

Review Article

Environmental Sustainability in Dental Practices: A Review of Constraints and Enablers

Yaser Abdulaziz Alsahafi*

BDS, MSD, CPH, PhD, Community Dentistry and Oral Epidemiology Department, College of Dentistry, Qassim University, Saudi Arabia

*Corresponding author email: y.alsahafi@qu.edu.sa

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Abstract

Background: Environmental sustainability has become an increasingly important concern in healthcare, with dental services contributing to greenhouse gas emissions, waste generation, and resource consumption. Although interest in sustainable dental practice is growing, the factors that support or hinder implementation remain fragmented across the literature.

Objective: This structured narrative review examines the constraints and enablers influencing the adoption of environmental sustainability practices in dental settings.

Methods: A semantic search was conducted using the Elicit academic search engine to retrieve the most relevant papers on sustainability in dental practice. Studies were screened based on predefined criteria, including relevance to dental practice, a sustainability focus, identification of constraints or enablers, and an empirical study design. Data was extracted on study characteristics, context, and key findings.

Results: Ten studies met the inclusion criteria, comprising seven primary research articles and three literature reviews. Financial constraints - particularly high initial costs and limited economic incentives - were the most frequently reported barriers. Infection control guidelines that prioritize single-use materials created additional structural challenges. Knowledge gaps, limited training, inadequate recycling infrastructure, and organizational resistance further impeded implementation. Enablers included strong practitioner awareness, positive attitudes toward environmental responsibility, targeted education and mentorship, long-term cost savings, supportive policies, and leadership engagement. Collaborative efforts between dental professionals, policymakers, and suppliers were also identified as essential enablers.

Conclusion: The adoption of environmentally sustainable practices in dentistry is shaped by a complex interplay of financial, regulatory, educational, and organizational factors. Addressing these challenges will require coordinated action, including regulatory reform, financial support mechanisms, structured sustainability training, and improved infrastructure. Strengthening these enablers can help dental systems - particularly in developing countries - transition toward more environmentally responsible models of care.

Key words

Environmental sustainability, Dental practice, Healthcare.

Introduction

Environmental sustainability has become an increasingly important priority within healthcare systems as the sector's contribution to global environmental degradation becomes more widely recognized. Healthcare activities are estimated to account for 4–5% of global greenhouse gas emissions. Dental industry contributes through energy consumption, procurement patterns, waste generation, and transportation associated with patients and staff [1, 2]. As climate change intensifies, dental services - like other areas of healthcare - face growing pressure to reduce their environmental footprint while maintaining high standards of patient care and infection control. Dental practices generate substantial amounts of waste, particularly plastics, single-use items, and biomedical materials, and they rely heavily on energy-intensive equipment and sterilization processes [3, 4]. The COVID-19 pandemic further increased dependence on disposable materials, amplifying environmental impacts and highlighting the ongoing tension between infection control requirements and sustainability goals [5]. Despite these challenges, interest in environmentally responsible approaches - often referred to as “green dentistry” - has grown. These approaches include waste reduction, energy efficiency, sustainable procurement, and more environmentally conscious clinical workflows [6].

However, the adoption of sustainability initiatives in dental settings remains inconsistent. Studies from various countries report financial constraints, high costs of sustainable products, and limited economic incentives as major

barriers [7–9]. Infection control guidelines that prioritize single-use materials create additional structural obstacles that many dental teams feel unable to challenge [10, 11]. Knowledge gaps, limited training, inadequate recycling infrastructure, and concerns about the performance of sustainable materials further hinder implementation [12, 14].

At the same time, several facilitators have been identified. Many dental professionals express strong awareness of environmental issues and positive attitudes toward sustainability, with increasing recognition of dentistry's role in planetary health [7, 9]. Educational initiatives, mentorship, and interdisciplinary collaboration have been shown to strengthen sustainability competencies and support long-term practice transformation [14]. Financial facilitators - such as long-term cost savings, reduced waste-management expenses, and government incentives - demonstrate that sustainable dentistry can be economically viable [15, 16]. Support from professional associations and regulatory bodies further enhances implementation efforts [7].

Despite growing interest, the literature remains fragmented, and no clear consensus exists regarding which barriers and facilitators exert the greatest influence on sustainability adoption. A structured synthesis is therefore needed to clarify these determinants and inform policymakers, educators, and practitioners in designing effective interventions.

The objective of this structured narrative review is to examine the constraints and enablers influencing the adoption of environmental sustainability practices in dental settings. By integrating findings from primary studies and literature reviews, this work aims to identify the most influential factors shaping sustainability implementation and highlight opportunities for advancing environmentally responsible dental care.

Methodology

This review examined published literature addressing environmental sustainability practices in dental settings, with a focus on identifying constraints and enablers to implementation. The review process consisted of three stages: literature search, screening, and data extraction.

Literature search strategies

A semantic search was conducted using the query *“What barriers and facilitators exist for implementing environmental sustainability practices in dental practices?”* across more than 138 million academic papers indexed in the Elicit search engine, which incorporates Semantic Scholar and OpenAlex. The 50 most relevant papers were retrieved for further assessment.

Screening:

Studies were screened based on their abstracts using the following criteria:

- involvement of dental professionals or dental practice settings
- explicit focus on environmental sustainability or green dentistry
- identification of barriers and/or facilitators
- examination of implementation processes
- relevance to clinical practice rather than manufacturing or laboratory contexts
- empirical study design (qualitative, quantitative, mixed methods, systematic review, or program evaluation)

Studies meeting these criteria were included following a holistic judgment of relevance.

Data extraction

Uniform data were extracted from each included study, including study context, design, geographic location, clinical setting, participant roles, and sample size.

Results

Characteristics of Included Studies

Ten studies met the inclusion criteria: seven primary research articles and three literature reviews, representing a range of geographic and clinical contexts (**Table - 1**).

Constraints to Sustainability Implementation

The review revealed various constraints to implementation of sustainability in dentistry. (**Table - 2**).

Financial Barriers

Financial constraints were the most frequently reported barrier (**Table – 2**). Studies from Portugal [7], India [8], and Jordan [9] consistently identified cost as a major impediment, with 44.6% of Portuguese clinical directors citing financial limitations [7]. High upfront costs for sustainable technologies [14], limited economic analyses demonstrating return on investment [15], and the higher price of environmentally friendly products - some of which do not yet meet performance expectations [10] - were commonly noted.

Regulatory and policy barriers

Infection control guidelines formed the second major category of obstacles (**Table – 2**). Dutch practitioners viewed infection control requirements as the most significant barrier [10], while UK staff expressed concerns about challenging established guidance [11]. Portuguese clinicians reported uncertainty regarding cross-infection control when using sustainable materials [7]. These guidelines often prioritize single-use items, creating direct conflicts with sustainability objectives [14]. A lack of government incentives was also reported in India [8] and Jordan [9].

Knowledge and awareness gaps

Knowledge gaps were widespread (**Table - 2**). In India, more than half of practitioners were unfamiliar with the concept of green dentistry [12]. Dutch practitioners demonstrated limited understanding of the main contributors to

dentistry's environmental burden [10]. Limited public and professional awareness, insufficient interdisciplinary knowledge, and unclear understanding of material-related waste impacts were also reported [13–15].

Table - 1: Summary of Articles included in the review.

Study	Study type	Country	Setting	Participants	Sample size
Volgenant et al., 2022 [10]	Primary study (qualitative)	Netherlands	Dental practices	Dentists, dental hygienists, dental assistants, managers, practice owners, suppliers	14 stakeholders
Neves et al., 2022 [7]	Primary study (quantitative)	Portugal	Dental clinics	Clinical directors (dentists or stomatologists)	245 participants
Chopra et al., 2017 [8]	Primary study (quantitative)	India	Private practices	Registered dentists	120 dentists
Al Shatrat et al., 2013 [9]	Primary study (quantitative)	Jordan	Private dental practices	Dentists	150 dentists
Richardson et al., 2016 [15]	Primary study (quantitative audit)	Not specified	Dental practices	Not specified	Not specified
Grose et al., 2016 [11]	Primary study (qualitative)	United Kingdom	Mixed NHS/ private practice	All practice disciplines	Not specified
Thakar et al., 2023 [12]	Primary study (quantitative)	India	Private practices	Dental students and practitioners	Not specified
Martin et al., 2021 [13]	Scoping literature review	Not applicable	Not applicable	Not applicable	Not applicable
Antoniadou et al., 2024 [14]	Scoping review	Not applicable	Not applicable	Not applicable	30 articles
Lopez de Leon et al., 2020 [16]	Literature review	Canada	Clinical settings	Oral health care professionals	8 studies reviewed

Training and Deficiencies

Lack of training was the second most common barrier in Portugal [7] (**Table – 2**), and specialized training was required for implementing new systems [14].

Infrastructure Limitations

It included inadequate recycling facilities [14], challenges in biomedical waste recovery and recycling [13], and limited recycling infrastructure in general [14] (**Table – 2**).

Organizational Challenges

Organizational obstacles (Table – 2) included inefficiencies, and time constraints associated with implementing new practices [14, 15]. resistance to workflow changes, supply chain

Table - 2: Identified constraints to implementation of Sustainability in Dentistry.

Constraints category	Specific constraints	Studies reporting
Financial constraints	High costs of sustainable products and technologies	Volgenant 2022 [10], Neves 2022 [7], Al Shatrat 2013 [9], Thakar 2023 [12], Antoniadou 2024 [14]
Financial constraints	High technology costs for implementation	Antoniadou 2024 [14]
Financial constraints	Lack of economic analysis on costs	Richardson 2016 [16]
Financial constraints	Costs of air conditioning systems	Neves 2022 [7]
Regulatory/policy	Infection control guidelines prioritizing single-use materials	Volgenant 2022 [10], Neves 2022 [7], Grose 2016, Antoniadou 2024 [14]
Regulatory/policy	Lack of government incentives	Chopra 2017 [8], Al Shatrat 2013 [9]
Regulatory/policy	Regulatory constraints	Antoniadou 2024 [14]
Knowledge/awareness	Limited knowledge of sources of planetary burden	Volgenant 2022 [10]
Knowledge/awareness	51.8% unaware of green dentistry concept	Thakar 2023 [12]
Knowledge/awareness	Lack of professional and public awareness	Martin 2021 [13]
Knowledge/awareness	Limited interdisciplinary knowledge integration	Antoniadou 2024 [14]
Knowledge/awareness	Unclear impact of material selection on waste	Richardson 2016 [15]
Training/education	Lack of information and training	Neves 2022 [7], Martin 2021 [13]
Training/education	Need for specialized training for new systems	Antoniadou 2024 [14]
Product availability	Sustainable products not meeting performance standards	Volgenant 2022 [10]
Product availability	Challenges in manufacturing, use, and disposal of materials	Martin 2021 [13]
Infrastructure	Limited recycling infrastructure	Antoniadou 2024 [14]
Infrastructure	Inadequate recycling facilities	Antoniadou 2024 [14]
Infrastructure	Challenges in biomedical waste recovery and recycling	Martin 2021 [13]
Workflow	Time and workflow constraints	Richardson 2016 [15]
Workflow	Patient and staff commute emissions	Martin 2021 [13]
Organizational	Cultural and organizational resistance	Antoniadou 2024 [14]

	to change	
Organizational	Supply chain inefficiencies	Antoniadou 2024 [14]
Quality concerns	Insecurity about cross-infection control with sustainable materials	Neves 2022 [7]
Quality concerns	Need for ongoing commitment to sustain improvements	Antoniadou 2024 [14]

Enablers of Sustainability Implementation

The review revealed various enablers of implementation of sustainability in dentistry. (Table - 3).

Knowledge, Awareness, and Positive Attitudes

High awareness levels were reported (Table – 3) in Portugal [7] and Jordan [9], and younger practitioners and women were more likely to express strong environmental concern [10, 12].

Educational Initiatives

Formal and continuing education, mentorship, leadership programs, and interdisciplinary collaboration (Table – 3) were shown to support long-term sustainability improvements [8, 14].

Financial Facilitators

Financial facilitators (Table – 3) included tax incentives for environmental certifications [7], long-term cost savings that could be reinvested in patient care [16], and profitability associated with waste reduction [15]. Government grants and supplier partnerships further supported implementation [14]

Supportive Policies and Guidelines

Policies such as the Portuguese Dental Association’s manual of good practices and EU waste-management regulations provided structural support (Table – 3) for sustainability initiatives [7, 14].

Leadership and Organizational Culture

Staff motivation, ethical commitments, designated sustainability champions, and professional association guidance (Table – 3) were all identified as important facilitators [7, 11, 14].

Discussion

The most persistent challenge identified across studies is the tension between infection control requirements and sustainability goals. This conflict appears across diverse healthcare systems, suggesting that it stems from structural regulatory frameworks rather than individual practice decisions. Dutch, Portuguese, and UK practitioners all expressed concerns about deviating from infection control guidelines, which currently favor single-use materials [7, 10, 11, 14]. Addressing this barrier will likely require regulatory bodies to reassess infection control protocols in light of emerging evidence on the safety and efficacy of sustainable alternatives.

Financial barriers also emerged consistently, particularly in lower-income settings (Table – 2). While initial costs for sustainable technologies and materials are high [10, 14], long-term savings through waste reduction and energy efficiency have been documented [15, 16]. This distinction between upfront investment and downstream savings helps explain the apparent contradiction between financial barriers and financial facilitators. Government subsidies, grants, and tax incentives may help bridge this gap.

Knowledge and training gaps were widespread but varied by demographic factors. Younger practitioners, women, and clinicians with higher patient volumes demonstrated greater awareness and willingness to adopt sustainable practices [10, 12]. However, even practitioners with high general awareness often lacked specific knowledge about the environmental impact of different materials and procedures [15]. This suggests that sustainability education must move

beyond general awareness to focus on actionable, practice-level competencies.

Infrastructure and product availability barriers reflect broader supply chain limitations. Inadequate recycling systems and limited

availability of high-performance sustainable materials cannot be resolved at the practice level alone. Successful facilitators - such as supplier take-back programs and industry partnerships - highlight the need for coordinated action across the dental sector [7, 14].

Table - 3: Identified enablers for implementation of Sustainability in Dentistry.

Enablers category	Specific enablers	Studies reporting
Knowledge/awareness	Growing awareness of planetary health	Volgenant 2022 [10]
Knowledge/awareness	High importance given to sustainability (96%)	Neves 2022 [7]
Knowledge/awareness	High knowledge of eco-friendly strategies	Al Shatrat 2013 [9]
Knowledge/awareness	Better awareness among high-volume practitioners	Thakar 2023 [12]
Education/training	Education critical for lean management success	Antoniadou 2024 [14]
Education/training	Need for formal and continuing education	Chopra 2017 [8], Al Shatrat 2013 [9]
Education/training	Mentorship and leadership programs	Antoniadou 2024 [14]
Education/training	Interdisciplinary learning and collaboration	Antoniadou 2024 [14]
Resources	Overviews and guides of sustainable methods	Volgenant 2022 [10]
Resources	Development of educational programs for lean skills	Antoniadou 2024 [14]
Resources	Continuous learning through feedback loops	Antoniadou 2024 [14]
Financial	Potential tax reductions for certifications	Neves 2022 [7]
Financial	Long-term practice savings for client care	Lopez de Leon 2020 [16]
Financial	Increasing profitability from waste reduction	Richardson 2016 [15]
Financial	Government grants and subsidies	Antoniadou 2024 [14]
Financial	Partnerships with suppliers reducing costs	Antoniadou 2024 [14]
Policy/guidelines	Portuguese Dental Association guidelines	Neves 2022[7]
Policy/guidelines	Strong regulatory backing in EU	Antoniadou 2024 [14]
Policy/guidelines	Policy development guidance	Al Shatrat 2013 [9], Lopez de Leon 2020 [16]
Products	Call for industry to develop sustainable products	Neves 2022 [7]
Products	Partnerships with suppliers offering eco-friendly materials	Antoniadou 2024 [14]
Leadership	Adherence to ethical codes and regulations	Neves 2022 [7]
Leadership	Designated lean champions	Antoniadou 2024 [14]
Staff attitudes	Strong desire to implement changes	Grose 2016 [11]

Staff attitudes	Women more involved in planetary health	Volgenant 2022 [10]
Staff attitudes	Younger practitioners (20-30 years) more willing	Thakar 2023 [12]
Culture	Satisfactory implementation across categories	Neves, et al. 2022 [7]
Culture	Lessons from practice encourage positive change	Grose, et al. 2016 [11]
External support	Collaboration between professionals, policymakers, industry	Antoniadou, et al. 2024 [14]
External support	Portuguese Dental Association support	Neves, et al. 2022 [7]
External support	Government incentives	Antoniadou, et al. 2024 [14]

Finally, organizational culture plays a crucial role. Although many staff members express motivation to adopt sustainable practices [11], workflow constraints and resistance to change remain significant obstacles [14, 15]. Leadership engagement, professional identity, and ethical commitments can help create an environment where sustainability becomes an integral part of clinical practice.

Conclusion

Environmental sustainability in dental practice is increasingly recognized as an essential component of responsible healthcare delivery, yet its implementation remains uneven across global contexts. This review highlights a complex interplay of structural, financial, educational, and organizational factors that shape the adoption of environmentally sustainable practices in dental settings. The most persistent challenge arises from the perceived conflict between infection control requirements and sustainability goals, a tension that cannot be resolved at the practice level alone. Regulatory bodies will need to reassess existing guidelines and consider evidence-based sustainable alternatives to enable meaningful progress.

Financial barriers - particularly high initial investment costs - continue to limit adoption, especially in low- and middle-income countries. However, evidence suggests that long-term operational savings, waste-reduction benefits, and targeted government incentives can offset

these challenges. Knowledge gaps and limited training further hinder implementation, underscoring the need for structured educational programs that equip dental professionals with practical, system-level sustainability competencies rather than general awareness alone.

Infrastructure limitations and supply chain constraints also play a significant role, indicating that sustainable dentistry requires coordinated action among policymakers, manufacturers, suppliers, and professional associations. Encouragingly, many dental professionals express strong motivation to adopt environmentally responsible practices, and several countries have already demonstrated that supportive policies, leadership engagement, and interdisciplinary collaboration can facilitate meaningful change.

Overall, advancing environmental sustainability in dentistry will require a combination of regulatory reform, financial support mechanisms, targeted education, and sector-wide collaboration. By addressing these interconnected barriers and leveraging identified facilitators, dental systems - particularly in developing countries - can move toward more resilient, environmentally responsible models of care that protect both patient health and planetary health.

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