes erroneously linked to other polarised attitudes and behaviours that can serve as strong detractors and demotivators to employing more sustainable oral healthcare. As professionals and educators, we should guard against and protect others from, these disinformation messages. A careful use of resources and approaches that are grounded in sound science must be employed across all levels of OHP education.

Using the evidence-based and subject-specific content statements

The content statements proposed in this paper have been developed from an extensive evidence base and have been mapped across nineteen curriculum subjects throughout the length of the OHP curriculum. It is unusual for educational content to be developed as a direct aim of a research investigation. Educators usually develop content that is informed by current and robust research in the field that is combined with their own expertise and experiences. However, a significant barrier to embedding ES in OHP and wider healthcare curricula is educator unfamiliarity with the topic and

a lack of practical guidance [21, 22, 96-99]. It is envisaged that this research will help to overcome this barrier by providing educators with evidence-based subject-specific statements that can be incorporated directly into their teaching – across any discipline.

The statements may be taken directly or modified according to the educator's expertise and the curriculum event it will be incorporated into. Additionally, the statements may be used in isolation, or if educators feel more detail is needed, the additional content column in Table 2 may be used to provide further information and examples. Table 4 presents examples of how the statements can be used in different areas of teaching. These statements could be included to augment existing teaching, perhaps through an additional slide to a lecture, or incorporated into clinical learning material.

Table 4 – Examples of the use of evidence-based statements in a variety of teaching topics

| Teaching Topics | Evidence-based Content Statement(s) to be incorporated |
|---------------------------------------|--|
| Prevention of Oral Cancer | <p>It is imperative to promote and maintain good oral health through the prevention of caries, periodontal disease, pulpal disease and oral cancers.</p> <p>An effective preventive regime carries an environmental burden, but this is much smaller than a disease-driven interventional treatment approach. We can mitigate the environmental impact of oral healthcare through effective preventive strategies.</p> |
| Operative Management of Dental Caries | <p>High quality operative care reduces repair, replacement and waste.</p> <p>Using fit for purpose dental materials and following evidence-based procedures will help to provide environmentally sustainable care and long-lasting clinical outcomes.</p> |
| Antimicrobial Resistance | <p>Reducing medicinal waste through evidence-based prescribing will mitigate the environmental impacts of the care you provide.</p> <p>Active engagement with environmental policies and regulations in oral healthcare will mitigate your environmental impact.</p> |
| Sedation in Paediatric Dentistry | <p>The single most effective strategy to improve environmental sustainability in oral healthcare is through disease prevention. This will result in less travel, less use of resources and less waste generation.</p> <p>Reducing the use of nitrous oxide will mitigate the environmental impacts of the care you provide.</p> |
| Digital Radiography | <p>Using digital radiography will mitigate the environmental impacts of the care you provide.</p> |

The consultation process with discipline experts established that some statements can be further adapted to the curriculum subject. The aim of this research is to provide statements that serve as a baseline message grounded in scientific evidence. Further modification by discipline experts is

expected as educators become more comfortable in embedding ES in their teaching. An example of some statements being tailored to individual disciplines can be found in Table 5.

Table 5 – Examples of further modifications to content statements when mapped to individual curriculum subjects

| Original Statement | Subject | Modified Statement |
|--|--|---|
| It is imperative to promote and maintain good oral health through the prevention of caries, periodontal disease, pulpal disease and oral cancers. An effective preventive regime carries an environmental burden, but this is much smaller than a disease-driven interventional treatment approach. We can mitigate the environmental impact of oral healthcare through effective preventive strategies. | Oral Medicine and Pathology | It is imperative to promote and maintain good oral health through the prevention of oral cancers. An effective preventive regime carries an environmental burden, but this is much smaller than a disease-driven interventional treatment approach such as tumour resection. We can mitigate the environmental impact of oral healthcare through effective preventive strategies and early identification and referral. |
| Selecting evidence-based fit-for-purpose materials, instruments, equipment and sundries will mitigate the environmental impacts of the care you provide. | Dental Biomaterials | Selecting evidence-based fit-for-purpose dental materials will mitigate the environmental impacts of the care you provide. |
| The single most effective strategy to improve environmental sustainability in oral healthcare is to focus on disease prevention. This will result in less travel, resource use and waste generation. | Paediatric Dentistry | The single most effective strategy to improve environmental sustainability in oral healthcare is to focus on disease prevention. This will reduce a lifetime of oral disease burden and will result in less travel, resource use and waste generation. |
| Aligned and integrated healthcare services with patient co-management of care mitigates environmental impacts. | Dental Public Health and Community Dentistry | Aligned and integrated oral healthcare services, including its commissioning, contracting, and monitoring, should consider their environmental impact. |

The ES content and messages identified in this work are designed to be clear and succinct. Notwithstanding, we recognise that their application to complex clinical management scenarios may be less clear and require a patient-centred critical decision-making process. In these cases, ES gains for different clinical management approaches must be carefully weighed up against each other and against the care needs for the patient. In any event, it is important to establish the educational principle that the default baseline setting for the management of a condition is always set by any robust evidence-based guidance or recommendations that are accepted by a recognised professional body. An example of this scenario is the clinical management of pericoronitis. The recurrent nature of the condition may require multiple patient visits that have to be balanced against the carbon footprint of its management. Clinicians should follow the accepted professional specialty guidelines [100, 101]. Conservative management may include multiple patient visits to care centres, multiple treatment episodes and ongoing specific home care and maintenance regimes with more cleaning, irrigation, and chlorhexidine mouthwash. Additionally, multiple prescriptions of antibiotics may be required. Conversely, a surgical management will require local anaesthesia and potentially sedation or general anaesthesia. Each of these two approaches has its

own environmental impacts from the surgical care, equipment, sterilisation, single use plastics and waste.

These investigations have achieved the aims of identifying suitable strategies to embed ES within an existing curriculum and creating evidence-based and subject-specific ES content. The focus groups included a significant number of academic staff and students and the consultation process for the evidence-based statements included views from three key stakeholders of OHP education. A potential limitation of this study is the acceptance of probable selection bias of participants within the focus groups and the consultation process. That is, despite a participant selection process that actively encouraged inclusivity and diversity of opinions; it is likely that study participants self-selected by virtue of their inherent interest in the subject. This is not necessarily considered to be a drawback in this study as the participant's interest (and bias) towards the subject enabled the acquisition of a comprehensive range of strategies and content statements for the inclusion of ES in the curriculum. Additionally, whilst the authors acknowledge that the use of flow chart is useful to present the findings of the literature searches, this was not possible due to the extensive date range of the literature search that spanned several years.

There is an acknowledgement of wide health inequalities across the world, both within countries and across borders. For the oral healthcare profession, this presents a real challenge with a need to balance preventive oral healthcare with sustainability goals [16]. Moreover, the evidence that supports our current understanding of the perceived educational challenges and the proposed solutions, arise from a relatively small number of higher education institutions [21-23]. It is important therefore, that the strategic educational approaches and content that are promoted in this document are considered in the cultural and socio-economic contextual framework of the region in which they are to be implemented.

Conclusions

There is an urgent need to include Environmental Sustainability in the education of Oral Health Professionals at all stages, from early undergraduate to postgraduate continuing professional development. This study identifies for the first time a comprehensive strategy for the inclusion and delivery of ES (method and content) in the curriculum. A novel method to define and map curriculum content has been explored and validated using a range of complementary methodologies. A comprehensive and robust list of evidence-based and subject-specific educational content statements have been defined in the field of Environmental Sustainability in dentistry and oral healthcare. These statements have been mapped to all curriculum subjects and it is envisaged that these can be adopted and integrated by educators into the existing curriculum, without the need to disrupt the core syllabus and course structure.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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