

## Knowledge, awareness and implementation of sustainable dentistry by dental faculty lecturers in clinical dental practice: a preliminary study

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### Abstract

Dentists, as professional oral health care providers, frequently utilize disposable dental products such as plastic cups, toothpaste tubes, dental floss, and plastic dental instruments, leading to the generation of dental waste. Dental faculty lecturers, as primary educators of dental students, play a key role in serving as role models. Their knowledge, awareness, and application of sustainable dentistry practices can significantly contribute to promoting sustainable dentistry among future dentists. The aim of this study was to identify the knowledge, awareness, and implementation of green dentistry among dental faculty lecturers in clinical dental practice. This preliminary study was conducted through a survey involving faculty lecturers at a private dental school in Surabaya, Indonesia. A total of 14 dentists participated as respondents. They were asked questions regarding their awareness, knowledge, and implementation of green dentistry in clinical settings. The majority of respondents reported understanding the concept of green dentistry and expressed awareness of its importance. However, they encountered challenges in its implementation, primarily due to high associated costs. Amalgam waste management and paper recycling practices were not adequately performed, although most respondents had already adopted computer-based record systems. In terms of infection control management, respondents generally exhibited a positive attitude in support of green dentistry. Nevertheless, the use of disposable cups remained relatively high. Energy and water-saving practices were reasonably well implemented, with the exception of the use of renewable energy sources and motion-sensor faucets. The implementation of sustainable practices in energy, water usage, infection control, and waste management were not consistent among all dental faculty lecturers. This highlights the need for enhanced education on sustainable dentistry at the undergraduate level, as well as outreach programs and regulations to support the adoption of sustainable dentistry practices among dental professionals.

**Keywords:** Awareness; Dentistry; Sustainable; Well-being

### 1. Introduction

The current waste condition in dental practices has significant implications for environmental sustainability, especially in the realm of green dentistry. Green dentistry aims to transform the dental field by minimizing its environmental footprint through strategies such as waste reduction, energy conservation, and the use of biocompatible materials, which collectively contribute to a more sustainable practice model in dentistry (1–3).

At present, dentistry generates substantial waste, mainly due to the reliance on disposable materials and the disposal of hazardous waste, which pose environmental and health risks. Improper waste disposal, including items like syringes, gloves, masks, plastics, and chemicals (4–6), often results in pollution of soil and groundwater, endangering both land

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and aquatic ecosystems. Inadequate waste management and weak regulatory enforcement exacerbate these environmental hazards (2).

Studies show that there is a considerable lack of knowledge and awareness about green dentistry among dental professionals, mostly due to insufficient information and support from institutions. As primary dental educators, faculty members hold a crucial role in contributing to curriculum development and in fostering professionalism and ethical conduct among future dentists (7,8). Many practitioners are unaware of current sustainability legislation and the potential advantages of adopting eco-friendly practices (5,9,10). The higher cost of eco-friendly supplies and waste management systems can discourage new practitioners from fully embracing green dentistry. Additionally, the gap between the desire for sustainable practices and the realities of clinical workload, time constraints, and patient demands often hampers the integration of greener methods (5,6).

The waste generated in dental practices not only harms local ecosystems but also contributes to broader environmental issues such as climate change and pollution (10,11). Green dentistry directly aligns with Sustainable Development Goal (SDG) 12, which focuses on responsible consumption and production (12,13). The dental sector can contribute to SDG 12 by reducing waste, promoting recycling, and using sustainable materials (14,15).

Incorporating green dentistry practices is essential for minimizing environmental impact and promoting sustainable dental care. Beyond waste management, green dentistry also includes the use of eco-friendly materials and energy-efficient practices. Adopting sustainable practices in dental care can help reduce pollution, conserve resources, and save costs for dental offices (16,17). By aligning with SDG 12, the dental profession can help promote responsible consumption and production, thus contributing to a more sustainable future.

Raising awareness and implementing sustainable practices can enable dental professionals to greatly reduce their environmental impact while also enhancing public health. The shift towards green dentistry addresses not only immediate waste management concerns but also supports global sustainability objectives, making it an essential area for ongoing research and improvement in the dental field. Therefore, in this study, we assess the level of knowledge, awareness, and implementation among private dental faculty lecturers in their daily practice.

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## 2. Materials and methods

This survey was held at the School of Dental Medicine, Universitas Ciputra, Surabaya, Indonesia. All participants were informed that the study adhered to the principles outlined in the World Medical Association Declaration of Helsinki. They were also notified that no personal or sensitive data were collected during or after the survey process. The survey was collected during the first week of March 2025.

This study represents a preliminary investigation, which will subsequently be expanded to include dental practitioners across regions of Indonesia to obtain a more comprehensive analysis. The survey aimed to evaluate the level of environmental sustainability awareness among dentists, who also occupy roles as Faculty lecturers. The questionnaire was developed using Google Forms (Mountain View, CA, USA, Alphabet) and distributed via a link shared through WhatsApp chat (Meta Platforms Inc., Menlo Park, CA, USA). Questionnaire items were carefully designed to avoid multiple negations, misleading questions, or vague terminologies. The development process followed guide best practice to developing questionnaire items and organizing the questionnaire by Gehlbach & Brinkworth (2011) and Gehlbach & Artino Jr (2018) (18,19). During survey completion, respondents were guided by the questionnaire developers to ensure accurate responses. The survey was completed by 14 out of 16 invited participants, yielding a response rate of 87.5%. All respondents answered every question, and no data were excluded from the analysis.

### 2.1. Inclusion and Exclusion Criteria

The inclusion criteria for this study were dentists who are Indonesian citizens, lecturers affiliated with the School of Dental Medicine at Universitas Ciputra, graduates of Dental Faculties in Indonesia, currently practicing in Surabaya, and aged between 22 and 65 years. The exclusion criteria included individuals who declined to provide informed consent or were unwilling to adhere to the survey completion guidelines.

### 2.2. Survey Instrument

The questionnaire consisted of 29 multiple-choice questions, adapted from previous studies by Shatrat et al. (2013) and Tancu et al. (2023) (10,20). It covered the following areas: (1) Awareness and understanding of the green dentistry concept (2) Knowledge and implementation related to the management of amalgam waste, radiographic waste, paper waste, infection control, energy, and water, was assessed using a four-point Likert Scale; and (3) Sociodemographic data

including age, gender, location of professional practice, and length of professional experience. The estimated time to complete the questionnaire was approximately 15 minutes.

### 2.3. Analysis Data

All the data from the study were presented in table, comprised of answers, n, and percentage.

### 3. Results

**Table 1** List of questionnaire items given to faculty lecturer respondents, covering the following domains: Awareness and understanding of the Green Dentistry concept (2 close-ended and 1 open-ended question); Knowledge and implementation related to the waste management (8 questions); Infection control (6 questions); Energy management (5 questions); and overall waste handling practices (3 questions) in relation to Green Dentistry. The respondents were assessed using a four-point Likert scale. Additionally, the questionnaire included 4 items related to respondent demographics.

Awareness and understanding of the Green Dentistry concept					
No	Questions	Yes (n, %)		No (n, %)	
1	Understanding the concept of Green Dentistry in dental practice	10 (75%)		3 (23.1%)	
2	Do you experience difficulties in incorporating eco-friendly dentistry in your practice?	7 (53.8%)		6 (46.2%)	
3	What issues may be faced during the implementation?	High cost (6) Difficult to implement (5) Lack of understanding of the concept (3) Perceived as not useful (2)			
Knowledge and implementation related to the waste management					
		Always		Occasionally	Never
1	Applying amalgam restorations	0 (0%)		2 (14.3%)	11 (85.7%)
		Always	Occasionally	Understood but not applied	No awareness and no engagement in practice
2	Amalgam waste is managed in accordance with proper disposal protocols	2 (14.3%)	1 (7.1%)	1 (7.1%)	10 (71.4%)
3	Utilization of digital radiographic imaging	5 (35.7%)	2 (14.3%)	5 (35.7%)	2 (14.3%)
4	Foil waste is disposed of properly	2 (14.3%)	2 (14.3%)	2 (14.3%)	8 (57.1%)
5	Fixer waste is disposed of properly	2 (14.3%)	1 (7.1%)	1 (7.1%)	10 (71.4%)
6	Recycling paper waste	1 (7.1%)	3 (21.4%)	4 (28.6%)	6 (42.9%)
7	Printing on both sides of paper	3 (21.4%)	8 (57.1%)	1 (7.1%)	2 (14.3%)
8	Use computer-based record system	7 (50%)	4 (28.6%)	1 (7.1%)	2 (14.3%)
Infection control management in the implementation of Green Dentistry					

1	Procuring dental supplies in wholesale quantities	3 (21.4%)	7 (50%)	1 (7.1%)	3 (21.4%)
2	Utilizing reusable (e.g., metal) cups	1 (7.1%)	2 (14.3%)	10 (71.4%)	1 (7.1%)
3	Use metal three-way syringe	9 (64.3%)	1 (7.1%)	3 (21.4%)	1 (7.1%)
4	Use biodegradable enzyme based cleaner	4 (28.6%)	4 (28.6%)	2 (14.3%)	4 (28.6%)
5	Wearing reusable gowns	10 (71.4%)	2 (14.3%)	2 (14.3%)	0 (0%)
6	Using sterilizable instruments and trays	11 (78.6%)	3 (21.4%)	0 (0%)	0 (0%)
<b>Energy management in the context of Green Dentistry</b>					
1	Using LED light bulbs	10 (71.4%)	3 (21.4%)	0 (0%)	1 (7.1%)
2	Light bulbs are either discarded as hazardous waste or recycled responsibly	6 (42.9%)	1 (7.1%)	2 (14.3%)	5 (35.7%)
3	Using renewable energy sources	0 (0%)	3 (21.4%)	6 (42.9%)	5 (35.7%)
4	All electronic devices, including computers and printers, are shut down and unplugged after use	8 (57.1%)	3 (21.4%)	1 (7.1%)	2 (14.3%)
5	Implementing motion sensor lighting systems in clinical spaces	2 (14.3%)	0 (0%)	4 (28.6%)	8 (57.1%)
<b>Water Management</b>					
1	Implementing motion-sensor faucets to reduce water waste	2 (14.3%)	1 (7.1%)	6 (42.9%)	5 (35.7%)
2	Utilizing dual-flush toilets for improved water management	6 (42.9%)	2 (14.3%)	3 (21.4%)	3 (21.4%)
3	Using water efficiently and effectively	11 (78.6%)	3 (21.4%)	0 (0%)	0 (0%)
<b>Respondent Identity</b>					
1	Gender	Male 4 (28.6%) Female 10 (71.4%)			
2	Age	25 - 35 years old 8 (57.1%) 36 - 45 years old 5 (35.7%) 46 - 55 years old 1 (7.1%)			
3	Practice location	Dental clinic 11 (78.6%) Private practice 3 (21.4%)			
4	Years of experience	5 - 10 years 8 (57.1%) 10 - 20 years 4 (28.6%) > 20 years 2 (14.3%)			

In response to questions that assess awareness and understanding of the concept of green dentistry, the majority of respondents (n = 10, 75%) indicated that they understood the concept. However, when it came to implementing green dentistry in clinical dental practice, half of the respondents (n = 7, 53.8%) reported experiencing difficulties. The

challenges they faced, ranked from most to least common, included: the high cost of implementation, the perception that it is difficult to carry out, a lack of understanding of green dentistry, and the belief that it is not useful.

The section on knowledge and implementation of waste management practices consisted of 8 questions, covering topics such as the handling of amalgam waste, radiographic waste, and paper waste. Only a small number of dentist respondents reported that they still perform amalgam fillings ( $n = 2, 15.4\%$ ). Among those who do place or replace amalgam restorations, only a few consistently manage amalgam waste properly ( $n = 2, 15.4\%$ ). Regarding digital radiography, 4 respondents (30.8%) stated that they always use digital radiographs, while 8 respondents (38.5%) are aware of digital radiography but do not use it. Among those still using conventional radiography, 7 respondents (53.8%) admitted they do not know how to correctly dispose of foil waste, and 9 respondents (69.2%) were unaware of the proper disposal method for fixer waste. Similarly, when it comes to managing paper waste, only a few respondents reported actively recycling paper or reducing paper usage. The majority have adopted a computer-based record system ( $n = 7, 53.8\%$ ), while 4 respondents still use a combination of both computer-based and paper-based systems.

The questions related to infection control in the context of green dentistry were divided into several areas, including bulk purchasing of dental materials, using reusable patient cups, using for metal three-way syringes, using enzyme-based cleaners, wearing reusable gowns / protective clothing, and sterilizing instruments and trays. Among these 6 questions, the practices that best reflected a green dentistry approach were the use of reusable gowns (always:  $n = 9, 69.2\%$ ; sometimes:  $n = 2, 15.4\%$ ) and the use of sterilizable instruments and trays (always:  $n = 10, 76.9\%$ ; sometimes:  $n = 3, 23.1\%$ ). These results suggest that while there is room for improvement in some areas, many respondents are already incorporating sustainable infection control practices into their routine.

In terms of energy use, most dentist respondents reported that they frequently use LED lighting ( $n = 9, 69.2\%$ ) and dispose of used light bulbs properly ( $n = 6, 46.2\%$ ). Awareness of renewable energy options—such as wind or solar power—is present, but shows limited adoption, with many respondents saying they are aware but have not adopted these solutions ( $n = 6, 46.2\%$ ). The habit of turning off electronic devices and unplugging cords when not in use has been widely adopted among respondents ( $n = 8, 61.5\%$ ). However, when it comes to the use of motion detector-based lighting systems, most respondents were unfamiliar with this technology ( $n = 7, 53.8\%$ ).

When it comes to the use of sensor-based water faucets, many respondents are unaware of this technology ( $n = 6, 46.2\%$ ), with only a small number ( $n = 2, 15.4\%$ ) actually using it in practice. However, in terms of effective and efficient water usage, the majority ( $n = 11, 84.6\%$ ) reported that they often take steps to conserve water, while only two respondents (15.4%) said they do so occasionally. This suggests that while awareness and adoption of water-saving technology may still be limited, the intention and effort to use water responsibly are already present among most respondents.

Most of the dentist respondents were female ( $n = 10, 76.9\%$ ) and the remaining participants were male ( $n = 3, 23.1\%$ ). The majority were in the 25–35 age group ( $n = 7, 53.8\%$ ), followed by those aged 36–45 ( $n = 5, 38.5\%$ ), and a smaller portion aged 46–55 ( $n = 1, 7.7\%$ ). A large proportion of respondents work in dental clinics ( $n = 10, 76.9\%$ ), while only a few private practice ( $n = 3, 23.1\%$ ). In terms of professional experience, most had been practicing for 5–10 years ( $n = 7, 53.8\%$ ). Notably, all respondents held at least a master's or specialist-level degree, indicating a well-educated and experienced group of dental professionals.

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#### 4. Discussion

With the increasing urgency of global warming, sustainability has become a more relevant and pressing topic—a concern echoed by organizations such as the United Nations and the World Economic Forum (21,22). In response to these global challenges, the Indonesian Government issued Presidential Regulation No. 59 of 2017 on the Implementation of the Sustainable Development Goals (SDGs). This regulation encourages educational institutions to actively contribute through the *Tridharma* of higher education: teaching, research, and community service, all aligned with the SDG framework. One of the goals—SDG 12, which focuses on responsible consumption and production—can be directly applied in the field of dentistry through the practice of green dentistry. Dental professionals frequently use single-use materials and generate toxic waste, which, if not properly managed, can negatively impact both human health and the environment. Therefore, it is essential for dentists to adopt more sustainable practices aimed at reducing or eliminating waste, ultimately minimizing harmful exposure and promoting a healthier ecosystem for the community.

In the results section, it was found that the majority of dentists no longer use amalgam for dental restorations, with only a small proportion still performing amalgam fillings. A survey conducted among dentists in Bandung also indicated a decline in amalgam usage, with only approximately six respondents (2.2%) still using amalgam as a restorative material

(23). Some patients still present with existing amalgam fillings; therefore, dentists who perform replacement of these restorations dispose of the amalgam waste using a dental bur. However, only a few respondents were aware of the proper methods for amalgam waste disposal, which include the use of disposable or reusable chair-side traps, vacuum pump filters, amalgam separators, or line cleaners (24). The Government of Indonesia has taken steps to reduce amalgam waste, including the ratification of the Minamata Convention on Mercury through Law Number 11 of 2017, which is further outlined in Presidential Regulation Number 21 of 2019 concerning the National Action Plan for Mercury Reduction and Elimination (RAN-PPM). Nevertheless, based on the results of this pilot study, awareness and understanding among dentists regarding proper amalgam waste management appear to remain low.

The use of digital radiographic imaging remains relatively low, with only approximately five respondents (35.7%) consistently using digital imaging and two respondents (14.3%) using it occasionally. The implementation of digital imaging is intended to reduce foil and fixer waste, as well as to minimize environmental exposure to toxic substances. However, digital imaging systems require a substantial initial investment, with a minimum cost of approximately USD 1,700. A total of 57.1% and 71.4% of respondents reported not knowing how to manage foil and fixer waste. Respondents who selected responses such as “occasionally,” “understood but not applied,” and “no awareness and no engagement in practice” regarding waste management accounted for 11 individuals (84.6%). This finding likely reflects the current situation among respondents who still utilize conventional radiography, in which understanding of radiographic waste management remains inadequate.

Paper usage remains poorly managed, as indicated by the low rates of paper recycling and limited adoption of double-sided printing practices. Waste management in urban areas of Indonesia currently follows the 3P paradigm: collection, transportation, and disposal. Waste is collected in containers, transported to Temporary Disposal Sites, and subsequently moved to Final Disposal Sites. Certain types of waste, such as bottles, newspapers, paper, and cardboard, are often collected by informal waste pickers for resale to recycling vendors (25). Nevertheless, the majority of respondents have adopted computer-based record systems. In dental practice, this includes the use of digital medical records and digital media for patient education.

The use of reusable instruments and materials—such as metal three-way syringes, protection coats or gowns, sterilizable instruments, and trays—was found to be relatively high. However, bulk purchasing of supplies, the use of reusable drinking cups, and enzyme-based cleaners remain low. A total of 21.4% and 50% of respondents reported that they always or occasionally purchase supplies in bulk. Bulk purchasing is considered more economically advantageous, which may explain why some respondents selected those options.

Ten respondents (71.4%) were aware of the availability of reusable cups but opted not to use them. Disposable cups remain the preferred choice for some respondents, primarily due to practicality and perceived benefits in reducing disease transmission between patients. This practice may have been influenced by habits developed during the COVID-19 pandemic, where heightened hygiene and safety measures were prioritized.

Regarding the use of enzyme-based cleaners, four respondents (28.6%) reported regular or occasional use, while another four stated they were unaware of such products. The lack of awareness may be attributed to limited socialization and marketing of enzyme-based cleaners among dental practitioners, leading to insufficient knowledge about their existence and advantages.

In terms of protection coats or gowns, nearly all respondents reported consistent use of reusable materials. Two respondents indicated they were aware of reusable options but did not adopt them, possibly due to convenience or habitual use of disposable materials carried over from the COVID-19 era. Our findings also revealed that reusable instruments and trays were preferred over disposable alternatives, likely due to cost-effectiveness and their durability over time.

Most respondents reported frequent or occasional use of LED light bulbs. From an economic standpoint, LED lights are more cost-effective, brighter, and longer-lasting compared to non-LED lights, making them a more appealing option. One respondent, however, stated that they were unaware of the type of lighting used, likely due to working in a clinic setting where such details may not be disclosed.

Proper disposal of light bulbs was practiced by 42.9% of respondents (6 individuals). However, a portion of respondents (2 individuals or 14.3%) admitted to neglecting appropriate disposal methods, and 5 respondents (35.7%) reported being unaware of how to properly dispose of used bulbs. There is a need for widespread public education and government-led waste management campaigns, starting from the neighbourhood level, to reduce waste accumulation that may negatively impact public health.

The use of renewable energy remains uncommon, primarily due to the high maintenance costs of solar panels and wind turbines. This finding aligns with respondents' feedback regarding green dentistry, in which 57.1% expressed difficulty in implementing green practices due to financial constraints. The use of motion detectors for room lighting was also unfamiliar to most respondents.

There is a reasonable level of awareness and effort among respondents to use water efficiently, as reflected in their water usage during handwashing and instrument cleaning. Regarding the use of dual-flush toilets, six respondents (42.9%) reported always using them. Other respondents provided varied responses, ranging from occasional use to complete lack of awareness. Dual-flush toilets are designed to adjust the volume of water based on need and can save up to 3 liters of water per use (26).

This study was conducted through self-assessment, which may result in discrepancies between the data collected and actual field conditions, as respondents tend to provide socially desirable responses. Additionally, the data may not accurately represent the general population, as most respondents in this study were from the millennial generation, had less than 10 years of work experience, were predominantly female, and held a minimum educational qualification of a master's or specialist degree. Nonetheless, the findings can serve as an initial reference and foundation for future research involving a broader and more representative population. It is recommended that subsequent surveys target dental practitioners in other regions, such as Surabaya, to gain a more accurate overview. These findings could then inform actionable steps and the development of policies aligned with the Sustainable Development Goals (SDGs).

It is crucial to promote the adoption of new habits, particularly through government regulations and policy support from professional organizations, in relation to waste management. Such efforts are necessary to foster practices that align with the SDGs and to mitigate the impacts of climate change. The lack of government support is suspected to be one of the contributing factors to the low implementation of green dentistry observed in this pilot study. Government support—such as through incentives or tax reductions for environmentally friendly products—would be beneficial in encouraging sustainable practices.

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## 5. Conclusion

Respondents were generally aware of the concept of green dentistry, yet its implementation remains suboptimal, particularly regarding knowledge of proper disposal methods for amalgam waste and used light bulbs. It is recommended that the government, through professional dental associations, provide regular education, seminars, and establish regulations on proper medical waste disposal.

Moreover, it is necessary to foster recycling habits within communities and to develop a well-structured and sustainable national recycling system to ensure effective recycling practices. Dental educators should possess adequate knowledge, awareness, and practical implementation of green dentistry principles, serving as role models and incorporating these values into dental education and curricula.

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## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the study.

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