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PRACTICES OF DENTAL AMALGAM DISPOSAL: A SCOPING REVIEW

PRÁTICAS DE DESCARTE DE AMÁLGAMAS DENTÁRIOS: UMA REVISÃO DE ESCOPO

PRÁCTICAS DE ELIMINACIÓN DE AMALGAMA DENTAL: UNA REVISIÓN DE ALCANCE

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ABSTRACT
Dental amalgam is frequently used as a restorative material due to its low cost and ease of application, particularly in areas with limited access to dental supplies and main indication on high caries risk patients. However, its use also raises concerns regarding potential effects on occupational health and the environment. The PRISMA 2020 method and the PubMed database were used, resulting in a final sample of 10 articles suitable for analysis. The knowledge gaps on the subject were organized into three axes: waste disposal and occupational exposure, dental waste management and regional challenges, and the future of sustainable dentistry. Among the factors influencing the choice of material are its durability, low cost, and professional experience. A relevant point identified was the lack of knowledge among professionals regarding the toxicity of amalgam, especially concerning proper disposal and exposure, which are often not carried out adequately.

KEYWORDS: Dental amalgam. Waste management. Dental Clinics. Medical waste.

RESUMO
O amálgama de prata dentário é frequentemente usado como material restaurador por ser de baixo custo e de fácil aplicação, principalmente em áreas com acesso limitado a insumos odontológicos e sua indicação em pacientes de alto risco de cárie. Contudo, seu uso também gera preocupações sobre os possíveis efeitos na saúde ocupacional e no meio ambiente. Este estudo analisou as práticas de descarte da amálgama dentária nos últimos 10 anos (2014-2024). Para isso, utilizou-se o método PRISMA 2020 e a base de dados PubMed, resultando em uma amostra final de 10 artigos adequados para análise. As lacunas de conhecimento sobre o tema foram organizadas em três eixos: descarte de resíduos e exposição ocupacional, gestão de resíduos odontológicos e desafios regionais, e o futuro da odontologia sustentável. Entre os fatores que influenciam a escolha do material, destacam-se sua durabilidade, o baixo custo e a experiência do profissional. Um ponto relevante identificado foi a falta de conhecimento dos profissionais quanto à toxicidade da amálgama, sobretudo em relação ao descarte e à exposição corretos, que muitas vezes não são realizados de forma adequada.

PALAVRAS-CHAVE: Amálgama dentária. Gerenciamento de resíduos. Clínicas odontológicas. Resíduos médicos.

RESUMEN
La amalgama dental se utiliza con frecuencia como material restaurador por su bajo costo y fácil aplicación, especialmente en áreas con acceso limitado a insumos odontológicos y la principal indicación en pacientes con alto riesgo de caries. No obstante, su uso también genera preocupaciones sobre los posibles efectos en la salud ocupacional y en el medio ambiente. Este estudio analizó las prácticas de eliminación de la amalgama dental en los últimos 10 años (2014-

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2024). Para ello, se utilizó el método PRISMA 2020 y la base de datos PubMed, lo que resultó en una muestra final de 10 artículos adecuados para el análisis. Las lagunas de conocimiento sobre el tema se organizaron en tres ejes: eliminación de residuos y exposición ocupacional, gestión de residuos odontológicos y desafíos regionales, y el futuro de la odontología sostenible. Entre los factores que influyen en la elección del material se destacan su durabilidad, el bajo costo y la experiencia del profesional. Un punto relevante identificado fue la falta de conocimiento de los profesionales respecto a la toxicidad de la amalgama, especialmente en lo que se refiere a la eliminación y a la exposición correctas, que muchas veces no se realizan de manera adecuada.

PALABRAS CLAVE: Amalgama dental. Gestión de residuos. Clínicas odontológicas. Residuos médicos.

INTRODUCTION

Inadequate management of Health Services Waste (HSW) can expose health professionals, waste handlers, patients and the general public to risks of diseases, adverse effects and injuries, as well as damage to the environment (Chakraborty; Saha, 2023). The difficulties in implementing appropriate disposal systems such as lack of access to suitable technologies, insufficient financial resources and the absence of professional training in waste management are warning to society (Patil; Shekdar, 2001). In developing countries, it is common for few healthcare professionals to be familiar with the procedures required for an effective waste management program, by the other way the responsibility for waste management is often assigned to poorly qualified professionals, who carry out most activities without proper guidance and with inadequate protection (Diaz *et al.,* 2005).

Health activities generate approximately 85% of ordinary waste, non-hazardous and similar to waste generated at houses. However, the other 15% of waste is considered hazardous and may be infectious, chemical, or radioactive (WHO, 2018). This data demonstrates the need for efficient disposal management of HSW, especially for hazardous waste, to reduce their impacts on the environment. According to the US Medical Waste Monitoring System, the amount of clinical waste generated by dental procedures is limited, but dental services generate only 3% of total medical waste (Tan; Noble, 1993).

Although the amount of waste generated by dental clinics is relatively low in the general context of health services, dental practices demand special attention due to the production of waste considered hazardous. Proper management of the waste generated by dental practices is crucial to ensure the safety of both dental professionals and patients, as well as contributing to the preservation of the environment (Sood, A. G.; Sood, A., 2011). Concerns have been raised about the poor management of dental amalgam waste, with concerns about the potential risks to human health and the environment from emissions of this waste (Mackey *et al.,* 2014).

Dental amalgam is recognized as an effective restorative material and continues to be widely used today due to its benefits, which include long durability and low cost.

These characteristics make it a suitable option for restorative procedures, particularly in communities with a high prevalence of caries, unfavorable socioeconomic conditions, and limited access to dental services (Santos *et al.,* 2017). This restorative material is a metallic alloy composed predominantly of silver (Ag), tin (Sn), mercury (Hg), and other metals, with mercury accounting for approximately 43% to 54% of its composition (Jesus; Marinha; Moreira, 2010). Dental amalgam presents the advantage of corrosion products releasing metallic ions that seal restoration margins and reduce microleakage, thereby preventing secondary caries. Owing to these properties and its low technique sensitivity, amalgam is especially indicated for extensive cavity preparations in high caries risk patients and in situations where adequate isolation with rubber dam is difficult (Anusavice 2013).

Although dental amalgam has been used for almost two centuries, its safety has never been tested and proven by any regulatory agency in the United States the debate on the safety of its use has been ongoing since 1845, with many studies concluding that its use could exposes patients to problematic toxicities (Jirau-Colón *et al.*, 2019). The studies have shown safety; the problem is the unused residues that the dentist can collect, and when removed, they are disposed directly into the environment. Dental amalgam fillings contain around 50% of mercury, which has generated controversy over the possibility that this material can cause various diseases. However, research shows that there is little evidence that mercury alloys have a significant impact on the overall incidence of human chronic diseases or mortality (Bates, 2006).

Most dental solid waste is disposed of at domestic disposal sites and landfills, without any recycling or separation procedures (Ozbek; Sanin, 2004). Thus, the aim of this study was to analyze dental amalgam disposal practices over the last 10 years (2014-2024) and apply the methodology of a systematic review to generate data and information for analyzing the results.

2. METHODOLOGY

The PRISMA 2020 method was selected to search for and analyze the studies that addressed the combination of dental amalgam and waste. For the collection of documents, the PubMed database was used. As the article is related to the field of Dentistry and environmental health, PubMed was chosen as the database because it is one of the most respected platforms globally in the health area, compiling publications indexed in high-quality scientific journals, which ensures greater reliability and accuracy of the information obtained, and it also provides Boolean operators that allow for a more precise and reproducible search of the articles.

First, the inclusion and exclusion criteria were defined. The main search strategy was constructed using the keywords “dental amalgam” and “waste,” combined with Boolean operators to ensure greater precision. The AND operator was used to retrieve articles containing both terms simultaneously “dental amalgam” AND “waste”), while the OR operator was applied to include

relevant synonyms or variations of each term, thereby expanding the scope of the search ("dental amalgam" OR "amalgam") AND ("waste" OR "residues"). Only full-text articles available online, in English language, and relevant to the study were considered. Exclusion criteria included books, conference reports, and grey literature.

In the second stage, the literature review was conducted following the PRISMA 2020 guidelines (Page *et al.,* 2021), excluding for titles and further abstracts of publications to identify studies addressing targeting studies with dental amalgam and its residues.

The articles were organized into a group: publications from the last 10 years (2014-2024). The search was carried out in August 2024. The initial sample contained 21 documents. After removing duplicates and documents that did not meet the inclusion criteria, a sample of 10 articles was identified. The abstracts were read by two of the authors and discussed with other researchers to select the relevant articles to answer the research question (Table 1).

Table 1. Inclusion criteria of papers

Criteria
Identify the recommended actions for the disposal of dental amalgam.
Identify current policies for the disposal of dental amalgam.
Evaluate the impacts of improper disposal of dental amalgam.
Identify gaps and opportunities related to the management of dental amalgam waste.

Source: Prepared by the authors

During the screening process, all articles were reviewed by the authors and initially selected by the two primary reviewers (GSF and GDS). In cases of disagreement regarding the inclusion of any article, the reviewers discussed their interpretations until a consensus. When it was not possible to reach an agreement, a third reviewer (JAR). After the previous stage, 10 articles (listed in Table 2) were selected to make up the final sample. The process of screening and selecting the literature is illustrated in Figure 1, and they were divided into 3 themes whose main objective fits best: use and impacts of dental amalgam, Dental Waste Management and Regional Challenges, and Initiatives and the Future of Sustainable Dentistry.

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Figure 1. PRISMA Literature Method

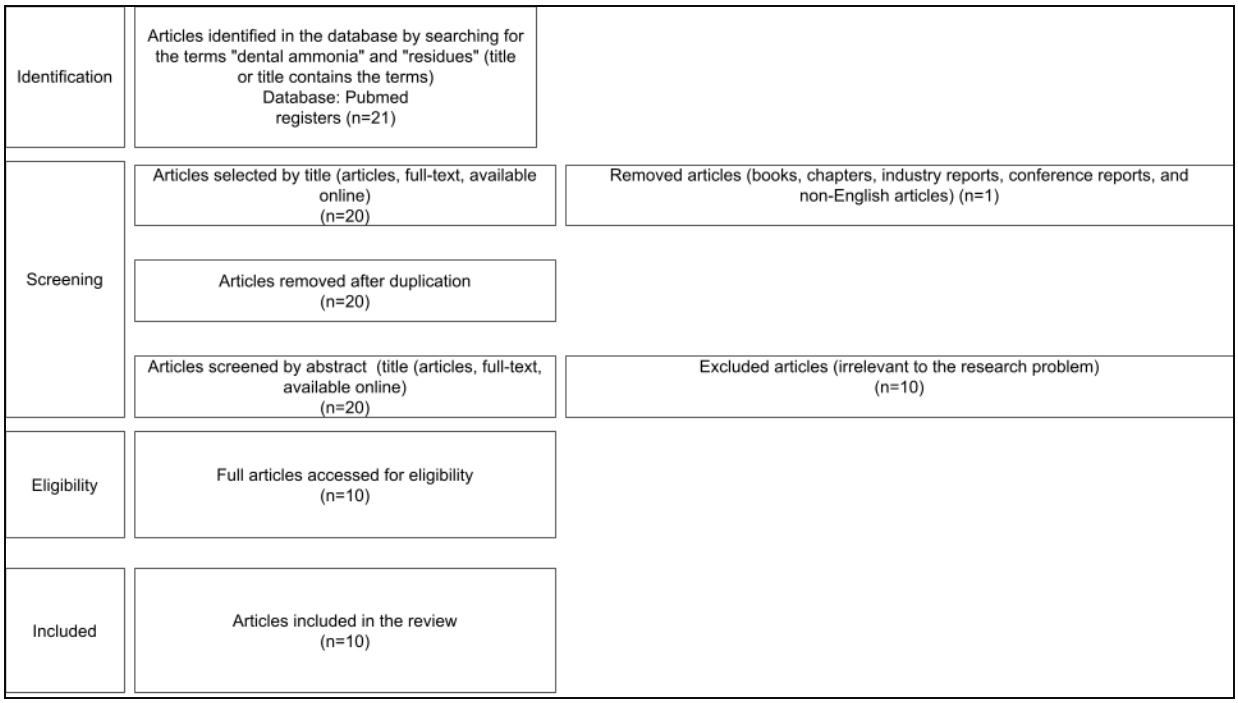

Table 2. Inclusion criteria for articles

	Author	Synthesis of Results	Aims	Region
1	Jamil et at., (2016)	The study found that mercury concentrations in dental personnel were significantly higher than in controls, particularly among older and more experienced dentists. Additionally, all dental wastewater samples exceeded permissible mercury limits. To protect the health of dental professionals, the study recommends immediate preventive measures, including using alternative filling materials to reduce mercury vapor exposure. It also suggests implementing specific legislation to address mercury in wastewater in Pakistan.	To assess the mercury accumulation in the blood stream of the dental personnel and its discharge into environment from the private dental practitioner's clinics from Lahore, Pakistan,	Pakistan
2	Ramesha et al., (2019)	This study showed that mercury was widely preferred and utilized even today as a restorative material by dentists and dental specialists, despite the availability of other	The objective of this study was to assess and record the mercury management and disposal strategies of dental practitioners belonging to the two South Indian	India

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		alternative strategies. Only a minor section of practitioners were found to be aware of the global changes in the guidelines pertaining to the handling and disposal of amalgam. We feel that Safe Mercury Amalgam Removal Technique, amalgam safety rules, and amalgam-free practice should be a part of the academic curriculum and continuing dental education.	states, Kerala and Tamil Nadu.	
3	Momeni et al., (2018)	This study showed a remarkable share of recyclable materials in the composition of dental waste and lack of special approach to manage waste in dental clinics. It is necessary to plan for minimizing generation of, separating, and recycling waste at source.	To assess dental waste production rate and composition and approaches used to manage these waste products in 2017 in Birjand, Iran.	Iran
4	Danaei et al., (2014)	Government agencies should establish monitoring programs for all dental offices and clinics to identify noncompliant activity and enforce recommended regulations.	To determine the current status of dental waste management in private and public dental clinics and private dental offices in Shiraz, southern Iran.	Iran
5	Makanjuola et al., (2021)	A minor proportion of public dental personnel had good knowledge and practice of proper mercury hygiene and BMW management. This shows there is an urgent need for training of health personnel on proper BMW handling and disposal in developing countries like Nigeria.	This study investigated the level of knowledge of BMW, observance of proper mercury hygiene and BMW management practice among public dental personnel in Lagos State, Nigeria.	Nigeria
6	Singh et al., (2014)	It was concluded that not all dentists were aware of the risks they were exposed to and only half of them observe infection control practices.	The objective of the study was to assess the awareness and performance towards dental waste including mercury management policy and practices among the dental practitioners in North India.	India
7	Khan et al., (2022)	Although there is a gap in knowledge among the dentists regarding amalgam disposal, dentists in Pakistan are reducing their use of dental amalgam in accordance with the guidelines of the Minamata Convention.	To identify and assess the use of amalgam and its waste management by dentists in Pakistan post-Minamata Convention guidelines	Pakistan
8	Vasthare et al., (2022)	Despite satisfaction with DA for its minimal failure, longevity and affordability, the authors found that most practitioners did not prefer its continued usage. This highlights	To explore the continued use of dental amalgam from a South Indian dental practitioners' perspective.	India

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		their concerns over mercury toxicity and soft tissue lesions and accentuates their community social responsibility. There is also an urgent need to educate dentists on mercury hygiene, mercury waste management and disposal.		
9	Cataldi et al., (2021)	The results revealed that dental unit wastewater is a problem underestimated by the scientific community, with the exception of dental amalgam wastes.In Italy there is a sentence of "Corte di Cassazione Penale, sez III, sentenza 17 gennaio 2013, n 2340" that regularized dental wastewaters as industrial ones, so they are inadequate to be disposed as domestic waters; but, at the same time, there isn't a specific law that regulates this king of waste.	To systematically study the incoming dental unit water and the waste one, focusing the attention on the problem of the wastewater contamination and its regulations	Itália
10	Zia et al., (2024)	Dental practitioners have good knowledge about green dentistry and positive attitudes towards environment conservation, but implementation in their practice is not adequate. Most common themes of knowledge, attitude and practice assessment in green dentistry are amalgam management, radiographic management, infection control, waste management, water, and electricity management.	Green dentistry is an emerging concept necessary to address the worsening climatic changes. It is essential to compile the existing literature on knowledge, attitude, and practice on green dentistry that can be accomplished by conducting a literature review. The objective of this literature review was to summarize and present the existing knowledge that dentists have regarding green dental practices, their attitude about this shift towards sustainability, and steps that they have taken in their personal practice to adhere towards an eco-friendlier dental approach.	

3. RESULTS AND DISCUSSIONS

The results were divided into three themes: Dental Amalgam Waste Disposal and Occupational Exposure, Dental Waste Management and Regional Challenges and the Future of Sustainable Dentistry.

A total of three articles were included in the theme: dental amalgam disposal, the theme Dental Waste Management and Regional Challenges had a total of five articles and finally the theme Initiatives and the Future of Sustainable Dentistry had only two articles.

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3.1. Dental Amalgam Waste Disposal and Occupational Exposure

The use of dental amalgam is widespread due to its properties such as resistance and durability, so some dental professionals still use this material, but dental amalgam is an extremely dangerous material.

Dental amalgam is a highly hazardous material, not only in relation to its final disposal, but also during clinical use, such use can affect both dental professionals and patients. Incorrect clinical handling must be understood and managed properly to minimize the negative health impacts on an individual with frequent contact with dental amalgam, Jamil in his study showed that the mercury levels found in dental professionals are higher than those observed in control groups, with the highest average concentrations in older and more experienced dentists. In addition, all dental wastewater samples showed mercury concentrations that exceeded regulatory limits (Jamil *et al.,* 2019).

In Pakistan, a study was conducted on the use of amalgam and its waste management by dentists, in accordance with the Minamata Convention guidelines. Of the 520 participants, 41.9% used amalgam, citing its durability as the primary reason. However, 54.6% considered the material unsafe, and 45.4% did not adopt specific preventive measures. Furthermore, 23.5% of the participants were aware of the recent guidelines, with 31.3% mentioning the Minamata Convention and 68.9% referring to other guidelines (Khan *et al.,* 2022).

The study of Khan *et al.,* (2022), showed that there is a gap in the knowledge of dental professionals on this subject, mostly the absence of education and awareness, which can lead to wrong decisions made, including the lack of correct handling, the lack of use of ventilation and the absence of personal protection which can increase exposure to mercury, further contributing to dental professionals contamination risks.

Most dental professionals have limited knowledge about the toxicity of mercury and do not see major risks for pregnant women and children, although more than 90% express concerns about its environmental toxicity (Vasthare *et al.*, 2022). The study conducted by Makanjuola *et al.,* (2021) showed that oral health professionals in Lagos, Nigeria, have limited knowledge about the risks of mercury and biomedical waste management, as well as little understanding of mercury hygiene practices and the safe disposal of waste. The results indicate an urgent need for further research and the development of effective programs to improve waste management in Nigeria and other developing countries.

Dental professionals' understanding of waste disposal and occupational exposure of dental amalgam, especially the toxicity of mercury, is essential, especially given its impact on public and environmental health. The lack of understanding of the risks associated with the generation and management of mercury waste is alarming and existing legislation may not be fully understood or

even enforced which highlights the need to improve the education and ongoing training of dental professionals.

Studies have indicated that the choice of dental amalgam is mainly influenced by its properties and the experience of professionals in dental clinics, who are the most affected by prolonged exposure to the material. Training programs focusing on the toxicity of mercury, its impact on the health of dental professionals and the importance of proper waste management are essential.

The analyzed articles highlight a knowledge gap on the subject, particularly regarding protocols for the disposal of dental amalgam. This lack of clarity ranges from the understanding of national legislation in each country to the application of the Minamata Convention, an international guideline. Furthermore, the limited awareness of professionals about the material's toxicity reinforces the need for greater investment in training, the development of validated disposal protocols, and the conduction of long-term studies on its environmental impacts.

3.2. Dental waste management and regional challenges

The binding international treaty, the Minamata Convention on Mercury, was signed in the Japanese city of Minamata, the site of the worst environmental and public health disasters related to mercury. The agreement aimed to minimize the adverse consequences of mercury on human health and the environment, addressing issues such as mineral extraction, importation, exportation, storage, and waste management of mercury-containing products. One of the most debated topics was the use of amalgam in dental fillings, a subject that has sparked global controversy for decades (Mackey *et al.,* 2014).

Currently, the use of dental amalgam has a limited lifespan due to environmental pollution, as stipulated by the Minamata Treaty. The guidelines propose a progressive and organized reduction in the use of dental amalgam, with the goal of total elimination by the year 2030. The Minamata Convention on Mercury, held in 2013, recommended the global reduction in the use of dental amalgam, considering the potential effect of anthropogenic mercury release into the environment caused by its use (Mulligan *et al.,* 2018).

Despite the recognition of these environmental risks, dental amalgam is still widely used by professionals due to factors such as cost, ease of handling, and long-term outcomes. A large portion of professionals, however, are unaware of the risks associated with improper disposal of mercury, including exposure to vapor and environmental contamination. Improper disposal practices persist, with particles of amalgam often discarded in sewage systems or trash bins (Momeni *et al.,* 2017). Furthermore, a study by Ramesh *et al.,* (2019) found that many professionals do not segregate waste or employ scientific methods for disposing of mercury, which exacerbates health and environmental hazards.

Although there are protocols for the disposal of dental amalgam, they are not always followed correctly, often due to insufficient knowledge, lack of appropriate materials, and inadequate policies (Danaei *et al.,* 2014) Singh *et al.,* (2014) observed that while many dentists are aware of the need for waste segregation, only half adopt adequate infection control measures, and many are unaware of how to manage waste properly. This highlights the need for educational programs to improve both practice and waste management.

The improper disposal of dental amalgam and the continued preference for its use despite the availability of mercury-free alternatives underscores the need for a reassessment of current practices. Efforts must be made to increase awareness and knowledge among dental professionals while implementing stricter policies and proper disposal methods. Danaei *et al.,* (2014) recommended that governments establish stricter regulations and increase monitoring in dental offices to address this issue.

The articles show that the absence of a regulatory body, or even regional regulations, may explain the lack of adherence to or the absence of safe protocols for dental amalgam disposal. Even with established international guidelines, improper disposal still occurs in sewage systems and regular trash. The low level of professional knowledge reinforces the need for training, while the scarcity of studies investigating alternatives to amalgam hinders the transition to safer practices.

3.3. Regional Challenges and the Future of Sustainable Dentistry

Dental practices, especially those involving potentially hazardous materials such as dental amalgam, can have significant impacts on both the environment and the health of professionals, patients, and students who handle these substances. The development of substitutes, such as composite resins, is crucial in reducing these impacts. Moreover, adopting green practices and proper management of dental waste is key to promoting sustainable dentistry (Zia *et al.,* 2024).

While dental professionals often express a positive attitude towards ecological practices, their actions frequently fail to align with their beliefs. The main barrier to adopting sustainable practices is the lack of prioritization of sustainability within the profession, especially in developing countries where economic constraints and insufficient knowledge prevail. In recent years, the scientific community has raised concerns about microbial contamination of water in dental treatment rooms and potential solutions to this problem. Although environmental contamination by dental amalgam is an important issue, it is essential to consider the broader context, as other materials and pharmaceutical products also contribute to wastewater contamination (Cataldi *et al.,* 2017)

The search for sustainable dentistry linked to more eco-friendly practices, along with the adoption of an environmental policy, can help address the challenges associated with dental

amalgam, promoting practices that minimize both environmental and human contamination. When considering the future of sustainable dentistry, it is evident that there is an awareness of the need to replace materials with less toxic alternatives, aiming for practices that are healthier for both professionals and the environment. However, many gaps remain, particularly regarding studies on new dental materials and pharmaceuticals, their relationship with water contamination, and, above all, their implementation in developing countries.

4. CONCLUSIONS

Although dental amalgam poses risks to the health of dental professionals and damages the environment, it is still widely used in developing countries. Factors such as the durability of the material, its low cost and the length of experience of the professional influence this choice. An important point identified is the gap in professionals' knowledge about the toxicity of the material, especially in relation to correct disposal and exposure of the material, which is often not carried out properly. This may be linked to a lack of knowledge about the risks involved.

It is necessary to promote educational activities on the subject, highlighting the problems that incorrect disposal can cause. In addition, the implementation of strict policies and proper amalgam disposal practices is essential, as the material is highly harmful and the lack of stricter regulations can contribute to inadequate disposal practices.

Although there are substitutes for amalgam, such as composite resins, it is important to emphasize that sustainable dentistry must prioritize the search for materials that do not harm the environment. Furthermore, research on this topic should not be limited to the field of microbial contamination, nor to developing countries, but should expand to a broader, global approach. It is important to highlight that the study presented some limitations due to the methodology used. The analysis was restricted to the database most related to the health field, chosen for including journals with higher scientific standards. Another aspect to consider is that only articles in English were eligible, which may have resulted in the omission of research published in other languages. Furthermore, the analysis period was limited to the last 10 years, aiming to focus on more recent evidence on the topic. These decisions may have restricted the inclusion of important studies published in other languages, in less conventional databases, or from earlier periods; however, they do not compromise the validity of the data found, providing an alternative perspective that can be replicated clearly and objectively.

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