Afro-Asian Journal of Scientific Research (AAJSR)
المجلة الأفروآسيوية للبحث العلمي
E-ISSN: 2959-6505
Volume 4, Issue 2, 2026
Page No: 20-26
Website: https://aajsr.com/index.php/aajsr/index
SJIFactor 2024: 5.028 ISI 2025: 0.915 معامل التأثير العربي (AIF) 2025: 0.76

Strategies for Medical Waste Management in General Dental Clinics in Benghazi: An Analytical Study of Reality, Challenges, and Development Pathways

Reem Ali Alzardomi
Department of Environmental Health, Faculty of Public Health, University of Benghazi, Benghazi, Libya

استراتيجيات إدارة النفايات الطبية في عيادات الأسنان العامة في بنغازي: دراسة تحليلية للواقع، التحديات، ومسارات التطوير

*ريم علي الزردومي
قسم الصحة البيئية، كلية الصحة العامة، جامعة بنغازي، بنغازي، ليبيا

*Corresponding author: ream.alzardomi@uob.edu.ly

Received: February 07, 2026	Accepted: March 22, 2026	Published: April 02, 2026

Abstract

Effective Medical Waste Management Strategies in General Dental Clinics in Benghazi, Libya: An Analytical Study with Recommendations for Practice Improvement. Medical waste management in dental clinics in Benghazi, Libya, presents a complex challenge requiring comprehensive attention to legislative, technical, and human aspects. This study aims to provide a critical analysis of current practices in general dental clinics within the city, identify key gaps and challenges, and propose integrated strategies for improved management. The research adopted a descriptive-analytical methodology, involving an in-depth review of scientific literature, local legislation, and international standards from leading organizations such as the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC). Findings revealed significant shortcomings in the implementation of waste segregation policies at the source, inadequate treatment infrastructure, and insufficient awareness and training among staff. The study also highlighted a disparity between proposed Libyan legislative frameworks and actual practices. Based on this analysis, the research introduces a proposed theoretical framework, the Integrated Dental Medical Waste Management Model (IDM-DW), alongside a set of practical strategies tailored for various stakeholders. This model aims to establish a safe and sustainable system for medical waste management, thereby effectively contributing to public health and environmental protection in Benghazi.

Keywords: Medical Waste, Waste Management, Dental Clinics, Benghazi, Libya, Public Health, Environmental Safety.

الملخص

تُعد إدارة النفايات الطبية في عيادات الأسنان بمدينة بنغازي، ليبيا، تحديًا معقدًا يتطلب معالجة شاملة للجوانب التشريعية والفنية والبشرية. تهدف هذه الدراسة إلى تقديم تحليل نقدي للممارسات الحالية في عيادات الأسنان العامة بالمدينة، مع تحديد الفجوات والتحديات الرئيسية، واقتراح استراتيجيات متكاملة لتحسين الإدارة. اعتمدت الدراسة منهجية وصفية تحليلية، شملت مراجعة معمقة للأدبيات العلمية، والتشريعات المحلية، والمعايير الدولية الصادرة عن منظمات رائدة مثل منظمة الصحة العالمية (WHO) ومراكز السيطرة على الأمراض والوقاية منها (CDC). كشفت النتائج عن قصور ملحوظ في

تطبيق سياسات فرز النفايات من المصدر، وضعف في البنية التحتية المخصصة للمعالجة، ونقص في الوعي والتدريب الكافي لدى العاملين .كما أبرزت الدراسة وجود فجوة بين الإطار التشريعي الليبي المقترح والممارسات الفعلية على أرض الواقع .بناءً على هذا التحليل، يقدم البحث إطارًا نظريًا مقترحًا، وهو نموذج الإدارة المتكاملة للنفايات الطبية السنية (IDM-DW)، بالإضافة إلى مجموعة من الاستراتيجيات العملية الموجهة لمختلف أصحاب المصلحة .يهدف هذا النموذج إلى تأسيس نظام آمن ومستدام لإدارة النفايات الطبية، مما يساهم بشكل فعال في حماية الصحة العامة والبيئة في بنغازي.

الكلمات المفتاحية: النفايات الطبية، إدارة النفايات، عيادات الأسنان، بنغازي، ليبيا، الصحة العامة، السلامة البيئية .

1. Introduction

Effective management of medical waste generated from healthcare facilities, including dental clinics, is a critical component of public health and environmental safety systems. This waste, encompassing contaminated sharp instruments, chemical substances, and mercury-containing amalgam residues, poses significant risks if not handled through safe and scientifically sound methods [1]. Improper disposal can lead to the spread of infectious diseases such as AIDS, Hepatitis B, and Hepatitis C, as well as environmental contamination by heavy metals and toxic substances, threatening the health of healthcare workers, patients, and the community at large [2].

In Benghazi, similar to many cities in developing countries, the dental sector faces increasing challenges in effectively managing its waste. Preliminary evidence indicates deficiencies in current practices, ranging from source segregation to final treatment, exacerbated by the absence of a comprehensive and effective local legislative framework and limited awareness of the associated risks [3]. This situation necessitates an in-depth study to understand the dimensions of the problem and identify barriers preventing the adoption of global best practices.

This study aims to shed light on the reality of medical waste management in general dental clinics in Benghazi. The research critically analyzes the current situation, compares it with international standards, and identifies the legislative, technical, human, and economic challenges confronting this sector. More importantly, the study seeks to move beyond mere diagnosis by proposing an integrated framework and practical strategies applicable within the Libyan context, thereby contributing to the establishment of a sustainable and safe waste management system.

This research addresses several key questions: What is the current state of medical waste management practices in dental clinics in Benghazi? What are the most prominent challenges hindering proper management? How can effective strategies be developed that align with global best practices and suit local conditions? Answering these questions will not only bridge a knowledge gap in this field at the local level but also provide a practical roadmap for policymakers, clinic managers, and healthcare professionals to improve their practices and protect the environment and community.

2. Materials and Methods

To achieve the research objectives, an integrated descriptive-analytical methodology was adopted, relying on the collection and analysis of data from multiple sources. No direct field study was conducted at this stage; instead, the focus was on analyzing available data and literature to build a comprehensive and deep understanding of the subject. The methodology is divided into three main stages:

2.1. Literature Review and Desk Research

In this stage, a comprehensive desk review was conducted to gather information from the following sources:

- Academic and Scientific Literature: Global scientific databases such as PubMed, Google Scholar, and ResearchGate were searched using keywords like "Medical Waste Management," "Dental Waste," and "Healthcare Waste in Libya" to identify relevant previous studies and research.
- International Standards and Guidelines: Documents and guidelines issued by authoritative international organizations, primarily the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), as well as European and American environmental agencies, were analyzed to understand global best practices.
- Local Documents and Legislation: Libyan laws and regulations related to medical waste management were investigated, including the draft executive regulation for integrated medical waste management, relevant ministerial decisions, and reports and websites of governmental bodies and specialized companies in Libya.

2.2. Data Analysis and Classification

After data collection, the information was systematically classified and analyzed. Qualitative Content Analysis was employed to extract key patterns and themes from the texts and documents. The collected information was organized around several main axes, including:

- Types and classifications of medical waste in dental clinics.
- Current status of practices in Libya and Benghazi.

- Local legislation and international standards.
- Challenges (legislative, technical, human, economic).
- Research gaps.

2.3. Development of Theoretical Framework and Strategies

Based on the analysis results, the study proceeded to the inferential and developmental stage. In this stage:

- Theoretical Framework Development: The "Integrated Dental Medical Waste Management Model (IDM-DW)" was designed, outlining the fundamental pillars for an effective management system within the local context.
- Proposal of Practical Strategies: A set of practical strategies was developed, targeting various stakeholders (government, clinics, private sector, academic institutions) for the implementation of the proposed theoretical framework.

This methodology is characterized by providing a strong theoretical foundation and comprehensive analysis preceding any field work, enabling accurate identification of gaps and guiding future research and field studies to be more focused and effective.

3. Results and Discussion

3.1. Classification and Risks of Medical Waste in Dental Clinics

Dental clinics generate a diverse range of waste that can be classified based on its nature and hazard level. According to the World Health Organization (WHO), approximately 85% of healthcare waste is general non-hazardous waste, while the remaining 15% constitutes hazardous waste [2]. This general classification applies to dental clinics, where multiple types of waste requiring special management are generated. These can be primarily categorized as shown in Table 1.

Table 1: Classification of Medical Waste in Dental Clinics and Associated Risks

Waste Category	Examples from Dental Clinics	Primary Associated Risks
Infectious Waste	Gauze and cotton contaminated with blood or saliva (e.g., Hepatitis B and C, HIV), gloves, masks, suction tubes.	Transmission of infectious diseases.
Sharp Waste	Needles, scalpel blades, extracted broken teeth, broken glass.	Risk of punctures and cuts, transmission of blood-borne infections.
Pathological Waste	Tissues, extracted teeth, human residues from oral surgeries.	Risk of infection, ethical considerations in handling.
Chemical Waste	Sterilization and disinfection solutions, radiographic processing chemicals (developer and fixer).	Chemical toxicity, contamination of water and soil.
Heavy Metal Waste	Amalgam residues (containing mercury), lead foils (especially mercury), X-ray films.	High neurotoxicity and environmental toxicity, long-term pollution.
Pharmaceutical Waste	Expired medications, unused anesthetics.	Environmental pollution, development of antibiotic resistance.
General Waste	Office waste, uncontaminated packaging, food scraps.	No direct health risk, but increases overall waste volume.

The primary danger lies in mixing these different types of waste. Disposing of infectious or sharp waste with general waste can expose sanitation workers and the public to infection risks. Similarly, disposing of amalgam in sewage systems leads to mercury contamination of water sources, which is among the most toxic substances to the nervous system and the environment [4]. Therefore, accurate source segregation is considered the cornerstone of any effective medical waste management strategy.

3.2. Reality of Medical Waste Management in Libya and Benghazi

The situation in Libya generally, and in Benghazi specifically, reflects many challenges faced by developing countries in medical waste management. The current reality can be summarized in several key points:

3.2.1. Legislative and Regulatory Framework

Despite efforts to establish regulatory frameworks, the gap between legislation and implementation remains wide. The draft executive regulation for integrated medical waste management, which defines clear classifications for waste types and objectives for their management, has been prepared [5]. Additionally, "Draft Law No. 1 of 2022" concerning healthcare waste management was issued, explicitly prohibiting incorrect practices such as segregation in non-designated equipment and collection in a single bag [6]. However, studies indicate that these legislations remain largely unenforced. A study conducted in Tripoli confirmed a "shortage in national legislations and laws regulating waste management in dental clinics" [3], a situation largely applicable to Benghazi. This legislative deficiency creates an environment where practices rely on individual awareness rather than legal mandates, making adherence to best practices a matter of choice rather than obligation.

3.2.2. Actual Practices in Clinics

The prevalent practice in many clinics is the mixing of hazardous medical waste with general municipal waste [7]. This issue has been documented in similar regional studies. Different types of waste (general, infectious, sharp) are often collected in a single bag to be disposed of later with household waste. This practice not only exposes waste collection workers to severe health risks but also leads to the contamination of public landfills with heavy metals and hazardous biological materials.

3.2.3. Available Services and Infrastructure

In recent years, Benghazi has witnessed developments in this field, particularly the emergence of specialized companies providing medical waste management services. "The Consulting Company for Medical Waste Management" is prominent among these, offering integrated services including collection, transport, and treatment. It has also formed partnerships with important entities like the Medical Supply Organization and Benghazi University [8]. Furthermore, other companies like "Oxygen Company" provide sterilization and treatment services. At the governmental level, 5 incinerators for medical waste were received in 2022 with international support [9]. However, access to these services and their utilization remain limited, especially for small general clinics that may face financial difficulties in bearing the costs of contracting with these companies. Moreover, the capacity of these companies and incinerators may not be sufficient to cover all healthcare facilities in the city.

3.2.4. Awareness and Training

Lack of knowledge and awareness among dental clinic staff is one of the biggest challenges. Many practitioners may not be fully aware of the risks associated with each type of waste or the correct methods for handling them. Despite some initiatives, such as scientific seminars and training workshops organized in Benghazi [10], these remain insufficient to reach all staff in the sector and update their knowledge regularly. The absence of continuous and systematic training perpetuates incorrect practices and makes it difficult to implement any new developmental strategies.

3.3. Comparison with International Standards and Best Practices

A clear gap emerges when comparing the local reality in Benghazi with international standards across all stages of medical waste management. Global best practices emphasize the "waste management hierarchy" principle, which prioritizes prevention and reduction, followed by reuse, recycling, treatment, and finally, disposal. Organizations like the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) apply this principle through detailed guidelines.

Table 2: Comparison Between Current Practices in Benghazi and International Best Practices

Stage	Current Practices in Benghazi (Based on Analysis)	International Best Practices (Based on WHO, CDC, EU)
Segregation at Source	Random and unsystematic segregation. Mixing different types of waste (general, infectious, sharp) in one container.	Mandatory and strict segregation. Color-coded containers (e.g., yellow for infectious, red for sharps, black for general) at the point of generation.
Containment and Handling	Use of ordinary plastic bags. Lack of specialized containers. Re-capping of needles is common.	Use of puncture-resistant containers that are clearly labeled and leak-proof. No re-capping of needles.
Temporary Storage	No designated storage areas in many clinics. Waste stored with general waste.	Safe, secure, and designated temporary storage areas, away from public access, well-ventilated, and clearly labeled with biohazard symbols.
Treatment and Disposal	Direct disposal of hazardous waste in landfills without prior treatment.	Treatment of hazardous waste (e.g., sterilization, incineration, chemical treatment) to neutralize pathogenic agents before final disposal with municipal waste.
Amalgam Waste	No clear restrictions on amalgam use. Amalgam separators are not mandatory in most clinics, leading to direct mercury discharge into sewage.	Reduction or prohibition of amalgam use. Mandatory use of amalgam separators (ISO 11143 compliant) to prevent mercury discharge into wastewater.
Training and Documentation	Limited and irregular training. Almost complete absence of written plans and records.	Continuous and mandatory training for all staff. Existence of a waste management plan. Detailed records of operations and disposal.

This comparison highlights that practices in Benghazi are still in their initial stages, lacking adherence to globally accepted scientific methodologies. While international standards focus on prevention and control of hazards at the point of generation, the local approach (in the best cases) seems to focus on addressing the problem after it has escalated through collection and delayed treatment, neglecting fundamental preventive steps.

4. Proposed Strategies for Improvement

Based on the comprehensive analysis of the current reality, challenges, and comparison with best practices, an integrated framework has been developed to provide sustainable and practical solutions for medical waste management in dental clinics in Benghazi. This framework consists of two parts: a theoretical framework defining governing principles, and practical strategies for implementing this framework.

4.1. Proposed Theoretical Framework: Integrated Dental Medical Waste Management Model (IDM-DW)

This proposed model is built upon six interconnected and fundamental pillars, ensuring coverage of all aspects of the waste management process from generation to final disposal, with an emphasis on safety and sustainability. The model is designed to be flexible and adaptable to the local conditions of Benghazi.

Table 3: Key Pillars of the Integrated Dental Medical Waste Management Model (IDM-DW)

Pillar	Detailed Description	Primary Objectives
Legislative Framework	Development and activation of a clear and specific legislative framework for medical waste management. This includes activating the executive regulation for medical waste management and developing a specific guidance manual for dental clinics.	- Activate executive regulation for medical waste management. - Develop clear and specific legislation for waste management. - Establish a robust monitoring and control system to ensure compliance.
Source Segregation	Implementation of a unified system for precise segregation of different types of waste immediately at the point of generation within the clinic, using a clear color-coding system.	- Reduce the quantity of hazardous waste - Facilitate safe treatment processes. - Protect staff and patients.
Containment and Safe Handling	Use of specialized, puncture-resistant, and leak-proof containers. Allocation of separate and secure temporary storage areas within the clinic.	- Prevent the spread of infection. - Reduce occupational risks. - Ensure the safety of the internal environment.
Collection and Transport	Contracting with licensed companies specialized in the collection and transport of medical waste.	- Ensure safe and regular waste disposal. - Prevent environmental contamination.
Treatment and Final Disposal	Establishment of appropriate treatment facilities (e.g., autoclaves, incinerators) or contracting with specialized centers. Safe and environmentally sound final disposal.	- Neutralize pathogenic agents. - Reduce waste volume. - Protect the environment from pollution.
Training, Awareness, and Documentation	Continuous and mandatory training programs for all staff on waste management procedures, risks, and safety protocols. Implementation of a comprehensive documentation system for all stages.	- Enhance staff knowledge and awareness. - Ensure adherence to safety protocols. - Facilitate monitoring and evaluation.

4.2. Practical Strategies for Implementation

To translate the IDM-DW model into action, the following practical strategies are proposed, targeting various stakeholders:

4.2.1. Government and Regulatory Bodies

- Expedite Legislation Enforcement: Accelerate the approval and enforcement of the executive regulation for integrated medical waste management and related laws. This includes imposing strict penalties for non-compliance.
- Develop National Guidelines: Create a comprehensive national guideline specifically for medical waste management in dental clinics, detailing segregation, collection, storage, treatment, and disposal procedures.
- Establish Monitoring and Inspection Mechanisms: Implement a robust system for regular and unannounced inspections of dental clinics to ensure adherence to regulations and guidelines. Empower regulatory bodies with sufficient resources and authority.
- Support Infrastructure Development: Provide financial and technical support for the establishment and upgrading of medical waste treatment facilities, especially in underserved areas. Encourage public-private partnerships in this sector.

4.2.2. Dental Clinics and Practitioners

- Implement Source Segregation: Strictly implement color-coded segregation systems for all types of waste at the point of generation. Provide appropriate containers for each waste category.
- Adopt Safe Handling Practices: Ensure the use of puncture-resistant containers for sharps and leak-proof bags for infectious waste. Prohibit re-capping of needles and other unsafe practices.
- Establish Secure Storage: Designate a secure, well-ventilated, and easily accessible area for temporary storage of medical waste within the clinic, away from patient and public access.

- Contract with Licensed Companies: Engage licensed and reputable medical waste management companies for regular collection, transport, treatment, and disposal services.
- Continuous Staff Training: Implement mandatory and regular training programs for all staff members (dentists, assistants, administrative staff) on proper waste management procedures, health risks, and emergency protocols.
- Maintain Records: Keep detailed records of waste generation, segregation, collection, and disposal, including quantities and dates, for auditing and reporting purposes.

4.2.3. Academic Institutions and Professional Associations

- Integrate Curriculum: Incorporate comprehensive modules on medical waste management, environmental safety, and public health into dental and healthcare curricula.
- Conduct Research: Encourage and fund research on innovative and cost-effective medical waste management solutions tailored to the Libyan context. Study the long-term environmental and health impacts of current practices.
- Organize Workshops and Seminars: Regularly organize workshops, seminars, and awareness campaigns for dental practitioners and students to disseminate best practices and update knowledge.
- Advocacy and Policy Input: Actively engage with government and regulatory bodies to advocate for stronger policies and provide expert input on legislative development.

4.2.4. Private Sector and Waste Management Companies

- Expand Service Coverage: Increase the geographical coverage of specialized medical waste collection and treatment services, especially to smaller clinics and remote areas.
- Invest in Technology: Invest in advanced and environmentally friendly waste treatment technologies (e.g., autoclaves, microwave disinfection) to reduce reliance on incineration where alternatives are viable.
- Ensure Compliance: Adhere strictly to national and international standards for medical waste handling, transport, and disposal. Obtain all necessary licenses and certifications.
- Offer Competitive Pricing: Develop flexible and affordable service packages for dental clinics, particularly small and medium-sized ones, to encourage compliance.

5. Conclusion

This study has provided a comprehensive analytical overview of medical waste management practices in general dental clinics in Benghazi, Libya, highlighting significant challenges in legislative enforcement, infrastructure, and awareness. The proposed Integrated Dental Medical Waste Management Model (IDM-DW) and its accompanying practical strategies offer a robust framework for addressing these issues. Effective implementation of these recommendations, through concerted efforts from government, clinics, academic institutions, and the private sector, is crucial for establishing a safe, sustainable, and compliant medical waste management system. This will not only mitigate health and environmental risks but also elevate the quality of healthcare services and contribute to the overall well-being of the community in Benghazi, aligning practices with international standards for Scopus-indexed journals.

References

[1] World Health Organization. (2014). Safe management of wastes from health-care activities (2nd ed.). WHO Press.
[2] Prüss-Ustün, A., Rapiti, E., & Hutin, Y. (2003). Estimation of the global burden of disease due to unsafe health care waste management. World Health Organization.
[3] El-Tayar, A. A., & El-Toumi, S. A. (2019). Assessment of medical waste management practices in dental clinics in Tripoli, Libya. Journal of Environmental Science and Engineering, 8(1), 1-8.
[4] United Nations Environment Programme. (2008). Mercury: A priority for action. UNEP.
[5] Libyan Ministry of Health. (n.d.). Draft Executive Regulation for Integrated Medical Waste Management. (Unpublished document).
[6] Libyan Ministry of Health. (2022). Draft Law No. 1 of 2022 Concerning Healthcare Waste Management. (Unpublished document).
[7] Al-Haj, A. A., & Al-Ghamdi, A. A. (2017). Medical waste management practices in dental clinics in Jeddah, Saudi Arabia. Journal of Environmental Protection, 8(10), 1195-1205.
[8] The Consulting Company for Medical Waste Management. (n.d.). Services and Partnerships. [Website].
[9] Libyan Ministry of Local Government. (2022). Reception of 5 Incinerators for Medical Waste with International Support. [Press Release].
[10] Benghazi University. (n.d.). Training Programs and Workshops on Medical Waste Management. [Website].