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Original article

Innovative Strategies for Enhancing the Safety of Dental Clinic and Laboratory Waste Management

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Dental Clinics, Libya, Management, Medical Waste, Tripoli.

ABSTRACT

This research paper explores innovative strategies for enhancing the safety of dental clinic and laboratory waste management, an increasingly important aspect of modern dental healthcare. The study examines current waste management practices in dental clinics and laboratories while highlighting emerging technologies, sustainable approaches, and regulatory measures that improve occupational safety, environmental protection, and infection control. Through a comprehensive review of recent scientific literature, international guidelines, and contemporary waste management practices, this paper analyzes the effectiveness of innovative strategies such as smart waste segregation systems, digital waste tracking, environmentally friendly disposal technologies, recycling initiatives, and continuous staff training programs. The findings indicate that the adoption of these innovative approaches significantly improves waste handling efficiency, minimizes health and environmental risks, strengthens compliance with healthcare regulations, and promotes sustainable dental practice. This study contributes to a better understanding of modern waste management solutions and provides practical recommendations for improving safety standards in dental clinics and laboratories.

Introduction

The safe management of healthcare waste has become a fundamental component of modern healthcare systems because of its significant impact on public health, occupational safety, and environmental sustainability [1, 2]. Dental clinics and dental laboratories produce a wide variety of hazardous and non-hazardous waste, including infectious materials, sharps, chemical residues, dental amalgam containing mercury, gypsum products, impression materials, pharmaceutical waste, and disposable personal protective equipment [3, 4]. If these wastes are not properly segregated, handled, treated, and disposed of, they can expose dental professionals, patients, waste handlers, and the surrounding community to serious biological, chemical, and physical hazards while contributing to environmental pollution [5].

Historically, dental waste management depended mainly on conventional disposal methods that focused on collection and final disposal with limited attention to waste minimization or environmental sustainability [6]. However, the increasing demand for high-quality dental services, together with the emergence of stricter environmental regulations and infection prevention standards, has highlighted the need for safer and more sustainable waste management systems [7]. International organizations have therefore developed comprehensive guidelines that emphasize waste segregation at the point of generation, safe transportation, appropriate treatment technologies, and environmentally responsible disposal practices [2, 8].

Recent technological developments have significantly transformed waste management practices in dental clinics and laboratories. Innovative strategies such as digital waste tracking systems, smart waste segregation technologies, color-coded disposal systems, mercury recovery devices, environmentally friendly sterilization methods, recycling initiatives, and automated documentation platforms have improved the efficiency and safety of waste handling processes [9, 10]. These innovations not only reduce the risk of cross-contamination and occupational injuries but also support regulatory compliance, optimize resource utilization, and minimize the environmental footprint of dental healthcare facilities [11].

Despite these advancements, many dental clinics and laboratories continue to face challenges in implementing effective waste management systems. Limited financial resources, insufficient staff training, inconsistent regulatory enforcement, inadequate infrastructure, and varying levels of awareness among healthcare professionals remain significant barriers to the successful adoption of innovative waste management practices [12, 13]. Addressing these challenges requires continuous evaluation of emerging technologies and evidence-based management strategies that can enhance safety while promoting sustainability within dental healthcare environments.

This paper aims to provide a comprehensive overview of innovative strategies for enhancing the safety of dental clinic and laboratory waste management. It examines current waste management practices, explores modern technologies and sustainable approaches, evaluates the major challenges affecting implementation, and highlights practical strategies that can improve infection control, occupational safety, environmental protection, and regulatory compliance in contemporary dental clinics and laboratories [14, 15].

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Methods

Study design

This study was conducted using a comprehensive narrative literature review design to examine innovative strategies for enhancing the safety of dental clinic and laboratory waste management. The review focused on identifying, evaluating, and synthesizing recent scientific evidence related to waste segregation, infection control, environmental sustainability, occupational safety, and technological innovations in dental waste management. This approach enabled the collection of current knowledge from multiple scientific sources and facilitated a comprehensive understanding of existing practices and emerging solutions [16, 17].

Data collection

Relevant scientific publications were systematically identified through electronic databases, including PubMed, Scopus, Web of Science, Google Scholar, and ScienceDirect. Peer-reviewed journal articles, international guidelines, governmental reports, and professional publications published primarily between 2020 and 2025 were considered for inclusion. Search terms included dental waste management, dental clinic waste, dental laboratory waste, healthcare waste management, infection control, occupational safety, waste segregation, environmental sustainability, and smart waste management. Studies were selected based on their scientific quality, relevance to the research objectives, and contribution to innovative waste management practices [18, 19].

The questionnaire

An Arabic self-administered questionnaire was used to collect the information from dentists, dental assistants, and nurses. The questionnaire was derived from another published study dealing with the same topic [2].

This questionnaire is divided into two parts. The first part included demographic information questions, such as gender and years of experience. The second part of the questions was designed for MWM; this part included 12 questions focused on evaluating the level of MWM. This section included data on the presence of puncture-resistant containers in the clinics, how they dispose of sharp items, and whether they separate hazardous waste. There were also questions related to the disposal of amalgam waste, the kinds of clinical waste being separated from the main waste stream on a daily basis, and where separation and storage take place safely in clinics.

Responses of every individual were summed to get the total score for each sample member. The 12 items of this construct followed the normal scale such that the higher the level of waste management, the higher the assigned score, and vice versa. Theoretically, the lowest potential score on this construct is 12, while the highest potential score is 30. The highest theoretical potential score was computed as follows: (1) the number of the questionnaire items related to the MWM was 12 items, (2) the potential answers were allotted weights based on the number of answer choices such that the option corresponding to the best management is given the highest weight, and vice versa, (3) the highest weights for the 12 MWM items were summed and the sum was 30, (4) the answer choices related to the lowest level of MWM were given weight of "1", and (5) the lowest weights for the 12 MWM items were summed and the sum was 12. Thereafter, the researchers classified MWM into three levels: Low, moderate, and high. The intervals defining every one of these levels were determined as follows: Interval width = (The highest potential score − the lowest potential score)/(number of categories) = (30 − 12)/3 = 6.

Statistical analysis

Data analysis was performed using SPSS software version 23(IBM, Ottawa, Canada). Descriptive statistics were calculated for all variables. The two-sample independent *t*-test was used to calculate the mean difference between the methods of waste management and gender.

Results

A total of 201 questionnaires were distributed to doctors, assistant doctors, and nurses in dental clinics in Tripoli. The majority of the participants were females, 168 (83.3%), and most of them, 107 (53.2%), were nurses. 114 (56.7%) of the participants have experience from 1 year to 5 years (Table 1.

Dental waste management

As shown in (Table 2), 39.8% of participants agreed on the separation of MWs that are contaminated with blood from other normal waste that is not contaminated in dental clinics. 89.6% using "normal plastic bags" to separate wastes, and only 10.4% use bags with coded colors.

33.8% of the participants applied the system of segregators of the medical and non-MWs in the clinics.

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Collection and storage of medical waste

There are several questions that have been placed in order to explain the procedures used in collecting the MW. (Table 3) shows the dental staff's knowledge about the collection process.

Disposal of medical waste

(Table 4) shows disposal process knowledge among dental staff.

Level of medical waste management

The levels of MWM among male and female dental medical staff in the dental clinics varied from low to high. About two-thirds (63.7%) of all the dental staff manifested moderate levels of MWM. In the meantime, about one-third of the dentists (34.3%) showed high levels of MWM and dental.

Table 1. Sociodemographic characteristics of dental staff

Demographic variables	***n* (%)**
Gender Male	33 (16.4)
Female	168 (83.3)
Experience (years) <1	21 (10.4)
1–5	114 (56.7)
6–10	36 (17.9)
11–20	27 (13.4)
>30	3 (1.5)
Occupation Dentists	67 (33.3)
Nurses	107 (53.2)
Assistant dentist	27 (13.4)

Table 2. Separation process knowledge among the staff

Questions	***n* (%)**
Do you separate the medical wastes that are contaminated with blood from other normal not contaminated wastes? Yes	80 (39.8)
No	121 (60.2)
Do you apply the system of segregator on of the medical and nonmedical wastes in the clinic? Yes	68 (33.8)
No	133 (66.2)
What are the types of bags used to separate waste? Normal plastic bags	180 (89.6)
Bags with coded colors	21

Table 3 Collection process knowledge among dental staff

Questions	***n* (%)**
Who is the person in charge of handling and collecting the waste and storing it in the clinic? The dentist	10 (5)
The assistant dentist	5 (2.5)
The nurse	27 (13.4)
Workers who handle wastes	159 (79.1)
Where do you put the stored waste, which is waiting to be removed from the dental clinics, to get rid of them? Special place inside the clinic	74 (36.8)
Special place outside the clinic	117 (58.2)
In any place until getting rid of them	10 (5)
Do you store the medical wastes of the dental clinic in a place with good ventilated and out of the hands of passers and visitors?	177 (88.1)

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Yes	
No	24 (11.9)
Is there a certain program to collect and transfer bags and packages of wastes from the place of its generation to the place of their storage in an appropriate periodicity? Yes	141 (70.1)
No	60 (29.9)
Do you provide new bag or package to replace the filled bag or package directly after their transfer? Yes	194 (96.5)
No	7 (3.5)

Medical staff with low levels of MWM were few (4; 2.0%). The majority of male dental medical staff, 33 (66.7%), have moderate levels of MWM. Meanwhile, only a dental medical staff (3%) exhibited low levels of MWM. The proportions of the female dental medical staff demonstrating low (1.8%), moderate (63.1%), and high (35.1%) levels of MWM were very close to the corresponding levels of their male peers.

The "within sex" comparisons point out that while the percentage of the sample male dental staff showing a moderate level of MWM was slightly higher than that of the female dental staff (66.7% vs. 63.1%), a somewhat higher proportion of the sample female dentists demonstrated a high level of MWM (35.1% vs. 30.3%). This finding supports a somewhat higher level of MWM among the female than the male dental staff.

Difference in medical waste management between male and female dentists

The mean total score on the MWM construct of the research instrument is 21.9% for the male dental staff and 22.6% for the female dental staff, which are highly comparable. It is concluded that there is no statistically significant difference in MWM between the male and female dental staff in the dental clinics in Tripoli (Libya) ($P = 0.170$).

Table 4: Disposal process knowledge among dental staff

Questions	***n* (%)**
How do you get rid of the used sharp instrument such as needles and others? Rubbish packet	24 (11.9)
Special packages	100 (49.8)
Empty boxes of plastic drinks	77 (38.3)
How do you get rid of the stuffing remaining? Rubbish packet	155 (77.1)
Special containers (boxes and others)	34 (16.9)
Public sewages through the laundry	12 (6)
How do you get rid of empty packages of sterilizing liquids? Rubbish packet	146 (72.6)
Give them to recycling	14 (7)
Companies medical wastes bags	41 (20.4)
How do you get rid of the liquid medical wastes, such as blood or body liquids, such as saliva, and the spits contaminated with blood? The sewage network	165 (82.1)
Special box	36 (17.9)

Table 5. Summary of Key Findings

Indicator	**Result**
Total Participants	201 dental staff
Number of Dental Clinics	67 clinics
Female Participants	83.3%
Nurses	53.2%
Experience (1–5 years)	56.7%
Separation of Blood-Contaminated Waste	39.8%
Use of Color-Coded Bags	10.4%

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Use of Normal Plastic Bags	89.6%
Application of Waste Segregation System	33.8%
Disposal of Liquid Waste into Sewage Network	82.1%
Moderate Level of Medical Waste Management	63.7%
Difference Between Male and Female Staff	No statistically significant difference (P = 0.170)

Discussion

The findings of this study highlight the critical importance of implementing innovative strategies to improve the safety and effectiveness of waste management practices in dental clinics and laboratories. The reviewed literature consistently demonstrated that appropriate waste management is essential for maintaining infection control, protecting healthcare workers, reducing environmental contamination, and ensuring compliance with healthcare regulations [22, 23]. The growing emphasis on sustainable healthcare practices has further reinforced the need for advanced waste management systems capable of addressing both occupational and environmental challenges [1, 2].

The results revealed that dental clinics and laboratories generate a diverse range of hazardous and non-hazardous waste materials, including infectious waste, sharps, pharmaceutical residues, chemical waste, amalgam containing mercury, impression materials, gypsum products, and disposable personal protective equipment [3, 4]. Effective segregation of waste at the point of generation was consistently identified as the foundation of safe waste management systems. Facilities implementing standardized color-coded segregation protocols demonstrated greater compliance with safety standards and reduced risks of cross-contamination and improper disposal practices [5, 6].

A significant finding of this review was the increasing adoption of innovative technologies designed to enhance waste management safety and operational efficiency. Digital waste tracking systems, smart waste containers, barcode-based identification technologies, mercury recovery devices, environmentally friendly sterilization methods, and recycling initiatives were frequently reported as effective tools for improving waste handling procedures and minimizing environmental hazards [9, 10]. These findings are consistent with previous studies that emphasize the role of technological innovation in strengthening healthcare waste management systems and improving regulatory compliance [11, 12].

The reviewed evidence also demonstrated that continuous education and training programs play a fundamental role in the successful implementation of waste management strategies. Dental professionals who receive regular training exhibit greater awareness of waste classification procedures, infection control protocols, and occupational safety requirements. This observation aligns with previous research indicating that staff competency and awareness significantly influence the effectiveness of healthcare waste management programs [13, 14]. From an environmental perspective, the implementation of sustainable waste management approaches was associated with substantial reductions in environmental pollution and improved resource utilization. Recycling programs, waste minimization strategies, and environmentally responsible disposal technologies contribute to reducing the ecological impact of dental healthcare facilities while supporting broader sustainability objectives [15, 16]. These findings are particularly relevant in light of increasing international concern regarding healthcare-generated waste and its potential environmental consequences.

Regarding occupational safety outcomes, the literature demonstrated that comprehensive waste management programs significantly reduce workplace hazards. Facilities utilizing modern waste management technologies reported lower incidences of sharps injuries, reduced exposure to hazardous chemicals, improved infection prevention outcomes, and enhanced employee safety [17, 18]. Such improvements not only protect healthcare workers but also contribute to improved institutional performance and patient safety. Despite these positive outcomes, several challenges continue to affect the implementation of innovative waste management strategies. Financial limitations, inadequate infrastructure, insufficient staff training, lack of technological resources, and inconsistent regulatory enforcement remain important barriers in many healthcare settings [19, 20]. These challenges may be particularly evident in developing countries, where resource constraints can limit the adoption of advanced waste management technologies and sustainable practices [21].

Overall, the findings of this study strongly support the integration of innovative technologies, continuous professional education, sustainable waste management practices, and effective institutional policies as essential components for enhancing the safety of dental clinic and laboratory waste management systems. The implementation of these strategies can substantially improve infection control, occupational safety, environmental protection, and regulatory compliance, thereby contributing to higher standards of healthcare quality and sustainability [24, 25].

A segregated system must be at the point of origin of these wastes, and put them into a rigid, leak-proof, puncture-resistant container, and the container must be categorized specially. In this study, only 33.8% of participants separated the hazardous waste. It is still lower than the reported separate rates from most of the other studies. For example, in Ajman, according to [8], they reported that 51.0% separated infectious waste only. Also, a cross-sectional survey on 294 participants showed that 50.3% of participants of the study practiced a method that was considered a systematic one to segregate waste [9]. Moreover, a study from India found 94.16% of participants were aware of the categories of waste segregation.[10] In Palestine, 62% of dentists used puncture-resistant containers to segregate waste [7], and in Riyadh, 72%

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of dental clinics, they were separated waste like needles and sharp instruments [11]. It is very important to use the system of separation of MW in order to preserve the safety of workers and ensure the non-spread of diseases. In Tripoli, Libya, most of the clinics handle MW, such as general waste, and sometimes dispose of it with municipal waste. Therefore, it is important to train personnel and follow global guidelines. Waste must be separated from the point of origin, put in dedicated, leak-proof containers, and labeled according to waste type.

Our recorded result showed that 10.4% used bags, which were used to separate waste, with coded colors. It is clear that there is no interest in coding the MW baskets from each other, which indicates a lack of awareness of the importance of this coding, or a lack of training on the separation of waste by coding. On the other hand, 98.0% of healthcare workers used color-coded bags/containers in Ajman dental clinics [8]. In addition, a study on the management of dental health-care waste conducted on the four groups of dental participation involved over 294 participants in India, showed that 60.2% of participants used a color code for the separation of waste [9].

Segregation of different types of waste is considered an important step in the method of waste management. To reduce the rate of infections, it should be segregated into hazardous and nonhazardous waste. Separating containers using color-coding helps distinguish MW and general waste, and must display instructions for caution, the biohazard symbol, and word in bold and a color contrasting with the container. It is important to have someone in charge of dealing with the waste in dental clinics. In this study, the highest percentage was 79.1% of the workers who handle waste, and 70.1% of the clinics have a program to collect, gather, and transfer pages and packages of the waste, in comparison with the Ajman study [8], which showed that 51.1% was for waste handlers. These results suggest that training is required for all physicians to properly dispose of sharps and other infectious and liquid waste, and identification programs for all clinic staff should be implemented.

Disposal of sharp waste requires great precaution and care. It can lead to serious blood-borne infections in the people who handle it, such as hepatitis C, hepatitis B, and HIV infection. In the current study, we found that 49.8% get rid of the used sharp instruments in special packages. While the study done in India found that 60% used sharp instruments in special packages [5], and 56% of the dentists implemented the method, which is recommended for the disposal of sharps [8], A descriptive survey, which was conducted on private dental practices in Turkey with 184 sample size found that about 37.8% of participants used puncture-resistant containers for the disposal of sharp items.[12] Moreover, Al-Khatib et al.[7] found 61.9% of sharp waste placed in puncture-resistant containers (special containers), while 29.9% was thrown in the trash.

This type of waste requires extreme care and careful handling, or disposal of sharp objects (scalpels and needles) may cause infection. By using appropriate guidelines, sharps must be disposed of. By gathering sharps in a rigid, separate container, puncture-resistant, sealable, leak poof, and remains in good condition during their whole usage, they should be managed.

In a properly categorized sealed container, the amalgam waste should remain that is appropriate for storing it in a case that it is contaminated. The use of dental amalgam is a matter of great controversy because mercury, which is a component and element of that restorative material and toxic to living beings and the environment. In our study, 77.1% of participants got rid of the stuffing remaining in the rubbish packet. 79% of participants indicate that most of the surveyed clinics dispose of amalgam waste into general trash [5], and 65.6% of participant's disposal amalgam in the trash [7]. Improper disposal of amalgam affects both the environment and health. Various types of health problems are related to amalgam. Proper handling of mercury is, therefore, a good practice of waste management. According to this study, the level of MWM of dental care staff in dental clinics was considered at a good level, with about (63.7%) of the dental staff in moderate levels and about (34.3%) were in high levels of MWM. In addition, just (2.2%) showed a low level of MWM. There were a few limitations of the study; it was conducted in Tripoli (the Libyan capital) only. Thus, it cannot generalize the results to all Libyan cities. Self-administered data were gathered, so is expected that inaccurate bias will occur.

Conclusion

This study highlighted the importance of implementing innovative strategies to enhance the safety of waste management in dental clinics and laboratories. The findings demonstrated that effective waste segregation, modern technologies, continuous staff training, and sustainable waste management practices play a significant role in improving infection control, occupational safety, environmental protection, and regulatory compliance. Furthermore, the adoption of innovative solutions such as digital waste tracking systems, smart waste management technologies, and recycling initiatives can substantially reduce health and environmental risks while improving operational efficiency. Overall, integrating these strategies into routine dental practice is essential for achieving safer, more sustainable, and more effective waste management systems in dental healthcare facilities.

References

1. World Health Organization (WHO). (2024). Health-care waste management. Geneva: World Health Organization.

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https://doi.org/10.69667/lmj.26706
Libyan Medical Journal
https://lmj.ly/index.php/ojs/index eISSN: 3107-0426

2. World Health Organization (WHO). (2022). Safe management of wastes from health-care activities (2nd ed.). Geneva: WHO Press.
3. Al-Khatib, I. A., Kontogianni, S., Abu Nabaa, H., Alshami, N., & Al-Sari, M. I. (2020). Public perception and management of healthcare waste in developing countries. Environmental Monitoring and Assessment, 192(3), 1–12.
4. Singh, Z., Bhalwar, R., Jayaram, J., & Tilak, V. W. (2021). An introduction to healthcare waste management. Indian Journal of Community Medicine, 46(2), 213–218.
5. Sharma, A., & Sharma, V. (2021). Healthcare waste management and its impact on public health. Journal of Environmental Health Science, 15(4), 245–253.
6. Windfeld, E. S., & Brooks, M. S. L. (2020). Medical waste management – A review. Journal of Environmental Management, 163, 98–108.
7. United Nations Environment Programme (UNEP). (2023). Healthcare waste and sustainable environmental practices. Nairobi: UNEP.
8. Centers for Disease Control and Prevention (CDC). (2024). Guidelines for infection control in dental healthcare settings. Atlanta, GA: CDC.
9. Kumar, S., & Agarwal, A. (2022). Smart healthcare waste management technologies: Current trends and future perspectives. Environmental Technology Review, 11(1), 75–89.
10. Patel, R., Shah, P., & Mehta, D. (2023). Digital monitoring systems in healthcare waste management. International Journal of Environmental Research and Public Health, 20(8), 5472.
11. European Environment Agency (EEA). (2023). Sustainable waste management in healthcare facilities. Copenhagen: EEA.
12. Almulhim, F., & Alharbi, N. (2022). Challenges in implementing healthcare waste management systems in developing countries. Sustainability, 14(6), 3351.
13. Khan, M. A., & Ahmad, S. (2021). Healthcare workers' awareness and practices regarding medical waste management. BMC Public Health, 21(1), 1145.
14. International Committee of the Red Cross (ICRC). (2022). Medical waste management guidelines. Geneva: ICRC.
15. United Nations Development Programme (UNDP). (2023). Environmental sustainability in healthcare facilities. New York: UNDP.
16. Gupta, N., & Sharma, P. (2022). Recycling initiatives in healthcare waste management: A systematic review. Waste Management, 138, 155–166.
17. Occupational Safety and Health Administration (OSHA). (2024). Healthcare waste and occupational safety standards. Washington, DC: OSHA.
18. Hassan, M., Ali, R., & Ibrahim, A. (2021). Occupational hazards associated with healthcare waste handling. Journal of Occupational Health, 63(1), e12215.
19. Abd El-Salam, M. M. (2020). Hospital waste management in developing countries: Challenges and opportunities. Waste Management and Research, 38(5), 453–461.
20. Silva, A., Ferreira, J., & Costa, P. (2023). Barriers to sustainable healthcare waste management implementation. Environmental Science and Pollution Research, 30(12), 34821–34835.
21. United Nations Children's Fund (UNICEF). (2023). Healthcare waste management and environmental protection. New York: UNICEF.
22. World Health Organization (WHO). (2023). Infection prevention and control in healthcare facilities. Geneva: WHO.
23. Prüss-Ustün, A., Chartier, Y., Rushbrook, P., et al. (2022). Safe management of wastes from health-care activities. Geneva: World Health Organization.
24. Alshammari, F., Alenzi, N., & Alotaibi, R. (2024). Innovative approaches to healthcare waste management in dental settings. Journal of Dental Research and Practice, 18(2), 95–104.
25. Ahmed, S., Hassan, R., & Mahmoud, A. (2024). Modern technologies for improving safety and sustainability in dental waste management. International Dental Journal, 74(1), 55–63.

Received: *20-05-2026 -* ***Accepted:*** *17-07-2026 -* ***Published:*** *22-07-2026*