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Original Research Article

DENTAL WASTE – MANAGEMENT AND STATISTICS

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Abstract

Waste management is a crucial issue in the contemporary world, playing a significant role in the fight against environmental problems. Inadequate waste management leads to the pollution of air, water, and soil with toxic and harmful substances and to the emission of greenhouse gases, thereby contributing to climate change, the reduction of biodiversity, and the destruction of ecosystems, as well as to the emergence of diseases and allergies in animals. The management of waste is primarily determined by its type and source, with recycling, incineration, and landfilling being the most common methods. The healthcare sector, with limited opportunities for waste reduction, has its own unique approach to waste management. In particular, dental waste presents a considerable environmental risk due to the hazardous and toxic substances it contains. A prime example of such substances is mercury (Hg), a toxic and bioaccumulative metal that was commonly used in dental amalgam for over a century. With the available statistical data, it is possible to recognize that dentistry can pose a serious threat to the environment, and steps can be taken to control and reduce the production of toxic waste and its potential impact on the environment.

Keywords: dental waste, healthcare, waste management, medical waste in Poland

1. INTRODUCTION

Waste management is a crucial issue in the contemporary world, playing a significant role in the fight against environmental problems. The generation of waste is somewhat inevitable - during the manufacturing of any product there will always be some by-products, and during the provision of any service there will always be waste. Inadequate waste management leads to the pollution of air, water, and soil with toxic and harmful substances and to the emission of greenhouse gases, thereby contributing to climate change, the reduction of biodiversity, and the destruction of ecosystems, as well as to the emergence of diseases and allergies in animals. Moreover, research addressing the ecological footprint of countries asserts that since the 1970s, humanity has been in ecological debt, spending significantly more resources than the Earth can reproduce [1]. It also has been proven that there is a correlation

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between waste accumulation and a country's level of welfare [2]. In economically developed countries, the rate of waste per person is higher. Research demonstrates that as population welfare levels increase, so does the proportion of inorganic waste, including plastic, metal, glass, paper, rubber, and other materials [2,3]. It cannot be unnoticed that there are more progressive waste management and disposal methods in more developed countries. One of the commoner concepts is Lansink’s Ladder, a concept declaring a hierarchy of waste processing methods [4].

Research conducted by Shershneva (2022) shows that effective waste management could reduce the index of personal waste. In countries with a small population and high welfare, such as Denmark, Sweden, and Belgium, the waste management system is effective and has a positive decoupling effect. However, there is a concern regarding an increasing amount of waste per capita and a substantial proportion of inorganic rubbish. In larger European countries and Japan, there is a lower level of waste per capita, a responsible approach to utilization, and restrictions on plastic usage. These countries, however, have a problem of proportional growth in wealth and waste. In countries with large populations, such as the USA, China, and Russia, there is a significant issue of increasing total waste, inefficient waste management, and a low level of recycling [2]. The different ways of dealing with medical waste differ from one country to the next. Approximately 25% of countries researched by Fadei (2023) segregated medical waste, while about 17% applied standard storage for all medical waste. Shortcomings were also found in the collection, storage, transport and transfer, and disposal of medical waste in different countries. Only approximately 25% of countries utilized all three approaches including autoclaving, incineration, and landfill for the disposal of medical waste, whereas 91% relied on incineration [5].

As research shows, the medical waste generation rate in different countries ranges from 0.14 to 6.10 kg per bed-day (a day during which a patient is confined to bed and stays overnight in a healthcare facility) [5]. But medical waste does not only consist of waste generated per bed-day in healthcare facilities.

It is also generated by other medical practices, such as dental practice. Dental waste in particular presents a considerable environmental risk due to the hazardous and toxic substances it contains. Although the amount of waste produced by an individual dentist may be insignificant, it can cumulatively have a substantial environmental impact [6,7].

Dentists, according to the International Standard Classification of Occupations (ISCO-08 Index of Occupational Titles), “diagnose, treat and prevent diseases, injuries and abnormalities of the teeth, mouth, jaws and associated tissues by applying the principles and procedures of modern dentistry. They use a broad range of specialized diagnostic, surgical, and other techniques to promote and restore oral health” [8]. The quantity of dentists varies among different countries. Fig. 1 presents a map illustrating the number of dentists (provided by the World Health Organization), as of the most recent year reported [9]. It is evident that China has the most significant number of dentists (637,000 reported in 2017). The next two countries with the highest numbers of dentists are the USA (201,900 reported in 2021) and India (222,816 reported in 2020). In contrast, the lowest number of dentists can be observed mainly in African and Caribbean countries (e.g. 2 dentists in Guinea-Bissau, 2021; 12 dentists in Benin, 2018).

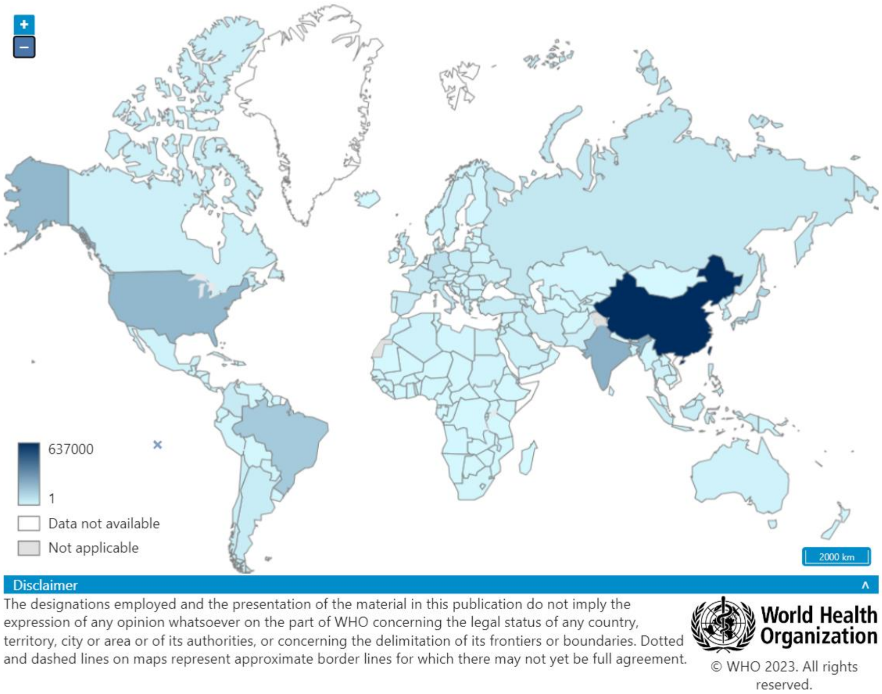

Fig. 1. Number of dentists (latest update from countries) [9]

But what is crucial is not only the precise quantity of dentists but also its calculated value per a certain number of individuals. Given the varying populations of each country, the demand for medical professionals differs as well. Tab. 1 displays the four nations with the greatest number of dentists per 10,000 individuals.

Table 1. Countries with the highest number of dentists per 10,000 individuals [10]

Country	Number of dentists per 10,000 individuals	Year of update
Sweden	17.73	2020
Uruguay	16.95	2021
Cuba	16.71	2018
Chile	14.81	2021

The quantity of dental waste produced per patient may differ depending on the type of dental treatment and the waste prevention measures in place. Various values, calculated from statistical surveys, can be found in the literature sources. The amount of waste generated per patient per day is approximately 0.1 kg [11,12]. According to WHO reports, approximately 85% of medical waste is non-hazardous general waste, with the remaining 15% classified as hazardous (infectious, toxic, or radioactive) [13]. WHO's "Guidance for climate-resilient and environmentally sustainable healthcare facilities" [14] suggests that healthcare facilities should be prompted to evaluate their environmental impact.

With the available statistical data, it is possible to recognize that dentistry can pose a serious threat to the environment, and steps can be taken to control and reduce the production of toxic waste and its potential impact on the environment [6].

2. DENTAL WASTE

Dentists use a variety of materials and professional equipment to provide the necessary treatment. Medical waste can be classified into several categories based on the characteristics of the waste. The categories and their definitions, as proposed by the World Health Organization (WHO), were organized in Table 2.

Table 2. Types and definitions of medical waste set by WHO [13]

Type of waste	Definition	Examples of such dental waste
Infectious	waste contaminated with blood and other bodily fluids (e.g. from discarded diagnostic samples), cultures and stocks of infectious agents from laboratory work (e.g. waste from autopsies and infected animals from laboratories), or waste from patients with infections (e.g. swabs, bandages and disposable medical devices)	swabs, stitches
Pathological	human tissues, organs or fluids, body parts and contaminated animal carcasses	parts of the gingiva, teeth
Sharps	syringes, needles, disposable scalpels and blades, etc.	dental instruments
Chemical	for example, solvents and reagents used for laboratory preparations, disinfectants, sterilants and heavy metals contained in medical devices (e.g. mercury in broken thermometers) and batteries	disinfectants, sterilants, mercury in dental amalgam
Pharmaceutical	expired, unused and contaminated drugs and vaccines	local anaesthetics
Cytotoxic	waste containing substances with genotoxic properties (i.e. highly hazardous substances that are, mutagenic, teratogenic or carcinogenic), such as cytotoxic drugs used in cancer treatment and their metabolites	-
Radioactive	such as products contaminated by radionuclides including radioactive diagnostic material or radiotherapeutic materials	-
Non-hazardous or general	waste that does not pose any particular biological, chemical, radioactive or physical hazard	packages

Some materials used in dental care pose a challenge to the environment [6,15]. Despite preventive measures such as amalgam separators, the waste is still released into the environment [15]. The impact is significant [6,7].

2.1. Dental Amalgam

One potentially hazardous material for the environment is dental amalgam, which comprises metals such as mercury and silver. Amalgam is a durable, cost-effective, and long-lasting restorative material used for dental filling [15-20]. Mercury has been used as an amalgam for more than 150 years [15]. This heavy metal accounts for up to 50% of the weight of amalgam [16] and is known for its bioaccumulating and toxic properties [20,21]. However, scientists have not identified a causal relationship between dental amalgam and adverse health effects. It is possible that the remaining issue is caused by the forms of mercury associated with dental amalgam, which are elemental and inorganic (less toxic than organic mercury) [22]. The placement and/or removal of dental amalgam restorations results in the generation of solid and particulate waste, such as elemental mercury vapor or dental amalgam scrap [6]. Once waste enters the environment and suitable conditions arise, the mercury can be used by bacteria that are able to convert it into the more toxic organic methylmercury [20,22]. In bioavailable form, mercury tends to enter the food web by accumulating in organisms (mostly fishes and birds) that could be eaten by people.

As the study shows, dental practitioners are responsible for 3-70% of the total mercury load entering wastewater treatment facilities [6,19]. The law requires dentists to make efforts to prevent amalgam waste from entering the environment (e.g. in Canada, dentists are required to collect, store and dispose of both coarse residue and fine amalgam particles removed by high-volume suction) [6]. One of the tools used for this purpose is the amalgam separator. An ISO 11143-certified amalgam separator is proven to reduce amalgam particles in dental wastewater by more than 95% [6,23,20]. Once collected, dental amalgam waste should be considered and managed as hazardous waste. Dental staff should be instructed to wear personal protective equipment (PPE) when disposing and managing amalgam waste. Proper storage of dental amalgam could also minimize the amount of elemental mercury vapor entering the environment [6].

2.2. Silver

Silver is also a component of dental amalgam but an even greater threat to the environment is posed by the silver thiosulfate in the radiographic fixer, which is used in the processing of dental radiographs [6]. It can be released into water systems and the environment through improper disposal of dental office waste. Used radiographic fixers should not be disposed of in drainage systems. This issue could be dealt with through appropriate measures. The most effective approach for silver waste management is via recovery and recycling. The suggested solution to this problem involves dental practices installing silver recovery units to recover the silver. Such units typically recover silver ions from the waste solution by displacing iron ions or by using a closed-loop electrolytic system [6].

2.3. Lead

Lead is a by-product of conventional radiography via the lead shields included in every film set to protect the films. As lead is toxic and remains persistent in the environment, it needs to be handled with great care. Although the lead shields are relatively small, the cumulative waste produced can be significant. Reducing environmental lead contamination caused by dental practitioners is a simple and low-cost task. There are two solutions aimed at reducing the amount of waste generated by lead shields. Firstly, recycling is a viable solution to address the issue of lead shields used on film sets. These shields could be collected and returned to the manufacturer. And the second option is digital radiography, which does not require film packets and, therefore, unnecessary lead shields [6,16].

2.4. Other waste

As dental practices are healthcare facilities, they also generate biomedical waste. Biomedical waste includes materials that are infectious or pathological (Tab.2). Such non-sharp biomedical waste, including blood-soaked gauze and tissues, should be stored properly and labeled with a biohazard symbol. Sharps (e.g. syringes, suture needles) should not be managed with general or biomedical waste. They should be stored in a puncture-resistant, leak-proof, properly labeled container until collection and incineration [6].

Another important issue is single-use plastic waste generated by dental practices [24]. Research has demonstrated that the dental industry utilizes a significant quantity of single-use plastics that end up as clinical waste. The increase of personal protective equipment (PPE) use during the COVID-19 pandemic is the single largest contributor of single-use plastics, as it is used for each clinical procedure [14]. There are some single-use plastics that cannot be completely eliminated because of the need to provide high-quality and safe healthcare. Plastic packaging is used to sterilely store new dental instruments and materials. But there are also disposable plastic cups, for example, that could be replaced with paper alternatives without compromising the high quality and safety of the service.

3. MANAGEMENT OF MEDICAL WASTE IN POLAND

The General Inspectorate of Sanitation examined the sanitary condition of providers of medical activities in 2022. The facilities were examined in two categories - the hygiene and sanitary conditions to be met by the equipment and premises where health services are provided, and the handling of medical waste. The investigation covered 15,324 medical facilities, including dental practices. It’s about 45% of all Polish healthcare facilities [25].

A total of 928 out of 1,177 registered hospitals in Poland were audited. The following hygiene and sanitary and/or technical problems were observed in 331 facilities. The negative assessment of these facilities was determined, among other things, by inadequate management of medical waste. A total of 9,948 out of 50,162 individual professional practices were also inspected. The 9,948 facilities inspected included 3,953 dental practices, 1,762 specialist dental practices and 207 group dental practices. Shortcomings were found in less than 1% of the facilities audited and were mainly related to the handling of medical waste, i.e. waste qualification, storage and internal transport [25].

In the previous year (2021), only 8,797 places were investigated. A total of 728 out of 1164 hospitals registered in Poland at the time were audited. The following hygiene and sanitary and/or technical problems were observed in 199 facilities. A total of 4,407 out of 51,237 individual professional practices were also inspected. The 4,407 facilities inspected included 1,764 dental practices, 859 specialist dental practices and 95 group dental practices. Shortcomings were found in less than 2% of the facilities audited and were mainly related to the handling of medical waste, i.e. lack of proper labeling of containers and bags for medical waste, lack of records of temperature readings in refrigeration equipment, lack of updating of the procedure for handling medical waste, inadequate sanitary and technical condition of rooms for storing medical waste [25].

Figure 2 displays statistical data for the most recent years. The majority of audits occur in individual facilities, with dental practices comprising most of these. The number of audited facilities varies depending on the year and conditions, such as the COVID-19 pandemic. Nevertheless, the percentage of observed sanitary shortcomings remains relatively stable, with around 1-2% of inspected facilities exhibiting such issues [25].

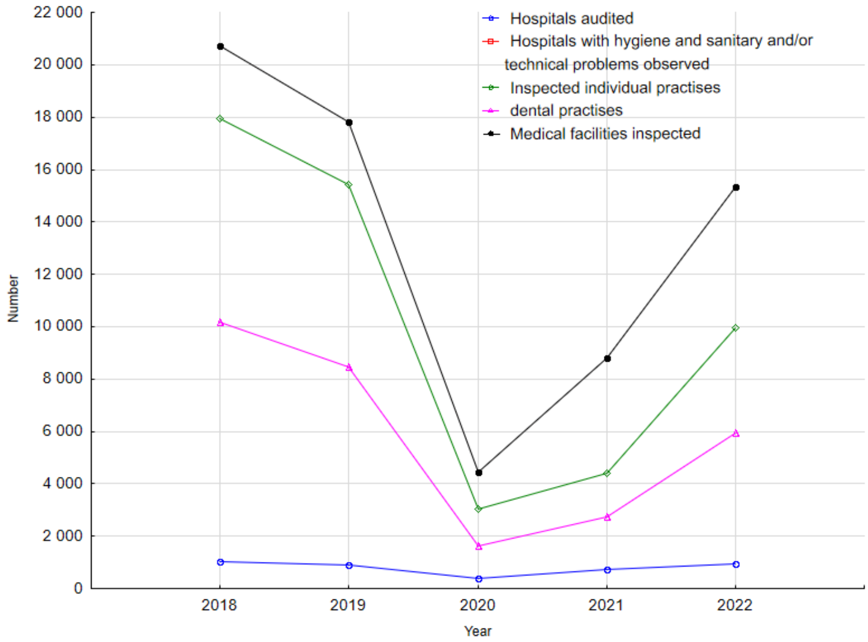

Fig.2. Statistical data of sanitation examination in Poland [25]

4. CONCLUSIONS

Dental waste presents a considerable environmental risk due to the hazardous and toxic substances it contains. Although the amount of waste produced by an individual dentist may be insignificant, it can cumulatively have a substantial environmental impact. With the available statistical data, it is possible to recognize that dentistry can pose a serious threat to the environment, and steps can be taken to control and reduce the production of toxic waste and its potential impact on the environment. Dental practitioners should be legally required to make an effort to collect and dispose of dental waste properly, particularly if a proposed solution to the problem is available. In several countries, including Poland and Canada, inspections are underway and regulations are being implemented concerning medical waste storage and labeling, among other aspects. It is evident that, irrespective of the number of healthcare sites assessed, the proportion of those with detected medical waste management issues remains at a comparable level.

REFERENCES

1. Sausheva, OS 2017. Ecological footprint as an indicator of economic growth at the present stage of development. *Russian J. of Resources, Conservation and Recycling* **4**, DOI:10.15862/13RRO417.
2. Shershneva, EG 2022. *Analysis of Correlation between Waste Accumulation and Countries Welfare Level*. IOP Conference Series: Earth and Environmental Science, vol. 988, doi:10.1088/1755-1315/988/2/022034.
3. Shilkina, SV 2020. Global trends in waste management and analysis of the situation in Russia. *Russian J. of Resources, Conservation and Recycling* **1**, DOI: 10.15862/05ECOR120.
4. Ermolaeva, Yu V 2017. Global waste management models: a sociological approach Scientific Result. *Sociology and Management* **3**, 61–76.
5. Fadaei, A 2022. Comparison of medical waste management methods in different countries: a systematic review. *Rev Environ Health* **18,** 339–348.
6. Hiltz, M 2007. The environmental impact of dentistry. *J Can Dent Assoc* **73(1)**, 59–62.
7. Farmer, GM, Stankiewicz, N, Michael, B, Wojcik, A, Lim Y and Ivkovic D 1997. Audit of waste collected over one week from ten dental practices. A pilot study. *Aust Dent J* **42(2)**, 114–117.
8. https://www.ilo.org/public/english/bureau/stat/isco/isco08/ [02.09.2023]
9. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/dentists-(number) [02.09.2023]
10. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/dentists-(per-10-000-population) [03.09.2023]
11. Krishnappa, P, Sreekantaiah, P, Hiremath, SS, Thapsey, H, Shivraj, NS and Murthy, NS 2015. Quantification of Dental Health Care Waste Generated among Private Dental Practices in Bengaluru City. *J Int Oral Health* **7(6)**, 84–87.
12. Antoniadou, M, Varzakas, T, Tzoutzas, I 2021. Circular Economy in Conjunction with Treatment Methodologies in the Biomedical and Dental Waste Sectors. *Circ.Econ.Sust*. **1**, 563–592.
13. https://www.who.int/news-room/fact-sheets/detail/health-care-waste [02.09.2023]
14. WHO Guidance for Climate Resilient and Environmentally SustainableHealth Care Facilities. https://www.who.int/teams/environment-climate-change-and-health [02.09.2023]
15. Hylander, LD, Lindvall, A, Gahnberg, L 2006. High mercury emissions from dental clinics despite amalgam separators. *Sci Total Environ* **362(1-3)**, 74–84.
16. Muhamedagic, B, Muhamedagic, L, Masic, I 2009. Dental office waste - public health and ecological risk. *Mater Sociomed* **21(1)**, 35–38.
17. Canadian Dental Association. CDA position on dental amalgam. 2005. https://www.cda-adc.ca/en/about/position_statements/amalgam/ [02.09.2023]
18. FDI World Dental Federation. FDI policy statement. WHO consensus statement on dental amalgam. 1997 https://www.fdiworlddental.org/who-consensus-statement-dental-amalgam [02.09.2023]
19. Chin, G, Chong, A, Kluczewska, A, Lau, A, Gorjy, S, Tennant M 2000. The environmental effects of dental amalgam. *Australian Dental Journal*, 246-249. doi: 10.1111/j.1834-7819.2000.tb00258.x.
20. Kao, RT, Dault, S, Pichay, T 2004. Understanding the mercury reduction issue: the impact of mercury on the environment and human health. *J Calif Dent Assoc* **32(7)**, 574–579.
21. Barron, T 2004. Mercury in our environment. *J Calif Dent Assoc* **32(7)**, 556–563.

22. Jones, DW 1999. Exposure or absorption and the crucial question of limits for mercury. *J Can Dent Assoc* **65(1)**, 42–46.
23. Vandeven, JA, McGinnis, SL 2004. Cost-effectiveness of removing amalgam from dental wastewater. *J Calif Dent Assoc* **32(7)**, 564–73.
24. Martin, N, Mulligan, S, Fuzesi, P, Hatton P.V 2022. Quantification of single use plastics waste generated in clinical dental practice and hospital settings. *Journal of Dentistry* **118**, 103948.
25. https://www.gov.pl/web/gis/raport-stan-sanitarny-kraju [15.09.2023]