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Clinical Guide Adaptation for Amalgam Waste Management in Dental Settings in Iran

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ABSTRACT

Objectives: Dental clinics are one of the major producers of mercury-containing waste due to the use of dental amalgam. The atmospheric transport and persistence of mercury and its compounds in the environment, coupled with their high potential for bioaccumulation and detrimental effects on human health and ecosystems, underscore the necessity for effective management of mercury waste. Due to the lack of comprehensive and integrated guidelines for the effective management of dental amalgam waste in Iran, the objective of this study was to adapt a guideline for the management of amalgam waste in dental settings within the country.

Materials and Methods: The method used was based on the adaptation principles presented by the Ministry of Health and Medical Education, and included searching and reviewing guidelines related to the management of amalgam waste in developed countries, extracting recommendations, revising the recommendations considering the local infra-structures and conditions, and receiving expert opinions and reaching consensus according to the RAND/UCLA Appropriateness Method.

Results: The final guideline includes 34 recommendations in 5 areas: management of the amalgam scraps, considerations for dental equipment, management of the extracted teeth containing amalgam restorations, management of the amalgam capsules, and considerations for placement and replacement of the amalgam restorations.

Conclusion: The use of this guideline in medical universities, public and private dental clinics, along with the supervisory role of the Ministry of Health and Medical Education, can be a way to minimize the environmental hazards of mercury.

Keywords: Dental Amalgam; Dental Waste; Practice Guideline

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INTRODUCTION

Dental waste, despite its small amount of production, is of great importance due to the presence of hazardous, toxic, pathogenic, and infectious agents. These wastes are divided into several categories including general waste (similar to household waste), infectious waste, chemical and pharmaceutical waste,

and toxic waste. Each category has its own specific hazards, and different management approaches are required to effectively prevent pollution and associated risks [1]. Infectious waste includes materials contaminated with blood, other body fluids, and sharp objects such as needles and blades. Chemical and toxic waste includes materials contaminated with silver and mercury from amalgam, lead foils, disinfectants, batteries, metals, and residues of dental materials and drugs. Due to their hazardous and toxic components, these materials require very high precision in collection, storage, and disposal to prevent harm to the environment and human health [2].

Amalgam, as a durable and technique-insensitive restorative material composed of a mixture of several metals including mercury, silver, tin, copper, and zinc, has been used in dentistry for more than two centuries. Mercury makes up half of the amalgam composition, turning dental offices into one of the main sources of mercury discharge into the environment. The utilization of mercury from amalgam accounts for approximately 3 to 4 percent (equivalent to 300 tons) of the global mercury consumption annually [3]. Due to its highly active nature and bio-accumulative potential, mercury poses significant health risks. These risks can have long-term adverse effects on human health and other living organisms, including neurological disorders and negative impacts on biological systems [4].

In other countries, diverse and advanced measures have been taken for the management and safe disposal of dental waste. These measures include the use of innovative technologies, legal solutions, and strong regulatory measures that help improve waste management practices and reduce environmental impacts [5]. One prominent approach in this field is the use of amalgam separators, widely utilized in many advanced countries such as the United States, Canada, and European Union member states. These devices effectively collect mercury present in dental waste and prevent its entry into water and soil systems [6]. Additionally, in countries like Sweden and Norway, strict laws have been established for controlling and monitoring the disposal of mercury-containing waste. These laws include restrictions on the use of mercury in dental products and requirements for using safe disposal techniques. In Germany, extensive recycling programs exist for dental waste, involving the collection, separation, and recycling of materials such as amalgam, lead foils, and batteries. These programs help reduce the environmental burden caused by these materials and contribute to improving environmental health [7-9]. In Australia, the government has implemented comprehensive educational programs for dentists and dental staff on the importance and proper methods of waste management [10]. These programs include workshops, seminars, and educational materials emphasizing the importance of environmental responsibility. These initiatives are examples of international efforts to address the challenges related to the disposal of dental waste and can serve as a model for other countries, including Iran, in implementing more effective waste management strategies.

Studies conducted in Iran indicate that many dental clinic staff, due to lack of awareness, do not take sufficient measures to minimize the production and separation of amalgam waste [1,11,12]. This inadequate waste management can lead to the occurrence and spread of various diseases. While a comprehensive study on the management and disposal of amalgam waste in dentistry has not been conducted in the country, this study was carried out with the aim of providing a clinical guide on amalgam waste management to be used as a source for raising awareness and promoting integrated management of amalgam waste in all dental clinics and centers nationwide. This guide will outline standard principles and procedures for the collection, storage, transportation, and safe disposal of dental waste to effectively prevent environmental pollution and health hazards resulting from these materials.

MATERIALS AND METHODS

The present study was conducted following the approval of the Ethics Committee in Biomedical Research at Tehran University of Medical Sciences (IR.TUMS.SPH.REC.1402.239) and based on the general principles of guideline adaptation according to the national model provided by the Ministry of Health and Medical Education of Iran [13, 14]. The study process was as follows:

1. Formation of the adaptation Team: A multidisciplinary adaptation team consisting of technical committee members (7 individuals) and expert panel members (13 individuals) was formed and the absence of conflicts of interest was examined. To ensure a comprehensive review of recommendations, all related specialties including dental biomaterials, dental public health and other dental specialties, environmental health engineering, biomedical engineering, medical ethics, biostatistics were involved. Also, efforts were made to invite representatives from all stakeholders and policymakers, including the Deputy Minister of Health, the Occupational and Environmental Health Center of the Ministry of Health, the Environmental Protection Organization, Medical Universities and Municipalities.

2. Defining the Scope and Domain: In this stage, after initial review of guidelines of developed countries, studies conducted in Iran, and expert opinions, the problem dimensions were identified and prioritized. All general dentists and dental specialists were identified as the target users of the guidance, and all dental service providers including universities, governmental and private centers were determined as the target centers of the current guidance.

3. Searching for guidelines: To this end, reputable websites publishing guidelines including National Institute for Health and Care Excellence (NICE), Scottish Intercollegiate Guidelines Network (SIGN), Guidelines International Network (GIN), National Health and Medical Research Council (NHMRC), The Alliance for the Implementation of Clinical Practice Guidelines (AiCPG), and New Zealand Guidelines Group (NZGG), and the national and international organizations' websites including the Ministry of Health, Minamata Convention organization, World Health Organization (WHO), Centers for Disease Control and Prevention (CDC), Occupational Safety and Health Administration (OSHA), American Dental Association (ADA), World Dental Federation (FDI), and California Dental Association (CDA), as well as general databases including PubMed, Trip Database, and Google Scholar were reviewed using search terms including dental waste, waste, dental, waste management, dental amalgam , amalgam, mercury, extracted teeth, environmental policy, policy, guideline, practical guideline, clinical practice guideline, protocol, government publication, regulation, and best management practice.

4. Assessing the guidelines: The full text of the found guidelines was assessed for transparency of recommendations, appropriate organization, currency, and absence of conflicts of interest.

5. Extraction of Recommendations: Following thematic categorization and review by the technical committee, all recommendations from reference guidelines were extracted into an Excel file and then translated into Persian.

6. Evaluation of Recommendations: Following the assessment of the country's current conditions and capabilities and making necessary modifications, the initial draft of the recommendations along with the source of each recommendation were sent via email to the expert panel for scoring (supplemental file 1). The panel were requested to evaluate the clinical advantage including benefits, risks, and costs, and the adaptability including applicability, user acceptance, and generalizability as low, medium, or high, and assign a comprehensive score from 1 (completely inappropriate) to 9 (completely appropriate) to each recommendation.

7. Decision-Making Process: The RAND/UCLA Appropriateness Method [15] was used for decision-making. In this regard, the first round of scoring was conducted, and the median scores were calculated.

Appropriate recommendations (median 7-9) with full agreement were selected as final recommendations at this stage, while inappropriate scenarios (median 1-3) with full agreement were eliminated. Scenarios with uncertainty (median 4-6) and scenarios lacking full agreement were revised and rescored after sharing the feedbacks received from the expert panel. Appropriate recommendations with full agreement (first priority) and partial agreement (second priority) were included in the final guidance.

RESULTS

After searching and reviewing the available guidelines, 11 guidelines [10, 16-25] were selected as the reference guidelines (Table 1). The complete list of recommendations along with their median scores and priorities is presented in Table 2.

Table 1. Source guidelines for the management of amalgam waste in dentistry

N	Title	Publisher	Target country	Publication year	Last revision
G1	Standard of Practice: Infection Prevention and Control Standards and Risk Management for Dentistry	Alberta Dental Association and College	Canada	2023	-*
G2	Best Management Practices for Amalgam Waste	American Dental Association	United States	2007	2022
G3	ADA Guidelines for Clinical Handling of Dental Amalgam	Australian Dental Association	Australia	2023	-
G4	The Environmentally Responsible Dental Office: A Guide to Proper Waste Management in Dental Offices	Northeast Natural Resource Center of the National Wildlife Federation	United States	1999	-
G5	Dental Amalgam: Public Health and The Environment	California Dental Association	United States	2016	2021
G6	Dental mercury hygiene recommendations	American Dental Association	United States	2003	2022
G7	Amalgam (Part 1): Safe Management of Waste and Mercury	World Dental Federation	International guide	2022	-
G8	Amalgam (Part 2): Safe Use and Phase Down of Dental Amalgam	World Dental Federation	International guide	2022	-
G9	Dental Amalgam Clinical Use and Disposal	New South Wales Ministry of Health	Australia	2020	-
G10	Extracted Teeth	Centers for Disease Control and Prevention	International guide	2023	-
G11	Managing Dental Mercury	New York State Department of Environmental Conservation	United States	2023	-

* There weren't any further updates available.

Table 2. Final recommendations along with median score and priority based on the RAND/UCLA Appropriateness Method

Domain	Subdomain	N	Recommendation	Median (1-9)	Priority[1]
Management of the amalgam scraps	Collection of amalgam scraps	1	Before rinsing and sterilizing amalgam-contaminated instruments, amalgam scraps should be collected from the surfaces of the instruments	9	1
		2	Excess amalgam remaining in the amalgam well should not be collected with a suction vacuum system	9	1
		3	Instruments contaminated with amalgam should not be rinsed over the sink. These instruments should be placed in the ultrasonic cleaner after collecting the amalgam scraps	7	1
		4	Amalgam-contaminated gauzes should be collected along with other amalgam waste	7	2
Considerations for the dental equipment	Cleaning solutions	5	Ultrasonic cleaning solution must be disposed through the water unit and by passing through an amalgam separator. Enzymatic ultrasonic solutions that are safe to use with amalgam or disinfectants without phenol, aldehyde, and chlorine (based on sodium bicarbonate) can be used	7	1
		6	Water line cleaners that minimize the dissolution of amalgam should be used. Bleaches and other chlorine-containing detergents should not be used. For this purpose, quaternary ammonium compounds can be used. It is essential to follow the manufacturer's recommendations regarding the type of disinfectant material for the unit	7	1
	Storage and transportation of amalgam waste	7	Due to the toxicity of mercury vapors, amalgam waste should not be heat-sterilized in the dental office	8	1
		8	Amalgam waste should not be placed with regular waste (in black bags), sharp waste (in safety boxes), infectious waste (in yellow bags), or any other waste intended for incineration	8	1
		9	The container for storing amalgam waste must have a wide opening and be air-tight	8	1
		10	The container for storing amalgam waste must have a clear label indicating "Amalgam Waste" along with the date the amalgam waste collection began	8	1
		11	The container for storing amalgam waste should not be filled with X-ray fixer solutions, water, or other liquids. If such liquids are already present, they should not be poured down the drain, but rather disposed of through the unit water-line (provided there is an amalgam separator) or handed over for safe disposal (to a licensed mercury recycler or hazardous waste disposal company)	8	1
		12	During the transportation of amalgam waste, the waste type, the delivering facility, the responsible receiving person, the date, and the destination must be recorded. The records of amalgam waste must also be kept at the dental facility	8	2

Cont'd Table 2

Considerations for the dental equipment	Trap	13	To collect amalgam waste entering the unit, all units must be equipped with traps	8	1
		14	The use of single-use traps is preferred, as there is a risk of amalgam spreading during cleaning of reusable traps	7	2
		15	Single-use traps should be placed in the amalgam waste container along with their contents. Reusable traps should be closed on the unit without rinsing under running water after emptying their contents into the amalgam waste container	8	1
		16	The trap should be replaced (single-use types) or cleaned (reusable types) periodically and based on the center's activity level. Before this process, the unit's water lines should be cleaned with an appropriate disinfectant solution (chlorine-free)	8	1
	Vacuum pump filter	17	To collect amalgam waste entering the unit, all units must be equipped with vacuum pump filters	7	2
		18	The vacuum pump filter should be replaced periodically based on the manufacturer's recommendations	7	2
		19	The vacuum pump filter should not be rinsed over the running water. After opening the filter, it should be placed on a tray or container to allow excess water to drain. The drained water, free of amalgam residues, can be discharged into the sewage. The filter should be sent back to the manufacturer in its original packaging	7	2
	Amalgam separator	20	All dental units must be equipped with an amalgam separator compliant with the national standard 11634 (aligned with ISO 11143) and approved by the National Medical Device Directorate (IMED) and monitored periodically as per the manufacturer's recommendations	7	1
Management of the extracted teeth with amalgam restoration	Storage and transportation	21	Extracted teeth containing amalgam restorations should not be placed with regular waste (in black bags), sharp waste (in safety boxes), infectious waste (in yellow bags), or any other waste intended for incineration	7	1
		22	Extracted teeth containing amalgam restorations should be sent for disposal in an amalgam waste container (by a company authorized for hazardous waste disposal or mercury recycling with a government permit)	8	1
	Disinfection	23	Extracted teeth containing amalgam restorations should not be sterilized by heat, as there is a risk of mercury vaporization and exposure to it. To disinfect the internal and external structures of these teeth, they can be immersed in a 10% formaldehyde solution for two weeks	9	1

Cont'd Table 2

Management of the amalgam capsules	Storage and transportation	24	To reduce the release of mercury vapor, empty amalgam capsules should be recapped	7	1
		25	Empty amalgam capsules and those that cannot be emptied should be collected separately in a container with a wide opening, air-tight, labeled "Amalgam Capsules," and sent for recycling or disposal (by a company authorized for hazardous waste disposal or mercury recycling with a government permit)	7	1
		26	Amalgam capsules should not be placed with regular waste (in black bags), sharp waste (in safety boxes), infectious waste (in yellow bags), or any other waste intended for incineration, or plastic recycling	8	1
Considerations for amalgam restorations placement and removal		27	Pre-encapsulated amalgam should be used, and bulk elemental mercury (powder and liquid amalgam) should not be used	9	1
		28	When using an amalgamator, the protective arm covering the amalgam capsule compartment should be completely closed to prevent possible capsule ejection and mercury spills	9	1
		29	To reduce the production of mercury waste, capsulated amalgams of different volumes (1 unit, 2 units, etc.) should be available and selected based on the size of the restoration	9	1
		30	When finishing, polishing, or removing amalgam restorations, the use of high-volume suction along with adequate water supply is recommended to reduce exposure to mercury vapor.	7	1
		31	Removal of previous amalgam restoration should be done as a single piece, if possible, so that the amalgam is trapped in the unit's trap. The restoration should be drilled around the edges, and the separated amalgam piece should be removed	8	1
		32	Direct skin contact with mercury or freshly mixed amalgam should be avoided.	9	1
		33	For treatment of pregnant patients (especially in the first trimester), breastfeeding mothers, patients with severe kidney disease, and children under 15 years of age, it is recommended to use cost-effective and mercury-free alternative restorative materials	8	1
		34	Existing amalgam restorations in the patient's mouth are not harmful and should not be removed or replaced with alternative restorative materials, unless deemed absolutely necessary by the dentist. There is no evidence to justify the removal of dental amalgam restorations for the purpose of alleviating and treating systemic conditions, except in a patient with proven sensitivity to amalgam	9	1

[1] Priority 1 means the appropriateness of the recommendation and complete agreement, while Priority 2 means the appropriateness of the recommendation and relative agreement among expert panel members.

DISCUSSION

In the present study, a thorough search and comprehensive review of available guidelines on amalgam waste management in various countries were conducted to extract practical recommendations. These recommendations were revised after examining national infrastructures and local conditions, as well as considering expert opinions in the field. Ultimately, 34 specific recommendations were adapted across five key domains: amalgam scraps management, considerations related to dental equipment, management of extracted teeth with amalgam restorations, management of amalgam capsules, and considerations for amalgam restorations placement and replacement, resulting in a comprehensive guideline for dental settings.

This guideline aims to promote environmental and health safety in dental centers by providing effective recommendations on how to collect, store, transport, and safely dispose of amalgam waste. The recommendations are based on the latest international standards and consider environmental factors to prevent pollution from mercury in amalgam, which can contaminate soil and water, threatening human and ecological health. Additionally, the guideline emphasizes the importance of dental equipment that comes into direct contact with amalgam, such as amalgam separators and wastewater line systems. This equipment must be designed and maintained to prevent mercury entry into the environment and should be updated according to the latest technologies. The management of extracted teeth with amalgam restorations is also highlighted, stressing the need to separate these teeth from other medical waste. Furthermore, the management of amalgam capsules and considerations related to the placement and replacement of amalgam restorations require strict adherence to health and safety guidelines.

In this study, a multidisciplinary team composed of various experts including dentists in public and private settings, environmental specialists, materials engineers, biostatisticians, as well as consultants and stakeholders from the Treatment Deputy of the Ministry of Health involved in supervisory and executive aspects, was utilized. The goal of this multidisciplinary team was to create a broad and comprehensive perspective on the challenges and possible solutions in managing dental waste, especially amalgam. This research team conducted a detailed examination and in-depth analysis of the current waste management conditions in Iran and compared it to international standards. Studies from leading countries in this field which have successful policies in reducing and recycling mercury, were analyzed. These assessments, along with consultative discussion sessions with experts and various stakeholders, led to the development of recommendations that could significantly improve the management of dental waste and reduce environmental pollutants. This study has endeavored to provide a scientific and operational framework for the management of dental waste in Iran by combining up-to-date scientific evidence, utilizing reputable international methods, and drawing on successful global experiences. This framework can serve as a model for other countries with similar conditions.

In the present study, a special focus has been placed on the importance of transparency and reproducibility of used methods, especially in qualitative studies. For this purpose, the national adaptation model developed by the Ministry of Health and Medical Education of the country has been used, which itself is based on a thorough review of valid international methods such as the ADAPTE toolkit [13,14,26]. These methodologies, which are primarily used to prepare clinical practice guidelines, have been applied in this study to develop waste management guidelines in environmental fields. These methods, with an emphasis on clarifying problems, developing search strategies and identifying potential solutions, evaluating and critical appraisal of these solutions, and ultimately making decisions based on sound scientific data, greatly contribute to improving the quality and accuracy of the intended guidelines. The lack of using tools like AGREE II for screening the guidelines in this study

was due to the different patterns between environmental health guidelines and clinical medicine guidelines. Still, all included guidelines were assessed in regards to their rigor of development, currency and clarity.

To ensure a through consensus among the expert panel members, the RAND/UCLA Appropriateness Method has been utilized. This method, relying on a structured and reproducible framework, is recognized as one of the best methods for consensus-building compared to other techniques such as informal consensus or classical Delphi methods. The use of this method not only contributes to increasing transparency and reproducibility in decision-making processes but also facilitates the consensus-building process among people of different expertise [15].

The current guideline specifically emphasizes the management of amalgam waste. This emphasis aligns with the goals of the Minamata Convention, which aims for the gradual reduction of amalgam use and the adoption of appropriate policies for managing mercury-containing waste until the complete elimination of these materials from dental processes [27]. Considering the situation in developing countries like Iran, facing challenges such as limited access to high-quality alternative restorative materials, high costs, and greater technical sensitivity of the alternative materials such as resin composites, along with the high risk of dental caries in the population, rapid elimination of amalgam does not seem feasible. In this regard, gradual reduction plans for amalgam use are essential and should be carefully planned and implemented based on the specific conditions of each country.

A study conducted by Aggarwal et al in 2019 in England shows that even in developed countries, reducing the use of amalgam can be accompanied by challenges such as increasing the out-of-pocket costs and exacerbating the health inequalities. This study emphasizes that changes in dental restorative materials should be made with consideration of their economic and social impacts on the population to prevent unintended consequences [28].

International guidelines provided by leading countries in the field of dental waste management primarily emphasize on strategies for amalgam recycling. This emphasis is due to the high potential of amalgam for effective recovery of mercury and other heavy metals, which can significantly contribute to reducing environmental pollution. In this regard, countries such as Sweden, Germany, and Canada have transformed the processes of amalgam recycling into a key component of their waste management by establishing appropriate infrastructure and developing precise laws and regulations. These processes involve collection, separation, and recovery of valuable metals present in amalgam, which not only brings environmental benefits but also economic advantages (10, 16-21). However, in Iran, the necessary infrastructure for widespread amalgam recycling is not available, and only a limited number of private companies and knowledge enterprises engage in this activity. These companies, utilizing available technologies to the best of their abilities, attempt to recycle amalgam, but due to insufficient government support and the absence of strict and precise regulations, recycling activities in this area are limited and inadequate. As a result, most used amalgams end up being disposed of through traditional methods such as sanitary landfilling or incineration, which can pose serious environmental risks. Therefore, the current guideline recommends focusing on the safe disposal of amalgam waste until the necessary infrastructure for broader and more effective recycling is established. This safe disposal includes using advanced disposal techniques such as specialized containers to prevent mercury leakage into the environment and advanced equipment for treating pollutants resulting from amalgam disposal.

Developing guidelines is only the first step in the process of improving dental waste management. To ensure the effective implementation of these recommendations,

there is a need for a continuous monitoring and evaluation system that regularly assesses progress and identifies implementation barriers. This process involves collecting data and feedback from dental clinics, evaluating user satisfaction with the new guidelines, and assessing the long-term environmental impacts of guideline implementation. Additionally, periodic reviews of the recommendations and their enhancement based on the obtained results, emerging technologies, and changes in laws and regulations will be crucial [29].

The use of the adapted waste management guideline in medical universities and public and private dental settings, alongside the supervisory role of the Treatment and Health Deputy Departments, can significantly contribute to reducing environmental risks associated with mercury and promoting sustainable approaches in dental waste management. This process not only aids in improving environmental conditions but also impacts public health and enhances awareness and responsibility within the dental community and the general public. These guidelines, as part of a comprehensive planning, assist specialists and dentists in employing safer and more effective methods for reducing risks related to the use and disposal of amalgam. It is essential that alongside the development and implementation of appropriate strategies for managing amalgam waste, broader research is conducted to more accurately assess the level of amalgam consumption nationwide. These studies should involve data collection on amalgam use in various dental facilities and statistical analysis to provide a precise evaluation of the current status and trends in amalgam consumption over time.

Additionally, gradual reduction plans for amalgam use should be formulated based on solid scientific evidence and considering available alternatives and dental facility capabilities. This planning should aim to minimize environmental impact while maintaining treatment quality. further studies are needed to evaluate the long-term effects of changes in dental restorative materials and optimize alternative technologies to achieve a more sustainable and safer dentistry for all. On the other hand, special attention should be given to the development and advancement of amalgam recycling technologies. Technological advancements in this area can optimize recycling processes and significantly reduce the negative environmental impacts of amalgam use. Continuous educational programs for dentists and healthcare facility staff on proper collection, disposal, and recycling of amalgam are vital, as this knowledge enables them to actively increase their environmental responsibility. These processes require close collaboration and coordination among research institutions, universities, dental centers, and regulatory organizations to ensure that all aspects of dental waste management are properly addressed and improved.

CONCLUSION

Comprehensive waste management strategies to reduce the potential harmful impacts of dental waste, especially in terms of mercury pollution, are vital. Efforts to improve waste separation processes, safe disposal, and recycling are necessary to protect public health and the environment. Furthermore, educational and training programs for dental clinic staff are crucial to ensure that dental waste is properly managed, emphasizing the importance of environmental responsibility in the healthcare sector. Implementing these measures will help reduce environmental pollution and promote a sustainable approach to dental healthcare activities, aligning with environmental health policies and initiatives that focus on preserving ecosystems and community health against the detrimental effects of hazardous waste.

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CONFLICT OF INTEREST STATEMENT

None declared.

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