



Mercury Exposure and Health Status of Dentists in Morocco, Casablanca—Settat Region

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Abstract

Introduction: Mercury exposure was a globally recognized health problem. In odontology, dental amalgam is the primary source of mercury, and dental staff were exposed to both metallic and vapor mercury. However, the harmful effects of this chronic low-dose exposure were still a matter of debate. **Objectives:** The study aimed to evaluate mercury exposure in dental clinics in the Casablanca region, identify sources of exposure, determine its impact on dentists' health, and assess the management of dental amalgam waste. **Method:** This cross-sectional study utilized online and paper-based questionnaires distributed to dentists in the Casablanca—Settat region. The sample size was accidental. **Results:** Out of 93 responding dentists, only 17 used dental amalgam, while 71 performed amalgam filling removal. Among them, 50% (8) used encapsulated amalgam, 25% (4) bulk amalgam, and 25% (4) used both forms. Safety measures during amalgam handling included the use of a rubber dam 23.7%, surgical suction 63.4%, irrigation 67.7%, and ventilation 62.5%. Regarding waste management, 84.7% believe waste sorting was mandatory, 38.5% stored amalgam waste in sealed containers, 52.2% sorted it with cytotoxic waste and only 29.8% collaborated with waste management companies. Only 14.3% of dentists attributed their health issues to amalgam handling despite experiencing symptoms related to amalgam toxicity, which appeared on an average of 7.27 years. **Discussion:** The placement, removal of amalgam, and improper amalgam waste management remained significant factors in mercury exposure, leading to various somatic, oral, and psychological issues. Adhering to the latest recommendations on amalgam use and waste management is essential. **Conclusion:** Mercury exposure in dental clinics was undeniable. Despite a low response rate, our study conducted in 14 urban areas of the Casablanca—Settat region was fairly representative of current practices and the overall health of practitioners in the private sector.

Subject Areas

Dentistry

Keywords

Mercury, Health Status, Dentists, Amalgam

1. Introduction

Mercury, is an omnipresent metal in liquid form at room temperature, had the ability to combine easily with other molecules, whether metallic, inorganic or organic. In conservative dentistry, mercury was used in its elemental form to create dental amalgams. It has been used in dentistry with satisfactory results for over a century, and its quality has improved over the years. However, despite these advantages, animal studies have shown that mercury vapor from amalgams is rapidly absorbed and distributed throughout the body, concentrating in organs, including those of the fetus [1] [2].

Exposure to small quantities of mercury over a long period can lead to a variety of health problems, affecting most physiological systems.

The World Health Organization states that “mercury may not have a threshold below which certain side effects do not occur”. A prospective cohort study of 129 subjects concluded that the intensity of general health problems decreased after removal of dental amalgam in patients with medically unexplained physical symptoms who attributed their health problems to dental amalgam [3] [4].

Dentists represent a population at risk of chronic mercury poisoning. Mercury gradually accumulates in the body through the stable bonds it creates with the thiol groups in proteins. In addition to this occupational exposure, dentists are subject to others forms of exposure affecting the general population, the main sources of which are dental amalgam fillings, methylmercury present mainly in seafood, thiomersal in certain vaccines, and smoking, all of which contribute to the body burden of mercury responsible for morbid disorders, especially if safety thresholds are exceeded or if natural detoxification mechanisms are lacking, particularly in cases of genetic susceptibility. Both the fitting and removal of amalgam restorations produce various categories of amalgam waste. Dental practices should adopt best practice in waste management [5] [6].

The aim of our study is to assess mercury exposure in dental practices in the Casablanca—Settat region, to determine the impact of this exposure on the health of dentists, and to evaluate the management of amalgam waste in these practices.

2. Materials and Methods

2.1. Type of Study

To carry out this work, we conducted a descriptive cross-sectional study. We used the results of a questionnaire to gather information that met our objectives, the information gathered corresponded to a situation limited in time without following its evolution

(cross-sectional) and our study aims to describe the data gathered (descriptive).

2.2. Sampling

In collaboration with an epidemiologist, we opted for accidental sampling.

2.3. Inclusion Criteria

- Dentists that had declared to be registered with the national council of the dental profession.
- Dentists that practiced in the Casablanca—Settat region.
- Dentists that agreed to take part in the survey.

2.4. Exclusion Criteria

- Dentists that were unable to respond or who refused to collaborate.

2.5. Study Location and Duration

The study took place from October 9 2023 to November 17 2023 via an online and paper questionnaire hand-delivered to dentists in the Casablanca—Settat region, with the exception of the cities of Casablanca and Mouhammadia.

2.6. Questionnaire

The questionnaire was written in French on Microsoft Word then printed in paper format and transferred to the Google Forms platform. Consisted of 23 clear questions understandable by everyone. It was divided into 4 main sections:

- The participant's identity.
- Occupational exposure to mercury.
- The practitioner's state of health.
- Mercury waste management.

3. Results

Tables 1-6 and **Figures 1-12** present a comprehensive summary and graphical depiction of the data collected from the questionnaire.

3.1. Response Rate

The number of valid participants who responded to the questionnaire (see **Appendix**) was 93 dentists.

3.2. Answers Received Regarding the Use, Shape, Installation, Removal of Amalgam

Table 1. Summary table of responses received.

The use of amalgam	82.8% (77) dentists do not use amalgam. 17.2% (16) dentists use amalgam.
The shape of the amalgam	50% (8) dentists use amalgam in the form of pre-packaged capsules only. 25% (4) dentists use bulk amalgam only. 25% (4) dentists use both forms.

Continued

Placement of amalgam 82.8% (77) dentists do not perform amalgam placement.
 9.7% (9) dentists perform more than one placement and less than 10 amalgam placements per month.
 7.5% (7) dentists perform more than 10 amalgam placements per month.

Removal of amalgam 23.7% (22) dentists do not remove amalgam.
 52.7% (49) dentists perform more than one amalgam removal and less than 5 amalgam removals per month.
 13% (12) dentists perform more than 5 and less than 10 amalgam removals per month.
 10.6% (10) dentists perform more than 10 amalgam removals per month.

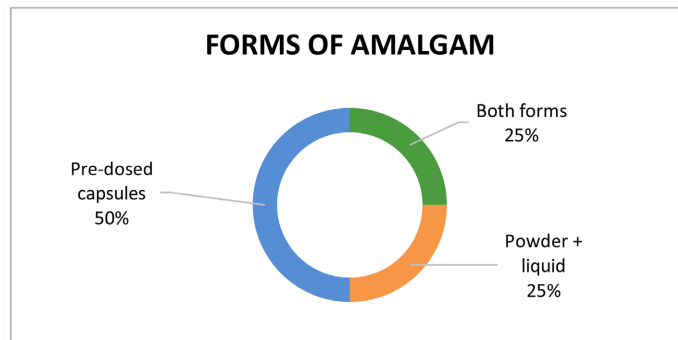


Figure 1. Forms of amalgam.

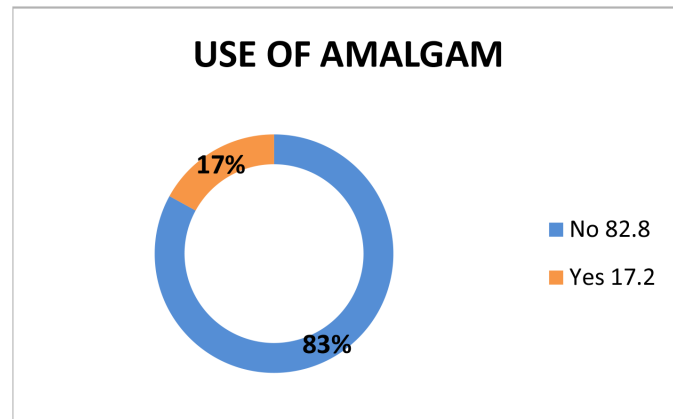


Figure 2. Use of amalgam.

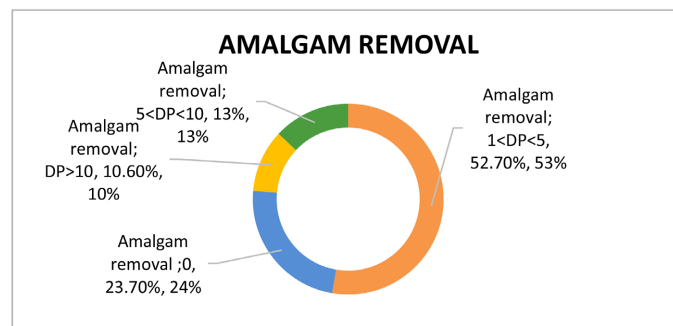


Figure 3. Number of amalgam fillings removals.

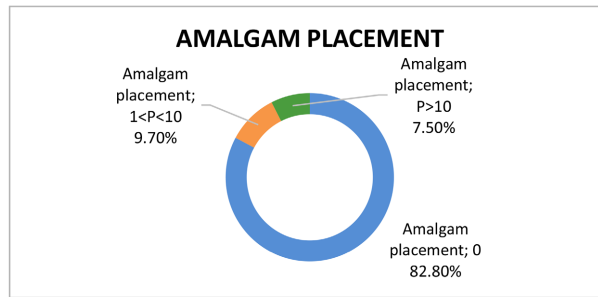


Figure 4. Number of amalgam fillings placements.

3.3. Sociodemographic Characteristics

- Distribution according to age, number of years of practice, gender, general health and city:

Table 2. Distribution of the sample by age.

Middle age	39.45
Standard deviation	10.74
Minimum	24
Maximum	64

Table 3. Distribution of the sample according to the number of years of practice.

Average number of years of practice	13.14
Standard deviation	9.69
Minimum	1
Maximum	32

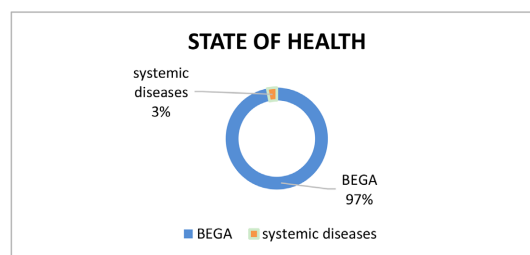


Figure 5. Distribution of the sample by health status.

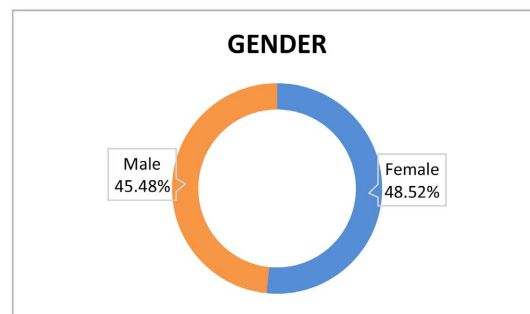


Figure 6. Distribution of the sample by gender.

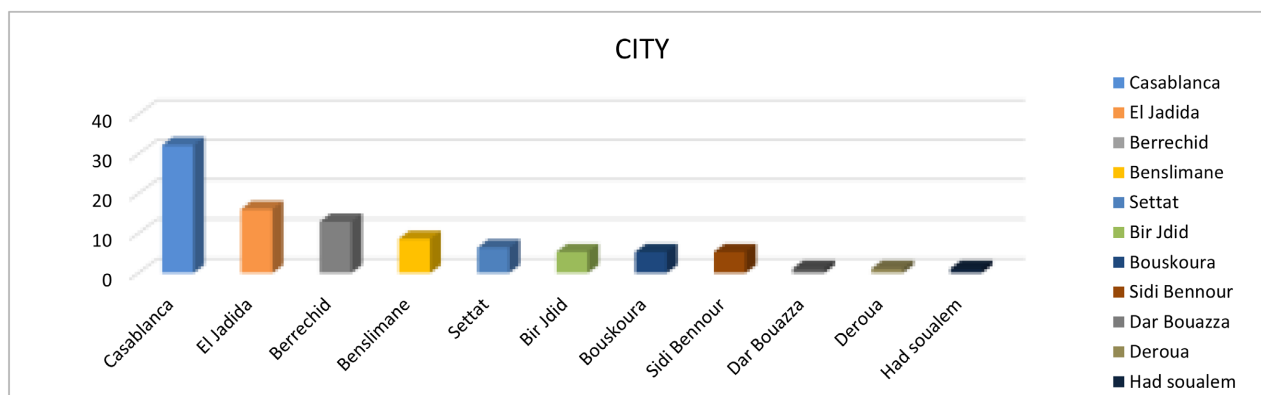


Figure 7. Distribution of the sample by city.

3.4. Operating Field, Suction, Irrigation and Ventilation of the Dental Practices

Table 4. Summary table of responses received regarding the use of the operating field, surgical suction, irrigation and ventilation of the office.

	Use of the operating field	The use of surgical suction	Use of irrigation	Ventilation of the office
Yes	23.7%	63.4%	67.7%	62.5%
No	76.3%	36.6%	32.3%	37.5%

3.5. Health Status of Dentists

Table 5. Summary table of responses concerning psychological and organic disorders and their frequency.

Symptoms	Frequency
ORAL SYMPTOMS	
Metallic taste	-
Dry mouth	-
Oral burns	--
Buccal ulceration	-
SOMATIC SYMPTOMS	
Cognitive/motor dysfunction	--
Allergies	-
Vertigo	-
Breathing difficulties	-
Headache	+
Intestinal pain	-
Diminished vision	+
Memory loss	-
Heart palpitations	-
Sweat	-

Continued

Chest pain	-
Rash	-
PSYCHOLOGICAL SYMPTOMS	
Depression	-
Anxiety	+
Fatigue	++
Insomnia	+

0%: --; 0% - 25%: -; 25% - 50%: +; 50% - 75%: ++; 75% - 100%: +++.

Table 6. Date of appearance of symptoms.

Date of appearance of symptoms	Standard deviation	Minimum	Maximum
7.27	7.64	1	28

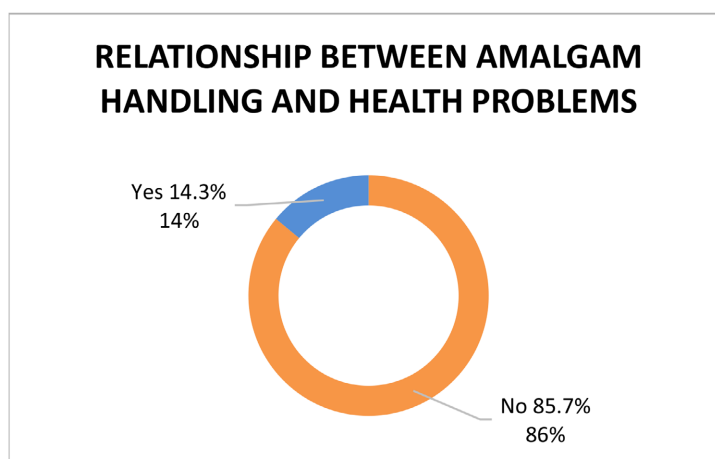


Figure 8. Relationship between amalgam handling and health problems.

3.6. Waste Management

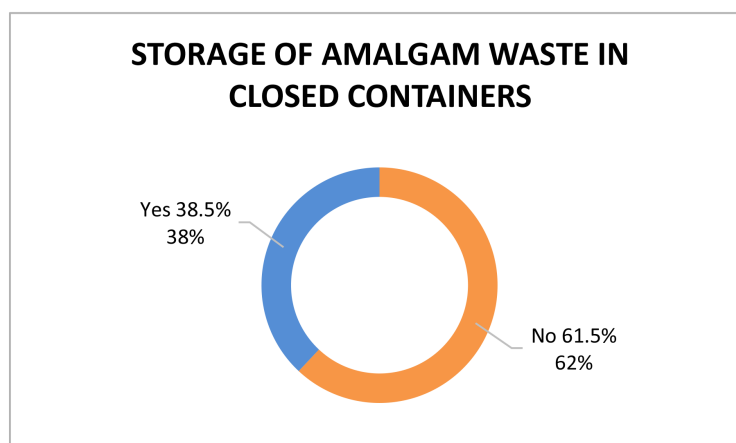


Figure 9. Storage of amalgam waste in closed containers.

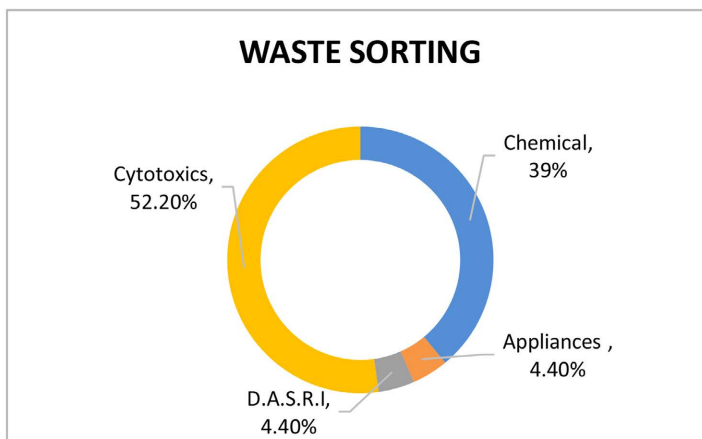


Figure 10. Waste storing.

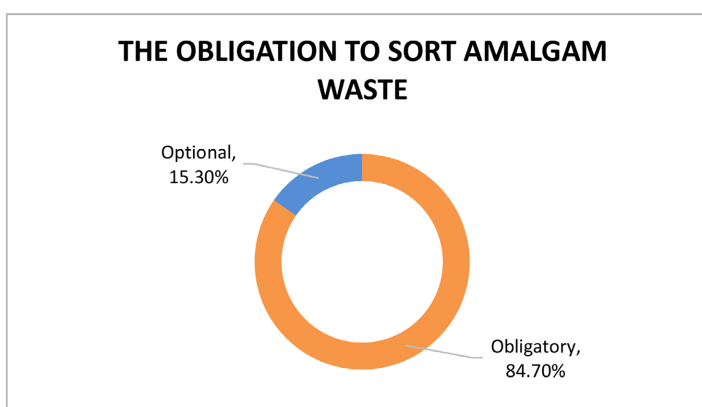


Figure 11. The obligation to sort amalgam waste.

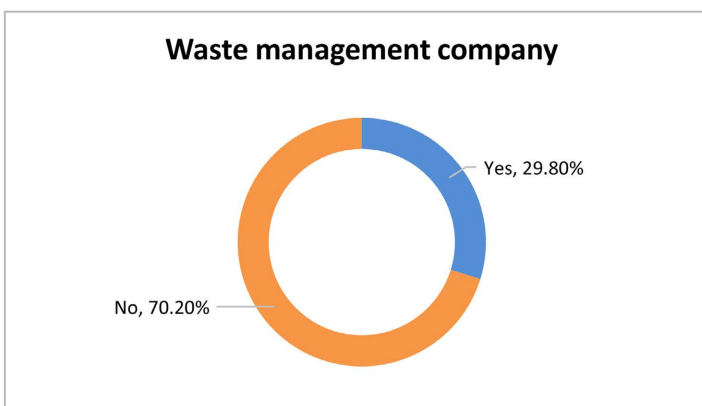


Figure 12. Waste management company.

4. Discussion

4.1. Discussion of Material and Method

4.1.1. Methodology

We based our study on a questionnaire of 23 questions sent to dentists in the Casablanca—Settat region working in the private sector on a random basis.

4.1.2. Difficulties and Biases

During our investigation we encountered the following difficulties:

- Dentists are often very busy, with hectic schedules.
- Some dentists may be reluctant to share sensitive information about their practice, for fear that it could be used negatively or that it could be leaked to competitors.
- Dentists may be subject to a significant administrative burden, and participating in a survey may be seen as an additional task that does not benefit their practice.
- Some dentists may not see the value or relevance of participating in a survey, particularly if the results are not directly applicable to their daily practice.

4.2. Sociodemographic Data

4.2.1. Gender

In our study the distribution of the population is more or less balanced with 51.6% of the dentists who responded to the questionnaire are women and 48.4% men. In a study similar to ours Attiya *et al.* (2020) participated in the Fez region 48 women or 47.52% and 53 men or 52.48% and in the Meknes region 32 women or 36.78% and 55 men or 63.22% [5].

4.2.2. Age

In our study we observed an average age of 39.45 years with a standard deviation of 10.74; the results obtained are approximate to those of the Fez region with an average of 38.02 years with a standard deviation of 9.33 and Meknes of 34.58 years with a standard deviation of 8.25 [5].

The health status of dentists deteriorates by 6% for each additional year of age, reflecting a reduction in their overall well-being.

4.2.3. The Number of Years of Practice

The results of our study showed an average of 13.14 years of practice years with a standard deviation of 9.69 years of practice. In the study by Attiya *et al.* (2020) the average year of practice in the Fez region is 11.84 years with a standard deviation 8.25; And in the Meknes region is 8.19 years with a standard deviation 8.24. In a study of 200 dental practices, Nixon highlighted a correlation between increased ambient mercury levels and age of the practice [5] [7].

4.2.4. General Condition

In our research, 97% of participants reported enjoying satisfactory health. We formulated this question in an attempt to avoid attributing a pre-existing general illness to the symptoms described. It should be noted that age, and by extension professional experience, has an unfavorable influence on the health of dentists, reducing the probability of being in good or very good health by 6% [5].

4.3. Occupational Exposure to Mercury

- Use of amalgam

In our study 82.8% of dentists do not use amalgam, this proportion is higher than that described in a similar study in the region of Fez and Meknes which is 23.96% [5].

The 77 dentists in our study justified their non-use of amalgam by the toxicity of mercury (61%), the aesthetic requirements of patients (42.8%), the development of composite resins and bonding (10.4%), patient refusal (9%), but also the physical properties of the amalgam which favor tooth fracture (6.5%). These dentists have opted for the use of dental composites.

The 17 dentists in our study explain their choice to use amalgam for its mechanical resistance and reliability 71 (37.5%), at the patient's request (31.2%), for its ease of installation in conditions not favorable for bonding (12.5%), but also its bacteriostatic properties (12.5%).

- The form of the amalgam

The results of our study showed that the use of amalgam in the form of pre-dosed capsules (50%) was more widespread than the use of bulk amalgam (25%), while others use both forms (25%).

The degree of exposure is strongly influenced by the type of amalgam used. The use of bulk amalgam increases the number of times of potential exposure since filling the mercury tank of the amalgamator with an increased risk of loss, during maintenance and recovery of the mixed amalgam. This is an extremely polluting method. Capsule users are only potentially exposed when they are opened [5] [8].

- Placing and removing the amalgam

In our study, 82.8% of dentists do not place any amalgam per month and 23.7% do not place any amalgam per month.

According to a study conducted in Iceland, amalgamated restorations fail for the same reasons as current composite restorations, that is, secondary caries and both mass and marginal fractures. Similarly, another study by Chisini, conducted by Luiz Alexandre *et al.* (2019), found that education level had an impact on the replacement of amalgam restorations, increasing the risk of replacement fourfold in those with higher education compared to those with less years of formal education. Over the next seven years, 136 (18.9%) of the presented amalgam restorations were replaced with composite resins [9] [10].

According to another study on the exposure of dental assistants, there is no significant link between the number of removals per week and mercuriurias for the amalgam removal phase. The removal technique must also be taken into account [11].

- Operating field, surgical aspiration, irrigation and ventilation

- According to our study, only 23.7% of dentists use the operating field when placing or removing amalgam.

In its meeting of May 19, 1998, the CSHPF in France suggested that milling and polishing amalgam should always be carried out under the operating field and according to a study on the exposure of dental assistants, the results of four-handed work are not statistically significant [11] [12].

- Our study shows that 63.4% of respondents reported using surgical suction during amalgam placement or removal. The results show that 67.7% of practitioners handle amalgam under irrigation. The amount of mercury vapor released into the air is reduced by the use of irrigation and surgical suction during amalgam placement or removal.

According to a 2009 survey of dentists in Monastir, Tunisia, 34% of health professionals work dry under suction and 66% use water spray. And in its meeting of 19 May 1998, the CSHPF in France suggested that amalgam milling and polishing should be carried out under both cooling and suction [12] [13].

- The results show that 37.5% of dentists who handle amalgam **do not ventilate the office** after placing or removing amalgam.

In 1971, Stewart and Stradling took measurements after turning off the ventilation and air systems. In 30 minutes, atmospheric mercury concentrations increased from 28 µg/m to 54 µg/m after amalgam preparation, then to 84 µg/m after ventilation, then to 64 µg/m after 5 minutes of ventilation. In France in its meeting of May 19, 1998, the CSHPF suggests working in ventilated spaces, and it is important that the office is ventilated several times a day. If an air conditioning unit is used, follow the manufacturer's instructions for regular filter maintenance [7] [11].

4.4. State of Health of Dentists

4.4.1. Medical Check-Up Visit and Blood or Urine Tests

Medical check-up visits and blood or urine tests allow regular monitoring of health status, mercuriuria and blood mercury levels, which allows the dentist to monitor the level of mercury ingested or inhaled and, therefore, mercury poisoning.

The average blood mercury level of participants in a study in Hamadan, Iran was 6.43 µg/l, SD = 1.31. Previous studies on this topic have shown varied results. While in research carried out by Muller in 1988, in Denmark, the mercury levels of 130 dentists were measured and in 40% of them, this concentration was greater than 5 µg/l. In the study carried out by Chang *et al.* in 1992, the average serum mercury level among dentists was 5 µg/l, and in another it was 8.2 µg/l [14]-[17].

Inorganic mercury is mainly inhaled through the respiratory tract, but it can also be absorbed to a lesser extent through the skin (3% to 4%) or the gastrointestinal tract (2% to 10%). Unlike metallic mercury, inorganic mercury cannot cross the blood-brain barrier and tends to accumulate primarily in the kidneys, the target organ. The main routes of elimination include urine and feces, with a half-life of approximately two months. According to studies of occupational mercury exposure, recent exposure to mercury is reflected in mercury concentration levels in blood and urine. However, at extremely low levels of mercury exposure, the association between exposure and mercury concentrations in blood or urine was notably weak [18]-[20].

4.4.2. Organic and Psychological Disorders

We formulated these questions with the aim of identifying the main symptoms

linked to exposure to mercury when dentists handle amalgam. Our results are supported by other studies:

- A study from Tübingen in 2001 suggests the involvement of dental amalgam in the triggering of various diseases. This study specifically highlighted a correlation between increased mercury concentration in saliva and increased frequency of gastrointestinal disorders [21].
- A study conducted in Norway by Moen and colleagues in 2008 found that dental assistants reported neurological and psychosomatic symptoms compared to a comparison group of practical nurses. Memory loss appears to be the most significant problem. And in a 2002 comparative study by Ritchie, which assessed symptoms in mercury-exposed dentists compared to a control group potentially not regularly exposed to mercury, dentists were significantly more likely to report memory problems than members of the control group (25.9% versus 9.4%) [22] [23].
- Study carried out in New Zealand on a group of 465 patients diagnosed with chronic mercury toxicity, 32.3% of them suffered from intense fatigue, 88.8% presented memory loss, and 27.5% suffered from depression [24].
- According to the study by Neghab *et al.* (2011) there was a significant association between the number of amalgams performed per day and the presence of neuropsychological and muscular disorders. Dentists more frequently reported symptoms such as hyperpigmentation, breathing problems, irregular heart-beat, hand tremors, upper limb spasms, mood swings, nervousness, anxiety, insomnia, erethism, memory deficit, depression and chronic fatigue compared to control groups. However, it is important to note that a potential confounding factor could be that dentists also report exposure to other harmful chemicals [25].
- Danish retrospective study Thygesen *et al.* (2011), found a significant association between the number of years of dental experience and the presence of symptoms. However, when they included participants' age in their analysis model, the association between work experience and symptoms became non-significant [26].
- In a study of two regions in central Morocco, dentists recruited for the study reported 46.35% neuropsychological problems, 18.23% dermatological problems, 13.02% respiratory problems, 10.94% digestive problems, 6.77% kidney problems, 4.69% cancer, 2.6% ENT problems and 1.04% heart problems. While in an English study, 25.53% of dentists suffered from emotional exhaustion, 34.42% reduced personal accomplishment and 8.88% depersonalization [5] [27].
- A study published in 2008 on self-reported health problems by dental doctors in Lithuania found a high prevalence of fatigue (91.5%), headaches (83.6%) and chest pain (38.4%). These disorders are experienced chronically by practitioners. Another study by Zwicker in 2014 showed that removing amalgam fillings increased the likelihood of reporting improvement in symptoms like memory loss and stomach problems, and decreased the likelihood of self-

reported symptom worsening compared to those who had kept their amalgam fillings [28] [29].

4.4.3. Relationship between Handling and State of Health

The majority of dentists (85.7%) surveyed do not think that the handling of amalgam caused the symptoms they present despite their good general condition and therefore the absence of systemic disease.

Contrary to our findings, a study conducted in Pakistan in 2019 found that an overwhelming majority of 216 dentists (90.4%) believed that amalgam poses a health risk to both dental staff and patients [8].

4.5. Waste Management

4.5.1. Storage of Amalgam Waste

The results showed a slight prevalence of medical dentists not storing amalgam waste in closed containers (61.5%) compared to storing it in closed containers (38.5%).

4.5.2. Garbage Sorting

Regarding waste sorting, in our survey, 39% of doctors sort amalgam waste with chemical waste, 52.2% with cytotoxic waste and 4.4% with household waste, and 4.4% with waste from healthcare activities with infectious risk (DASRI).

In another study conducted in Pakistan, only six dentists, all private practitioners, claimed to store mercury in a sealed container for recycling. The overwhelming majority reported throwing it in the trash and/or down the sink [30].

The European Union, for example, has identified dental care as a major source of mercury emissions, contributing to massive mercury releases in wastewater (46 t Hg/year), sludge from wastewater treatment systems (13 t Hg/year) and surface water (1 t Hg/year), resulting from mercury not captured in the final effluents of treatment plants [31].

Unlike chairside traps, filters and sieves, amalgam separators remove particles with an efficiency ranging from 95% to 99%. Studies have demonstrated a significant reduction in the mercury content of wastewater using these devices [32].

4.5.3. The Obligation to Sort Waste

84.7% of doctors questioned say that waste sorting is obligatory. These results are also consistent with a study conducted in Senegal in 2014, where 101 dentists, representing 72.5% of those surveyed, reported practicing the separation of biomedical waste from household waste. Indeed, according to Chardon (2022), sorting constitutes the crucial step in the management of biomedical waste. It must be carried out at the source of the waste, be reliable and durable, respecting criteria such as simplicity, consistency, stability over time and monitoring [33] [34].

4.5.4. Waste Management Company

Our survey reports that only 29.8% of doctors work with a waste management company.

This is consistent with a study conducted in India in 2019, where 33.4% of professionals used biomedical waste management services. The results obtained are comparable to those of the region of Fez and Meknes, where 71.34% of those questioned use the municipal household waste management network [5] [35].

Another study carried out at the level of private and public dental practices in the provinces of Rabat and Kenitra in 2017, focusing on the level of management of medical and pharmaceutical waste produced, indicates that only 28% of dentists declared having a contract with a company waste management [36].

5. Recommendations

The FDI World Dental Federation supports the World Health Organization in minimizing mercury risks to patients, dentists, dental teams and the environment during the placement or removal of dental amalgam.

The following recommendations are adopted by the FDI General Assembly, September 27-29, 2021, Sydney, Australia:

- Waste

Oral health personnel should be trained to minimize the quantities of mercury-containing waste and adopt best management practices to ensure that all waste generated is disposed of in accordance with applicable environmental legislation.

All amalgam waste, including used amalgam capsules, excess amalgam not used for restoration and amalgam waste retained in chair side filters, vacuum pump filters and amalgam separators amalgams, must be collected and stored safely until handed over to an authorized mercury recovery company.

Extracted teeth restored with amalgam must also be recycled with amalgam waste. Amalgam separators complying with ISO 11143 should be installed in dental offices/clinics where dental amalgams are used or disposed of:

- Mercury hygiene

Oral health personnel must be trained to manage mercury and dental amalgam appropriately and safely by following the following rules:

- Only use amalgam in single-use capsules in accordance with standard ISO 20749: 2017 Oral medicine - Dental amalgam in pre-dosed capsules;
- Avoid direct skin contact with mercury and recently prepared dental amalgam;
- Use high volume evacuation systems as well as water cooling during polishing or amalgam removal;
- Recap single-use capsules after use;
- Keep used capsules and amalgam waste in a closed container, then dispose of them using a mercury collector;
- Clean amalgam contaminants from instruments before sterilization or heat disinfection;
- Do not use bleach or cleaners containing chlorine to flush wastewater lines.

6. Conclusions

The use of amalgam is now banned in several countries, Norway, Sweden and

other countries such as Ireland, Finland and Slovakia, which have announced a timetable that will see amalgam banned over the next few years.

While other countries, such as France, have banned the use of bulk mercury, and dental amalgam can only be used in pre-dosed encapsulated form. Exposure to mercury in certain dental practices that use amalgam is undeniable. This is why it is crucial to raise awareness among dentists so that they follow the latest recommendations for handling amalgam, as well as for managing amalgam waste.

However, our study, which was carried out in 14 towns and cities in the Casablanca—Settat region, despite the low response rate from dentists, is fairly representative of current practices and the general health of practitioners in the private sector.

Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix

Questionnaire for the exposure to mercury and health status of dentists in Morocco, Casablanca—Settat region

Question 1:

Age: ____
Health: _____
Gender: Male Female
City: _____
Duration of practice: _____

Question 2: Do you make dental amalgam restorations?

Yes no
If yes, why _____
If not why _____
If so, in what form do you use it:
 Pre-dosed capsule
 Powder + liquid

Question 3:

On average, how many amalgam restorations do you make per month:

On average, how many amalgam fillings do you place per month:

Question 4:

When handling amalgam, do you use:
The operating field Yes no
Surgical aspiration Yes no
Irrigation Yes no
Ventilate the treatment room after each amalgam manipulation Yes no

Question 5:

Do you regularly
 Health check-ups
 Blood tests
 Urine analyzes

Question 6:

During your practice have you noticed:
Oral-type symptoms
 Metallic taste
 Dry mouth

- Burns
 - Mouth ulcers
- Psychological symptoms

- Depression
- Anxiety
- Fatigue
- Insomnia

Somatic symptoms

- Cognitive/motor dysfunction
- Allergy
- Vertigo
- Breathing difficulties
- Headaches
- Intestinal pain
- Decreased vision
- Memory loss
- heart palpitation
- Sweat
- Chest pain
- Rashes

Date of onset of symptoms: _____

Do you think that handling amalgam may be responsible for your health problems?

- Yes no

Question 7:

How do you manage amalgam waste?

Do you store waste in containers:

- Yes no

In your opinion, amalgam is part of what type of waste:

- Chemical waste
- Household waste
- Waste from healthcare activities with infectious risk (DASRI)
- Cytotoxic waste

According to you, waste sorting is:

- Optional Required

Do you work with a waste management company?

- Yes no