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Research Article

From Clinic to Policy: Advancing Sustainable Dentistry through Public Health Systems

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Abstract:

Background: Dentistry generates significant biomedical waste, utilizes energy-intensive resources, and employs materials harmful to the environment, such as dental amalgam. The concept of dental sustainability is in line with international targets like the UN Sustainable Development Goals (SDGs) and the Minamata Convention on Mercury.
Aims: This narrative policy review analyzes how dental associations and public health systems may lead policy, educate, advocate, and reform dentistry to make it more sustainable.
Methods: The study was performed based on peer-reviewed sources, as well as international policy and professional guidelines. PubMed, Scopus, Google Scholar, WHO, FDI, ADA, NHS, and national regulatory bodies were target sources of evidence. A synthesis of literature on the effects of the environment, sustainability programs, waste management, amalgam phase-down, digital dentistry, and governance of health systems was performed
Result: Worldwide efforts, including the FDI Sustainability in Dentistry Policy Statement (2021) and national strategies, including the NHS Net Zero Plan, show evidence of an ever-growing trend in favor of sustainability in the dental care sector. Nevertheless, lack of financial resources, poor awareness, poor management systems, and inconsistent implementation of policies hinder achievements. Clinical standards can be influenced by dental associations, and the wider change is enabled by the involvement of the regulation, reform of procurement, and development of the infrastructure by the public health systems.
Conclusion: The integration of sustainability in dentistry requires a collaborative effort from both professional associations and public health systems. Improving policy, education, innovation, and regulation can ensure that dentistry contributes positively to both oral health and environmental protection.

Keywords: Environmental protection; Narrative policy rivew; Public health systems; Sustainable dentistry; SDG 3

1. INTRODUCTION

Sustainability has emerged as a key focus in healthcare in the twenty-first century, influencing the way systems use resources to manage their operations, control the services provided, and respond to their effects on the environment. Dentistry, as well as any other healthcare sector, has a significant ecological impact since dental services require the use of single-use plastics, chemical substances (dental amalgam), high-energy technologies, and water consumption. These environmental pressures have been further aggravated by the global growth in the burden of oral diseases along with the increasing demand on restorative and preventative care (Najeeb et al., 2025; Hackley & Luca, 2024; Deshpande, 2024). Dentistry has many points of intersection with major goals of the United Nations Sustainable Development Goals (SDGs), in particular, SDG 3 (Health and Well-being), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) (United Nations 2015). These objectives necessitate clinical, organizational, and policy restructuring from an environmental perspective (Haque, 2025).

The Minamata Convention on Mercury by the World Health Organization (2013) (United Nations 2015) and the Sustainability in Dentistry Policy Statement by the FDI World Dental Federation 2021 are indicators of an increased awareness of the environmental responsibilities of dentistry in the world. Nevertheless, the process of translating these global obligations to national action, professional and practice is also uneven, particularly in the low- and middle-income countries (LMICs) (Ahmed & Mannan 2015; Martin et al., 2021; Chaudhary et al., 2015). Dental associations and public health systems have a critical role in advancing sustainability by influencing education, regulation, wastes management, procurement and clinical practice standards (Najeeb et al., 2025; Bamedhaf et al., 2025).

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Although there has been a growing international awareness, national policy and clinical standards on how this should be translated into action are still slow. This time lag is usually occasioned by narrow political focus, lack of monetary resources, lack of institutional coordination, and absence of definite accountability frameworks of most countries. This kind of systemic inertia highlights why policy leadership, public health systems, and professional associations need a thorough examination on how they could become faster in adopting the use of sustainable dental practices.

The innovative aspect of this review is the proposal of the specific policy framework that applies to LMICs (option a), the focus on the model that involves the method of integrating sustainability into the public health system (option b) with the help of the governance strategies, such as compulsory amalgam separators, eco-accreditation, and public-private partnerships (option c). As opposed to the previous international scanning, it applies Bangladesh as a case to seal policy gaps in resource-weak environments.

Therefore, this narrative policy review explores the issue of dental sustainability today, examines the policy environment across the globe, contrasts the methods between one that is socially conscientious and vulnerable in LMICs, and how environmental responsibility can be incorporated into dental public health systems in the future.

2. MATERIAL AND METHOD

The presented narrative policy review was grounded in a selective synthesis of peer-reviewed articles, policy reports and professional recommendations on sustainability in dentistry. PubMed, Scopus, Google Scholar, and official websites of the World Health Organization (WHO), FDI World Dental Federation, American Dental Association (ADA), and the NHS England were searched. The main search terms were: sustainable dentistry, green dentistry, environmental impact of dentistry, dental waste management, dental amalgam phase-down, digital dentistry innovations, oral health policy in LMICs and sustainability in public health systems, which were used with Boolean operators (AND/OR) where necessary. The search was restricted to literature in the years 2015-2025 to include current trends and developments and the policy; older landmark sources (e.g., Minamata Convention 2013) were also included as long as they were foundational to the subject. Inclusion criteria: peer-reviewed articles, policy statements, and guidelines on sustainable dental practices, waste management, digital initiatives, environmental policies, or system governance in the high-income and LMIC settings are present. Exclusion criteria Exclusion of non-dentistry sources, non-policy related content, non-English publications, and any study published prior to 2015 unless it is a landmark. Around 50-60 sources were analyzed and synthesized in narrative (no formal dual screening and meta-analysis were conducted). Articles and reports were taken into consideration if they addressed such issues as sustainable dental practices, waste management, digital innovations, environmental policies, or governance in the oral health systems. Non-dentistry sources that did not relate to the specific policy and were not in English were screened out. This methodology sought to find the representative evidence and policy paradigms across two experimental settings of high-income and low/middle-income countries (LMIC). Although not a systematic review, attempts were made to address the bias of selection by predetermined inclusion and exclusion criteria (discussed above), extensive database searches, and targeted use of specified keywords, and purposive selection of various sources (including global policy documents and LMIC-specific studies) to balance representation as opposed to exhaustive coverage.

3. RESULT AND DISCUSSION

3.1 Result

Current Challenges in Dental Sustainability Dentistry encounters a stratum of environmental issues that manifest via clinical programs, material selection, organizational behaviors, as well as system level limitations. Among the most important ones is the large amount of biomedical and plastic waste produced at a dental facility. Healthcare produces 85% general and 15% hazardous waste all over the globe with dental practice hospitals adding infectious waste at >90% (World Health Organization, 2024). Clinics produce 0.161 kg total waste daily (0.130 kg infectious) in LMICs such as India and project 41,535 kg annual infectious, city-wide in the densely populated areas (Krishnappa et al., 2015, Martin et al., 2021). The COVID-19 pandemic also increased the quicker usage of the disposable personal protective equipment, which boosted the quantity of plastic waste that needed incineration (Ganguly & Chakraborty 2024). Waste segregation has not been properly put into practice among most LMICs. Bangladesh is an exemplary representation of LMICs in which dental clinics and general waste are often mixed and not disposed of according to the standards of proper treatment (Ashiquzzaman et al., 2024). Another serious issue is the pollution with chemicals. Dental amalgam still is a significant source of mercury emission in the world. During placement, polishing, and removal of amalgam waste, as well as during improper disposal, mercury can be released, and it is very dangerous to the environment and health issues (World Health Organization 2013). In spite of multiple amalgam phase-down policies implemented by other countries, amalgam continues to be commonly applied in Bangladesh and other situations because of affordability and accessibility. Moreover, the developer and fixer reagents that are generated during traditional radiographic processing also contain silver and other chemicals that damage aquatic ecosystems when released in the unprocessed condition (Woolen et al., 2023). Additional chemical load is also taken up by disinfectants, solvents and impression materials. A lot of energy and water is also used in dental clinics. Autoclave, suction, compressor, curing lights and HVAC systems do not only lead to the energy consumption but also the carbon emissions in dental

clinics since 15-18 percent of total carbon footprint in dental practices is attributed to energy use (primarily electricity and gas). (Di Spirito et al., 2015). Dental unit irrigation, ultrasonic scaling, sterilization, and cleaning use a significant amount of water. The use of diesel-powered generators in places where power becomes unstable also increases emissions. Ignorance and inadequacy in training have proved to be a major obstacle to long-term practice. Despite the growing concern about environmental questions among dental students and practitioners, the notion of sustainability is rarely addressed in dental programs or during the continuing professional development program (Haque et al., 2024). Sustainable alternatives are viewed as expensive or time-consuming by many dentists and are generally not well supported by institutions. In Bangladesh, no official such as the Bangladesh Medical and dental council (BDMC) or the Bangladesh Dental Society (BDS) have had sustainability as a formal professional requirement. Lastly, the systemic and policy barriers constrain the possibility to practice environmentally responsible dentistry. Most nations do not have any waste management policies specifically aimed at dental waste management, and biomedical waste regulations are not always enforced. Infrastructure of waste collection and recycling is usually isolated and particularly in rural locations. In Bangladesh, the management of the private dental clinics is not well organized, and there is a considerable variation in the way these clinics manage their waste. All these challenges show that there is a great need to implement policy actions and reforms of institutions.

3.2 DISCUSSION

3.2.1 Global Policy Landscape

International agreements, national policies and professional guidelines define the global policy environment of sustainable dentistry. An important international legally binding document is the Minamata Convention on Mercury (2013) that compels parties to substantially reduce the utilization of dental amalgam as the prime solution to curtail mercury pollution by this source (United Nations Environment Programme, 2013; Minamata Convention Secretariat, ongoing updates).The signatories to the Convention such as Bangladesh are urged to encourage preventive care, use alternatives to mercury, enhance waste disposal arrangements, and use amalgam separators in dental clinics. Most developed nations with high incomes have incorporated Minamata requirements in the domestic regulations and this has led to a substantial decrease in the amalgam utilization.

Professional organizations too have been in the center stage. Sustainability in Dentistry Policy Statement issued by FDI World Dental Federation 2021 presents such areas of adjusting the adverse consequences of dentistry as the minimization of waste, the adoption of edible food, the introduction of online functioning, and the enhancement of sustainability in dental education (FDI World Dental Federation 2021). A number of national organizations have come up with new strategies. The American Dental Association (ADA) encourages effective conservation of the environment by providing advice on the disposal of amalgam, recycling, and waste. NHS Net Zero Plan in the United Kingdom extends decarbonization policy of the country to the dentistry sphere, focusing on the use of green procurements, digitalization, and minimized travel emissions (NHS England 2020). Digital dentistry has been pioneered by Scandinavian nations, which have saved a lot of material waste and use of amalgam (Hegedüs et al., 2022). In South Asia, things are, however, still behind. The directorate general of health services (DGHS) under Bangladesh involves control of waste generated by biomedical processes, although requirements of the dentistry field are tiny. Bangladesh Dental Society (BDS) is involved in professional training and advocacy but does not have any formal sustainability frameworks. Sustainability has not been incorporated into undergraduate courses or postgraduate courses in dental training since the Bangladesh Medical and Dental Council (BMDC) has not developed any curriculum to mandate sustainability in the courses. Although Bangladesh is a signatory to the Minamata Convention, effective implementation, monitoring and enforcement of the convention need to be strengthened.

Likewise, NITI Aayog and the Ministry of Health and Family Welfare in India have started encouraging the use of green healthcare infrastructure and responsible disposal of waste in accordance with Swachh Bharat Mission in the country. Even though not yet dental-specific, all these frameworks represent a policy change towards having environmentally responsible health systems that can be used to facilitate sustainable dentistry.

On the whole, even though the world is moving towards sustainable dentistry, there are still vast differences between low and high-income environments. Local adaptation, investment and leadership are necessary to help close the gap in global policy translation into national action.

3.2.2 Role of Public Health Systems

The international agreements, national regulations and professional guidelines influence the global policy environment over sustainable dentistry. The Minamata Convention on Mercury (2013) is the most powerful policy tool in the world as it requires a slow but steady decrease of dental amalgam to curb the pollution of mercury. All countries ratified to the Convention such as Bangladesh are urged to encourage preventive care, use mercury-free alternatives, strengthen waste management systems and install amalgam separators at the dental facility. The majority of the high-income countries incorporated Minamata requirements as a part of the national regulations and saw a marked decrease in the use of amalgam.

Environmentally responsible dentistry requires the existence of good waste management infrastructure. The public health systems will be able to secure adequate waste segregation, offer collection services, the

regulation of the disposal facilities, and the compulsory installation of amalgam separators in all the dental divisions. Enhancing the collaboration between municipal waste departments and public health authorities has been found to be of particular importance in states such as Bangladesh where there are numerous instances of private dental clinics that do not have regular waste collection systems (Ashiquzzaman et al., 2024).

Another significant avenue of mitigating the environment is through digital dentistry. Use of digital radiography, CAD/CAM, 3D printing, and electronic health records do not require radiographic chemicals, impression materials, and significant amounts of paper (Hegedüs et al., 2022). Tele dentistry is able to cut on patient travel, which reduces consumption of fuel and emissions. Nevertheless, digital transformation also presupposes a significant amount of financial contribution, professional education, and the provision of a stable technological environment, which is not always available in low- and middle-income countries (LMICs). sustainable practice is based on regulation and governance. Environmental standards can be included in the regulatory systems of the public health systems, thus mandating dentists to adhere to waste management regulations, reporting of waste management, and environmental audits. Reformulation of national oral health policies with the frameworks, including Minamata Convention, will maintain consistency and accountability (Lakhani & Givati 2024; Khanna et al., 2023). Support Systems such as subsidies, grants and tax allowances are necessary to encourage the adoption of sustainable technologies by the private clinics. Waste management services and digital transformation may also be delivered through the public-private partnerships. Coordinated leadership can facilitate a sector-wide shift to environmentally responsible dentistry through the efforts of the public health systems.

3.2.3 Comparing Approaches: Developed vs Developing Countries

Sustainable dentistry in developed and developing countries has notable differences in the availability of economic resources, technology power, political potency, and the level of community awareness. Well, established biomedical waste management system, strict enforcement of regulations and good professional association are common to the high-income countries leading to sustainability. The usage of modern radiography in digital forms, CAD/CAM, electronic records, and minimally invasive methods has played a major role in reducing the environmental effects (Al-Buhaisi et al., 2024). Dentistry has also been included in more comprehensive decarbonization plans by national health systems, including the NHS in the UK, focusing on reduction of green procurement and travel (Leavy et al., 2025).

On the contrary, LMICs encounter several challenges. Waste management infrastructures tend to be either insufficient or sporadic, particularly in the rural setting. The reason why dental amalgam is still in use is that it is cheap, long lasting and easy to access even though there are international agreements to discontinue mercury. The incorporation of digital dentistry is low because of the high cost of equipment, insufficient training, sporadic electrical connexon, and low access to broadband. In Bangladesh, India, Nepal, and Pakistan, where most dental service provision is offered by private clinics, these facilities are often independently managed without national waste management standards (Chaudhary et al., 2025; Zia et al., 2024; Al-Buhaisi et al., 2024; Capoor & Parida, 2021; Singh et al., 2018).

Nevertheless, sustainable innovations can also be enacted in developing countries. The associated clinical burden and environmental impact of restorative care can be minimized through community-based preventive programmed and mobile dental services. Remote consultations can be helped by tele dentistry strategies and will reduce patient travel and carbon emissions. Developing cheaper digital technologies and solar-driven devices offer new opportunities of more sustainable practice even in resource-limited conditions (Mikayelyan et al., 2024). However, there is a need to facilitate the sustainability gap between high and low-income countries through massive policy support, regulatory changes, as well as professional training. Table 1 provides a comparative overview of key aspects influencing the implementation of sustainable dental practices in developed versus developing countries, highlighting disparities in policy, infrastructure, technology, and priorities.

Table 1. Comparison of sustainability-related factors in dentistry between developed and developing countries

Aspect	Developed Countries	Developing Countries
Policy & Regulation	Strong enforcement of environmental and clinical regulations (e.g., NHS, EU directives, ADA guidelines)	Policies often weak, fragmented, inconsistently implemented, or voluntary
Infrastructure	Well-established recycling systems, biomedical waste management facilities, and environmental monitoring	Limited or absent biomedical waste management systems; poor segregation and disposal mechanisms
Technology	High adoption of CAD/CAM, 3D printing, digital radiography, and teledentistry	Limited adoption due to cost constraints, lack of training, and inadequate electricity/digital infrastructure

Aspect	Developed Countries	Developing Countries
Materials	Reduced reliance on dental amalgam; greater use of resin-based, metal-free, and eco-friendly alternatives	Amalgam widely used due to affordability, availability, and durability
Focus	Clear focus on reducing environmental impact and achieving carbon-neutral goals	Priority remains basic oral-health access and affordability rather than environmental sustainability

Note. Developed from WHO 2020, FDI World Dental Federation 2021, and recent literature on sustainability in dentistry within LMIC contexts.

3.2.4 Future Directions and Policy Recommendations

A multi-sectoral initiative that includes policy change, clinical innovation, professional education, and specific research is vital to the promotion of sustainable dentistry.

Short-term priorities (1–3 years)

a. Integrate sustainability principles in the undergraduate and postgraduate and continuing professional development programs, including life-cycle assessment, environmentally friendly materials, digital processes, and waste management as modules to train practitioners with the required skills. National dental councils and professional societies should take the forefront during the immediate integration of the curriculum in a setting like Bangladesh.
b. Introduce dental-focused garbage control measures, including the use of amalgam separators, appropriate radiographic garbage and chemical garbage disposal, and the implementation of greener performance standards during the licensing of a clinic.
c. Open up to available financial tools, such as subsidies on energy-efficient and low-waste equipment, tax subsidies, and private-public joint ventures to collect and recycle waste to reduce the financial constraints especially in resource-constrained environments.

Medium- to long-term priorities (3–10 years)

a. Provide a formal system of national eco-dentistry accreditation with quantifiable standards of waste reduction, energy savings, green purchasing, and carbon footprint mitigation, which can provide organized directions on environmental friendly operations.
b. Design incentive programmes, including programmes which are equivalent to the same as the green building certification but focused on dental facilities, to encourage clinics to make amenable enhancements towards provable sustainability.
c. Encourage innovation by investing in long-term governmental and university research, capacity-building and academic-industry partnerships dedicated to digital technologies, 3D printing, application of artificial intelligence, and biodegradable biomaterials.
d. Enhance the international and regional cooperation through effective involvement with the world organizations and the South Asian dental networks to promote knowledge sharing, policy coordination and technical advice towards localized implementation.

By strategically assigning importance and integrating leadership in these areas, dental care will eventually be able to align clinical care with environmental care, bringing about sustainable improvements in the oral health of the population and the overall planetary health.

3.2.5 Implications

This review highlights the urgent need to integrate sustainability into dental practice, policy, and education, particularly in LMICs such as Bangladesh. For policymakers, it underscores the importance of strengthening regulatory frameworks, enforcing waste management standards, and aligning national policies with global commitments like the Minamata Convention. For public health systems, the findings emphasize the role of governance, infrastructure development, and public–private partnerships in enabling sustainable transitions. At the clinical level, dentists and institutions are encouraged to adopt environmentally responsible practices, including waste segregation, digital technologies, and reduced reliance on hazardous materials. Overall, sustainability should be embedded as a core component of quality oral healthcare delivery.

3.2.6 Research Contributions

This narrative review contributes to the growing literature on sustainable dentistry by offering a comprehensive synthesis of global policies alongside a focused analysis of LMIC contexts. It introduces a context-specific policy framework tailored to resource-constrained settings and proposes a system-level integration model linking governance, clinical practice, and public health systems. By using Bangladesh as a case example, the study bridges the gap between global sustainability agendas and local implementation challenges. Additionally, it highlights actionable strategies such as eco-accreditation, digital transformation, and policy-driven incentives, thereby providing a practical roadmap for future research and policy development.

3.2.7 Limitations

This study has several limitations. As a narrative review, it lacks the methodological rigor of systematic reviews, including formal quality appraisal and meta-analysis, which may introduce selection bias. The reliance on English-language publications and selected databases

may have excluded relevant regional studies, particularly from LMIC contexts. Additionally, while Bangladesh is used as a representative case, findings may not be fully generalizable to all low- and middle-income countries due to contextual differences in policy, infrastructure, and resources. Future research should include empirical studies and comparative analyses to validate and expand upon these findings.

4. CONCLUSION

The Future of dentistry requires sustainability as a dire necessity and an immediate need. This review depicts that dentistry is also a contributor to environmental degradation in terms of biomedical waste, chemical pollution as well as excessive consumption of resources. International systems like the Minamata Convention and FDI policy statements have been significant as a sense of direction but have still not taken shape on the national level, especially in the LMICs. In addition to policy compilation, this adds a novel LMIC-oriented structure (a), system integration pattern (b), and governance plan (c) of responsible sustainability, which confronts inequitable application in situations such as Bangladesh.

The major stakeholders in eliminating this gap are dental associations and public health systems. Training, clinical standards, and advocacy can be influenced by professional bodies, procurement, waste infrastructure, environmental compliance, and even digital transformation can be reformed by health systems. Financial, infrastructural and behavioral barriers need to be dealt with through organized policy and system change. Integrating the concepts of dental practice and SDGs and environmental principles, dentists will have the opportunity to support oral health and the health of the planet, securing a sustainable future of the profession.

To promote sustainability as a part of quality oral healthcare delivery, the national dental councils and professional associations must incorporate environmental performance indicators into dental education and accreditation systems, as well as for the licensure and make sustainability a key part of the accountability.

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AUTHOR CONTRIBUTION STATEMENT

The author was solely responsible for the conception and design of the study, literature search, data interpretation, drafting of the manuscript, critical revision for important intellectual content, and final approval of the version to be published

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