

ORIGINAL RESEARCH

Biomedical waste management in dental practice in the city of Guayaquil, year 2025

Gestión de residuos biomédicos en la práctica odontológica de la ciudad de Guayaquil, año 2025

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ABSTRACT

Introduction: Proper biomedical waste management is an essential component of the health sciences, particularly in dental clinics where professionals are exposed to a wide range of infectious agents. Objective: To determine compliance with biomedical waste management among dental professionals in Guayaquil. Methods: An observational, descriptive study was conducted with a sample of 170 participants. Data were collected using a structured 20-item questionnaire divided into five sections, with Likert-scale response options. The questionnaire showed good reliability (Cronbach's alpha = 0.850). Results: For segregation, agreement was highest for rubber dam use (69.4%) and high-power suction/continuous irrigation (78.8%), while fewer participants reported the presence of filters/grates (41.2%) and ventilation/air filtration systems (48.2%). Regarding amalgam disposal, the use of a sealed container was reported by 55.3%, safe storage of chemicals by 71.2%, and the availability of an environmental waste manager by 74.7%, whereas delivery to a company for reuse was low (20.0%). For standardization, most respondents disagreed with reusing sharps (74.1%), and agreement was reported for replacing sharps containers at three-quarters capacity (67.7%), disinfection with sodium hypochlorite (61.2%), and handling of anatomical waste (64.7%). In the risk domain, color-coding was reported by 75.3% and daily disposal of general waste by 61.7%, while the availability of an exclusive refrigerator for anatomical waste was low (17.1%) and recycling was reported by 50.0%. For barriers, moderate agreement was observed for identifying kilograms of hazardous waste generated per day (50.6%), controlling disposal costs through weighing (48.2%), and applying internal compliance ratings (54.1%), with training standing out (64.1%). Conclusion: Dental waste management showed moderate compliance, with better performance in routine operational practices

Keywords: Dental amalgam. Biosafety. Dental clinic. Waste management. Biomedical waste.

RESUMEN

Introducción: La correcta gestión de los residuos biomédicos forma parte de un elemento esencial en el ámbito de las ciencias médicas, sobre todo en las clínicas odontológicas donde los profesionales están expuestos a una gran cantidad de agentes infecciosos. Objetivo: determinar el cumplimiento de la gestión de residuos biomédicos por parte de profesionales odontólogos de Guayaquil. Método: estudio observacional, descriptivo con una muestra de 170 participantes. El instrumento de recolección fue un cuestionario estructura de 20 ítems dividido en 5 secciones con opciones de respuesta en escala de Likert. La confiabilidad del cuestionario con alfa de Cronbach fue de 0,850. Resultados: En segregación, predominó el uso de dique de goma (69,4%), aspiración/irrigación continua (78,8%), presencia de filtros/rejillas (41,2%) y ventilación/filtración (48,2%). En eliminación de amalgama, se reportó uso de envase hermético (55,3%), almacenamiento seguro de químicos (71,2%) y disponibilidad de gestor ambiental (74,7%), baja entrega a empresa para reutilización (20,0%). En estandarización, se indicó no reutilizar cortopunzantes (74,1% en desacuerdo), en recambio de contenedor a ¾ (67,7%), desinfección con hipoclorito (61,2%) y manejo de residuos anatómicos (64,7%), en Riesgo, se evidenció codificación por colores (75,3%) y eliminación diaria de desechos comunes (61,7%), baja disponibilidad de refrigeradora exclusiva (17,1%) y reciclaje (50,0%). En barreras, hubo acuerdo moderado en

identificar kg de residuos peligrosos (50,6%), controlar costos por pesaje (48,2%) y aplicar calificación de cumplimiento (54,1%), destacando capacitación (64,1%). Conclusión: la gestión de desechos en odontología muestra un cumplimiento moderado, con mejor desempeño en prácticas operativas rutinarias.

Palabras clave: Amalgama dental. Bioseguridad. Clínica odontológica. Gestión de residuos. Residuos biomédicos.

INTRODUCTION

In the healthcare sector, biomedical waste refers to waste generated during the patient care process, as well as the generation of biological, chemical, or infectious substances during treatment or scientific research.¹ In Ecuador, this type of waste is referred to as healthcare waste and is classified as infectious-biological waste, that is, materials contaminated with blood or saliva that may pose a biological risk; sharps, such as devices containing a sharp point contaminated with bodily fluids that may cause an infectious risk; and anatomical-pathological waste, such as extracted teeth, which are managed as infectious-biological waste. Chemical waste must also be considered, including formaldehyde, disinfectants, and X-ray developing solutions, as well as waste from mercury-containing devices, such as dental amalgam.²

One of the hazardous types of healthcare waste addressed in this research, due to its significant environmental impact and the health concerns it poses to dental patients, is the management of mercury-based amalgam. Mercury is a toxic chemical element that negatively affects child development and the neurological, immune, and digestive systems.^{3,4} Ecuador is one of the countries that signed and complies with the Minamata Convention on Mercury in 2013, an agreement promoted by European and Asian nations. However, it entered into force in the country in 2017, with the goal of gradually eliminating mercury-based products due to the emergence of alternative dental materials. Appropriate collection and segregation are expected to be achieved by 2032.⁵

This research focuses on biomedical waste management, understood as the policies that establish procedures for the generation, collection, storage, and transportation of waste, which must be followed by healthcare personnel who handle or dispose of biomedical waste in institutions providing care to humans or animals.¹⁶ The purpose of biomedical waste management is to minimize the infectious and hazardous impact of healthcare waste on workers and patients; prevent improper use or disposal of waste; promote the recycling and reuse of authorized materials; reduce environmental impact; and minimize public exposure to the harmful effects of chemical, biological, genotoxic, and cytotoxic waste.¹⁷

Biomedical waste management includes the segregation and classification of healthcare waste at the point of generation, followed by treatment, including sterilization, chemical disinfection, and incineration.¹⁸ Implementation and/or practice is established according to the regulations of each country. Several studies have also reported differences depending on whether the setting is rural or urban, infrastructure availability, and the level of training and awareness among healthcare professionals.^{18,19} According to the World Health Organization (WHO), more than 85% of waste generated by the healthcare sector is classified as non-hazardous, while the remainder is hazardous, including flammable, infectious, carcinogenic, and toxic waste.⁶

Rodrigues de Sousa et al.⁷ reported that 22.9% of waste is infectious-biological waste, categorized as hazardous, including gloves, gowns, gauze, and cotton containing bodily fluids. Chemical waste accounted for a smaller proportion (2.2%), while sharps represented 1.3%. These findings were associated with significant deficiencies in healthcare waste management plans, including inadequate segregation practices and limited recycling of waste.⁷

Mamoori et al.⁸ conducted a study involving 412 private dental clinics in Jordan and found that more than 40% of healthcare professionals disposed of infectious waste without complying with biosafety regulations. Extracted teeth accounted for 48.5%, expired medications for 44.4%, chemical substances for 53.2%, and X-ray films for 35%. These materials were treated as ordinary or general waste, without complying with the country's healthcare safety measures.

Regarding the disposal of dental amalgam, which contributes to increased mercury levels in the ecosystem, indiscriminate disposal of amalgam particles through drains by dental personnel contributes to contamination by this chemical element in amalgam sludge and wastewater. One study reported that 55.8% of dental restoration amalgam was discarded through drainage systems, while 43.2% was disposed of with regular waste. Most participants were unaware of certified waste transportation services for amalgam recycling.⁹ One of the main challenges in reducing healthcare waste is inadequate waste management in more than 70% of hospitals and clinics in Latin American countries, where most waste is contaminated with blood and saliva. Such waste is often improperly discarded and ultimately contributes to soil and water degradation, in addition to causing health consequences.¹⁰

Healthcare personnel are among those most exposed to chemical and infectious-biological risks, which may lead to communicable diseases resulting from bacterial and parasitic infections, as well as injuries caused by objects contaminated with bodily fluids.¹¹ This occurs because waste is not processed according to the procedures established in the *Manual de Gestión Interna de los residuos y desechos generados en los establecimientos de salud*, published by the Ministry of Public Health of Ecuador in 2019 and validated by the WHO.² This situation is supported by the study conducted by Telayneh et al.,¹² who reported that more than 40% of healthcare workers had been affected by hepatitis B and C, while 2.55% had HIV, due to occupational exposure during the performance of their duties.

Cruz Ramos et al.¹³ state that hazardous waste management in dental care involves segregation, storage, and/or handling and transportation. The most recurrent failure among healthcare personnel is segregation, particularly packaging and labeling, followed by internal transportation and storage in containers, without exposure to infectious and biological risks. The main limitations to proper biomedical waste management are insufficient professional knowledge, limited financial resources, inadequate infrastructure, poor monitoring and enforcement of legal regulations, and lack of motivation.¹⁴

In this regard, Berhe et al.¹⁵ demonstrated that workload and financial resources are the main barriers to complying with appropriate infectious healthcare waste management practices. This is related to the large volume of biomedical waste generated and the limited time available for patient care, whereby waste handling becomes an additional burden that may result in negligence in healthcare waste segregation. Institutional support for staff training and updating knowledge of laws and regulations related to dental healthcare waste management is also limited.

In Ecuador, specifically in Guayaquil, there are no up-to-date studies on healthcare waste management practices in dental clinics. Therefore, the degree of compliance and the level of knowledge regarding biomedical waste management regulations remain unclear. It is consequently essential to assess how dental professionals manage such waste in order to identify training and operational gaps and propose recommendations for improvement that promote safe practices, reduce environmental impact, and ensure responsible clinical operations at all times.

Based on the above, the following research problem was formulated: To determine the level of compliance with biomedical waste management practices among dental professionals in Guayaquil. To this end, the study established the methods used to segregate hazardous and non-hazardous dental healthcare waste, assessed knowledge of waste standardization, evaluated current practices for the disposal of dental amalgam, and identified barriers to the implementation of biomedical waste management among dentists in the city of Guayaquil.

MATERIALS AND METHODS

Research Design

This study employed a quantitative, cross-sectional approach using an observational-descriptive design based on data collected through a survey to assess the level of knowledge and compliance with biomedical waste management protocols among dentists in Guayaquil.

Population and Sample

The sample size was calculated based on an undetermined or large (infinite) population, resulting in a sample of 170 practicing dentists who had graduated and were working in clinics or private practices in the city of Guayaquil during the 2025–2026 period.

Selection Criteria

The study included practicing dentists working in clinics or private practices in the city of Guayaquil who agreed to participate by signing informed consent. Participants who did not complete the questionnaire or experienced difficulties accessing the Google Forms platform were excluded.

Techniques

The technique used in this study was a survey administered through a structured questionnaire designed in Google Forms. The questionnaire addressed knowledge and practices related to waste management, segregation of hazardous and non-hazardous waste in dental clinics, dental amalgam disposal, waste standardization models, risk levels associated with improper waste handling, and barriers to implementing healthcare waste management.

The reliability analysis yielded a Cronbach's alpha coefficient of $\alpha = 0.858$. This value falls between 0.80 and 0.89 and is considered indicative of good internal consistency, suggesting that the questionnaire items are closely related and measure the same underlying construct, namely biomedical waste management in dental practice.

Procedures

First, an updated literature search was conducted on biomedical waste management protocols in order to develop the questionnaire items. Once the survey and informed consent form had been approved, the questionnaire was uploaded to Google Forms. Participants who met the selection criteria were sent the link through digital or personal communication channels. The data were tabulated and interpreted using tables and graphs. Statistical analyses were also performed, followed by the preparation of the discussion and conclusions based on the results.

Data Analysis

The information collected through the Google Forms questionnaire was exported to Excel for cleaning and data processing and subsequently analyzed using the SPSS statistical software. Variables were presented using absolute and percentage frequency tables and bar graphs.

RESULTS

Responses from 170 dental professionals regarding biomedical waste management in dental practice were analyzed.

Regarding the section assessing the segregation of hazardous and non-hazardous waste in dental clinics, the use of a rubber dam during amalgam removal showed a majority of responses in the "agree" and "strongly agree" categories (69.4%). This indicates that, in a significant proportion of cases, a control measure intended to reduce material dispersion and contact with the oral environment is applied (Table 1). Regarding high-volume suction and continuous irrigation, a higher percentage of responses was also concentrated in the "agree" and "strongly agree" categories (78.8%). This result suggests that this practice is more widely incorporated as part of routine clinical procedures (Table 1).

When participants were asked about the availability of filters or screens to retain amalgam fragments and prevent them from entering water systems, the distribution was more divided, with relevant proportions in both the "disagree" (22.4%) and "agree" (25.3%) categories. This indicates a possible lack of standardization in this component or variability in the availability of these devices among establishments (Table 1). The question regarding non-recirculating ventilation or high-volume filtration for microparticles showed a greater concentration of responses in the "agree" and "strongly agree" categories (48.2%), indicating that these measures are available (Table 1).

Table 1. Segregation of hazardous and non-hazardous waste in dental clinics

Questions	Scale	N	%
During dental care, do you reuse dental rotary burs and scalpel blades (sharps) after disinfection and sterilization (autoclaving)?	Strongly disagree	100	58.8%
	Disagree	26	15.3%
	Neither agree nor disagree	14	8.2%
	Agree	16	9.4%
	Strongly agree	14	8.2%
Do you dispose of sharps waste containers when they are three-quarters full?	Strongly disagree	14	8.2%
	Disagree	14	8.2%
	Neither agree nor disagree	27	15.9%
	Agree	52	30.6%
	Strongly agree	63	37.1%
During dental care, do you disinfect sharps using 0.5% or 1% sodium hypochlorite for 30 minutes?	Strongly disagree	17	10.0%
	Disagree	10	5.9%
	Neither agree nor disagree	39	22.9%
	Agree	52	30.6%
	Strongly agree	52	30.6%

Questions	Scale	N	%
In dental practice, do you use intermediate cleaning and disinfection for the disposal of anatomical waste (extracted teeth)?	Strongly disagree	9	5.3%
	Disagree	18	10.6%
	Neither agree nor disagree	33	19.4%
	Agree	51	30.0%
	Strongly agree	59	34.7%

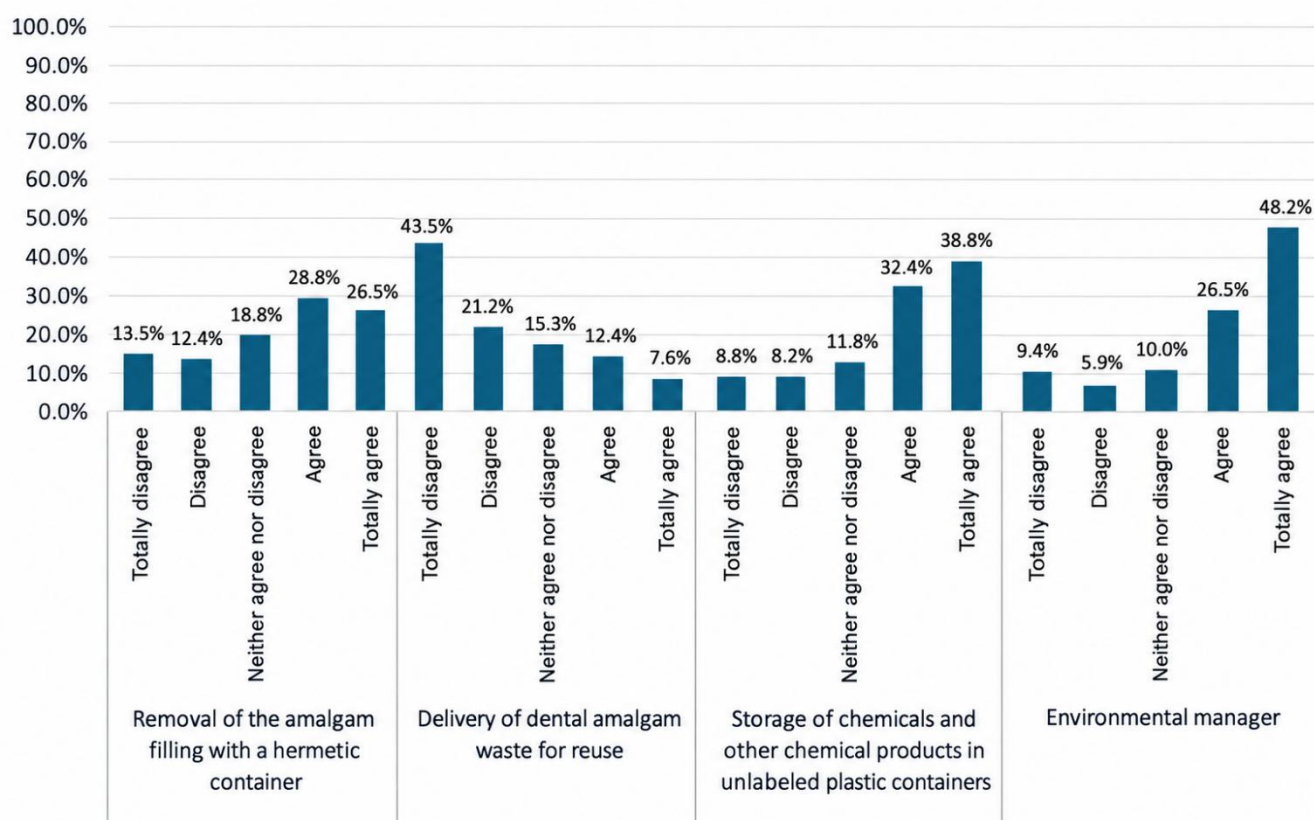
Regarding the section assessing current dental amalgam disposal practices, the question concerning the use of a leak-proof, airtight, chemical-resistant container for amalgam disposal showed a majority of responses in the "agree" and "strongly agree" categories (55.3%). This suggests that a significant proportion of dentists recognize and apply basic containment conditions, demonstrating appropriate handling of residual material (Figure 1).

Regarding the delivery of dental amalgam waste to a company for reuse during the provision of dental services, there was a lower concentration of responses in the "agree" and "strongly agree" categories (20%). This indicates that few dentists apply this practice when managing amalgam waste (Figure 1).

The question concerning the storage of chemicals, disinfectants, and flammable agents in appropriate containers showed a higher concentration of responses in the "agree" and "strongly agree" categories (71.2%). This suggests that safety measures associated with the storage of potentially hazardous substances are more standardized within dental office routines (Figure 1).

Regarding the availability of an environmental waste management provider for the disposal of chemical and flammable waste, responses were predominantly concentrated in the "agree" and "strongly agree" categories (74.7%). This result indicates that a considerable number of healthcare settings have some level of support or a formal channel for managing this type of waste, thereby reducing improvisation in disposal practices (Figure 1).

Figure 1. Current dental amalgam disposal practices



The analysis of the section concerning the waste standardization model showed that the question regarding the reuse of rotary burs and scalpel blades (sharps) after disinfection and sterilization had a low proportion of responses in the "agree" and "strongly agree" categories (17.6%). This suggests a low reported rate of reuse of these instruments associated with sharps (Table 2).

Regarding the disposal of sharps containers when they reach three-quarters of their capacity, there was a high proportion of agreement (67.9%). This result suggests that there is a clear operational criterion regarding the point at which containers should be replaced, indicating greater adherence to measures intended to prevent overflow, unnecessary handling, and accidental exposure (Table 2).

The question concerning the disinfection of sharps using sodium hypochlorite at concentrations of 0.5% or 1% for a defined period of 30 minutes showed that the majority of participants selected the "agree" category (61.2%). This indicates that most participants recognize disinfection as an important preliminary step in the waste management process (Table 2).

Regarding intermediate cleaning and disinfection for the disposal of anatomical waste (extracted teeth), the results showed a favorable trend, with a greater concentration of responses in the "agree" and "strongly agree" categories (64.7%). This finding suggests that preventive measures are adopted before the final disposal of this type of waste (Table 2).

Table 2. Waste Standardization Model

Questions	Scale	N	%
During dental care, do you reuse dental rotary burs and scalpel blades (sharps) after disinfection and sterilization (autoclaving)?	Strongly disagree	100	58.8%
	Disagree	26	15.3%
	Neither agree nor disagree	14	8.2%
	Agree	16	9.4%
	Strongly agree	14	8.2%
Do you dispose of sharps waste containers when they are three-quarters full?	Strongly disagree	14	8.2%
	Disagree	14	8.2%
	Neither agree nor disagree	27	15.9%
	Agree	52	30.6%
	Strongly agree	63	37.1%
During dental care, do you disinfect sharps using 0.5% or 1% sodium hypochlorite for 30 minutes?	Strongly disagree	17	10.0%
	Disagree	10	5.9%
	Neither agree nor disagree	39	22.9%
	Agree	52	30.6%
	Strongly agree	52	30.6%
In dental practice, do you use intermediate cleaning and disinfection for the disposal of anatomical waste (extracted teeth)?	Strongly disagree	9	5.3%
	Disagree	18	10.6%
	Neither agree nor disagree	33	19.4%
	Agree	51	30.0%
	Strongly agree	59	34.7%

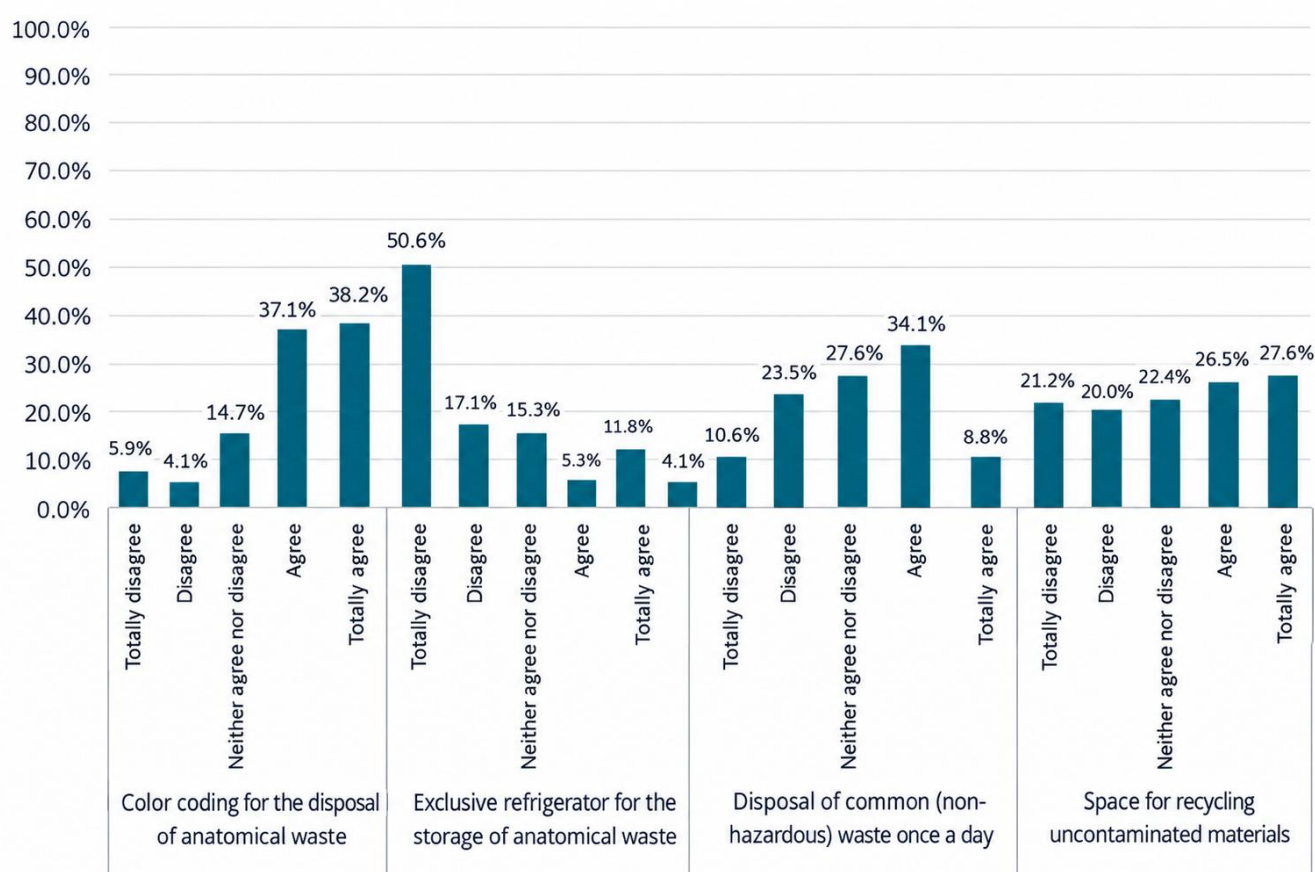
The section assessing risk levels associated with improper waste handling showed a clear predominance of favorable responses to the question regarding color coding for the disposal of anatomical waste. The concentration of responses in the "agree" and "strongly agree" categories (75.3%) suggests greater standardization in the identification and disposal of this type of waste (Figure 2).

Regarding the question of whether the dental clinic where the participants perform their duties has a refrigerator exclusively for the storage of anatomical waste (extracted teeth), a low concentration of responses was observed in the "agree" and "strongly agree" categories (17.1%), indicating limited standardization regarding this equipment in the clinical setting (Figure 2).

Regarding the disposal of common (non-hazardous) waste once a day, a tendency toward agreement was also observed (61.8%). This suggests that, in a significant proportion of healthcare settings, there is a relatively consistent routine to prevent waste accumulation (Figure 2).

Regarding the availability of space for recycling uncontaminated materials, a relevant proportion of respondents reported favorable conditions (50%). This pattern indicates that recycling is integrated across the settings, suggesting the presence of appropriate organizational strategies or logistical availability (Figure 2).

Figure 2. Risk levels associated with improper waste handling



Regarding the section assessing barriers to the implementation of waste management, the question concerning the daily identification of the number of kilograms of hazardous waste disposed of showed an important proportion of responses in the "agree" category (50.6%). This result indicates progress in internal control and management traceability (Table 3).

The question concerning cost control through weighing also showed a concentration of responses in the "agree" and "strongly agree" categories (48.2%). This indicates that participants recognize economic control mechanisms associated with the disposal of infectious waste (Table 3).

Regarding whether the dental clinic where participants provided services applied an assessment of compliance with internal healthcare waste management procedures, the favorable trend was maintained, with 54.1% of responses in the "agree" and "strongly agree" categories. This indicates that internal evaluation or verification processes are being conducted, which are key aspects for maintaining a protocol continuously (Table 3).

Regarding participation in healthcare waste management training lasting at least eight hours, a majority of responses were concentrated in the "agree" and "strongly agree" categories (64.1%). This suggests that participants have had opportunities for professional updating that

may help reduce barriers associated with insufficient knowledge or a lack of technical criteria concerning healthcare waste management (Table 3).

Table 3. Barriers to the implementation of waste management

Questions	Scale	N	%
At the dental facility where you work, do they identify the number of kilograms of hazardous solid waste disposed of per day?	Strongly disagree	13	7.6%
	Disagree	29	17.1%
	Neither agree nor disagree	42	24.7%
	Agree	40	23.5%
	Strongly agree	46	27.1%
Do you monitor the costs of infectious biomedical waste disposal through weighing measurements?	Strongly disagree	12	7.1%
	Disagree	26	15.3%
	Neither agree nor disagree	50	29.4%
	Agree	33	19.4%
	Strongly agree	49	28.8%
At the dental clinic where you provide your services, is compliance with internal healthcare waste management procedures assessed?	Strongly disagree	8	4.7%
	Disagree	25	14.7%
	Neither agree nor disagree	45	26.5%
	Agree	48	28.2%
	Strongly agree	44	25.9%
Have you participated in healthcare waste management training lasting at least 8 hours?	Strongly disagree	9	5.3%
	Disagree	12	7.1%
	Neither agree nor disagree	40	23.5%
	Agree	41	24.1%
	Strongly agree	68	40.0%

DISCUSSION

In the section on the segregation of hazardous and non-hazardous waste in dental clinics, the overall trend was concentrated in favorable responses regarding control practices during amalgam removal. The observed pattern indicates that direct operative practices are applied more frequently than infrastructure or complementary equipment measures. In this regard, the World Health Organization (WHO)⁶ emphasizes that healthcare waste includes both hazardous and non-hazardous fractions and that safe management is critical because of the risk of exposure and contamination. Therefore, segregation and preventive controls are not optional in clinical practice.

Maceda et al.²² have indicated that the management of waste containing toxic components, including metals and clinical by-products, requires specific technical precautions to minimize release and accidental contact. In the same context, the study by Makanjuola et al.⁹ on mercury hygiene and biomedical waste management among dental personnel describes practice and control gaps, particularly when operational or system barriers are involved. Muriau et al.¹ emphasize that actual compliance depends not only on knowledge but also on institutional support and the availability of supplies.

In this study, the section on current dental amalgam disposal practices showed that the best-performing component was related to safe storage and the existence of a person or mechanism responsible for waste management. This reflects important operational progress in the management of amalgam-related waste within dental services. In this regard, Makanjuola et al.⁹ emphasized that waste management in dentistry should include clear procedures for classification, containment, and removal to prevent exposure and secondary contamination. According to the WHO,⁶ the observed pattern is consistent with a scenario in which progress has been made in containment and internal management, while challenges persist when practices depend on external logistics and comprehensive standardization.

In the section concerning the waste standardization model, the strongest component was compliance with operational guidelines, including timely replacement of containers, disinfection, and management of anatomical waste. This suggests an appreciable degree of

standardization in routine procedures related to waste management. In this context, Mahesh et al.¹⁸ mention that the most frequent failures are related to incomplete segregation, irregular handling of sharps, and weaknesses in compliance monitoring, particularly when regulations have not been fully incorporated into the clinical workflow. Likewise, Dhole et al.¹⁹ emphasize that standardization depends on operational protocols, training, and supervision, rather than theoretical knowledge alone. According to the WHO,⁶ the observed results are consistent with majority compliance with critical actions, although there is still room for improvement in consistency and process assurance.

In the section concerning risk levels associated with improper waste handling, the most widely implemented practices corresponded to easily applicable operational procedures, such as color coding and daily disposal, whereas measures requiring specific physical resources, such as dedicated refrigeration and, to a lesser extent, recycling areas, showed greater variability and lower consolidation.

In relation to this finding, studies such as that by Janik-Karpinska et al.²³ indicate that analyses of healthcare waste emphasize that the hazardous fraction, although a minority, has the greatest potential for harm and requires robust controls to prevent exposure and contamination. Likewise, Wilmott and Duane²⁴ associate responsible waste management with measurable impacts on public health, including water, sanitation, and safety. In this regard, the regulatory framework established by Ecuador's Ministry of Public Health² sets out procedures for the classification, containment, and management of waste within healthcare establishments, supporting the importance of color coding and regular waste removal as essential components of risk control.

In the section concerning barriers to the implementation of waste management, the results indicated that implementation may be supported by training and control mechanisms, although their application varies according to the component assessed. In this context, Wilmott and Duane²⁴ have described a frequent barrier as the challenge of transforming "knowledge" into a measurable management system, including weighing, internal auditing, and compliance monitoring, particularly when these activities compete with clinical workload and operational limitations. Antonidou et al.²⁵, in their analysis of non-biodegradable waste loads and their impact, emphasize that management and disposal costs can become a significant limitation when clear control and financing mechanisms are not available.

CONCLUSIONS

Waste management in the dental setting, based on participants' responses, was found to rely primarily on established operational practices, such as control measures during procedures, color coding, and routine disposal practices.

In contrast, components that depend on infrastructure, traceability, and administrative control, including specific equipment, measurement of waste volumes and costs, and systematic verification of compliance, showed greater variability.

A limitation recognized in this study is that, because the questionnaire used a Likert-type scale, the results were based on self-reporting and may not fully reflect what is actually carried out in daily practice. Future research is therefore recommended to complement questionnaires with a checklist or on-site observation, including audits of containers, labeling, storage areas, and waste disposal routes.

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“Conceptualization and design: J Álvaro Chile Cayo, María Angélica Terreros de Huc; Literature review: Álvaro Chile Cayo, María Angélica Terreros de Huc; Methodology and validation: Álvaro Chile Cayo, María Angélica Terreros de Huc; Formal analysis: Álvaro Chile Cayo, María Angélica Terreros de Huc; Investigation and data collection: Álvaro Chile Cayo; Resources: Álvaro Chile Cayo; Data analysis and interpretation: Álvaro Chile Cayo, María Angélica Terreros de Huc; Writing – original draft preparation: Álvaro Chile Cayo; Writing – review and editing: Álvaro Chile Cayo, María Angélica Terreros de Huc; Supervision: Álvaro Chile Cayo, María Angélica Terreros de Huc; Project administration: Álvaro Chile Cayo, María Angélica Terreros de Huc; Funding acquisition: Not applicable.”

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