Original Article

# Blood Mercury Level and Its Determinants among Dental Practitioners in Hamadan, Iran

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## Abstract:

**Objective:** Exposure to mercury can occur in occupational and environmental settings. During clinical work with dental amalgam, the dental personnel are exposed to both metallic mercury and mercury vapor. The aim of the present study was to investigate blood mercury level (BML) and its determinants among dentists practicing in Hamadan city, Iran.

**Materials and Methods:** This cross sectional study was done on all dental practitioners of Hamadan (n=43). Dentists were asked to complete a questionnaire, and then 5 ml blood samples were obtained from them. After preparation, mercury concentration of each sample was measured by cold vapor atomic absorption device. Pearson correlation test and regression models served for statistical analysis.

**Results:** The mean blood concentration of mercury was 6.3 µg/l (SD=1.31 range 4.15-8.93). BML was positively associated with age, years in practice, working hours per day, number of amalgam restorations per day, number of amalgam removal per week, sea food consumption, working years in present office, using amalgam powder, using diamond bur for amalgam removal, dry sterilization of amalgam contaminated instruments, and deficient air ventilation.

**Conclusion:** BML of dentists in Hamadan was higher than standards. Working hours and number of amalgam restorations per day were significantly correlated with blood mercury.

**Key Words:** Mercury; Dental Amalgam; Iran

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## INTRODUCTION

Mercury (chemical symbol Hg) is one of the heavy metals and important toxic elements, which can be released from various sources including diet, water, air, and materials used in some occupations [1-3]. For example, having fish containing mercury causes an increase in the mercury level of the body [2,4]. Mercury can be created in the nature by degassing from the earth and the oceans crest [5,6]. It is present in the atmosphere [6]. At the moment occupational direct exposure to mercury, exist in more than 600 jobs. Workers of factories producing neon lamps, papers, dyes, and jewels, and to a lower degree, factories processing chlorine, soda, insecticides, and

fungicides suffer from mercury exposure [5]. In addition, mercury is released from fossil fuels [5] coal burning [7] and industrial wastes [5,6].

Chronic exposure to toxic metals such as mercury is an increasing widespread problem [8]. Mercuric chloride is a highly reactive compound, which can harm cells by a variety of mechanisms including direct interaction with sulphydryl groups of proteins and enzymes [8].

While in most people the main source of exposure to mercury is organic mercury available in the foods [1], dentists and dental staff are also exposed occupationally to this metal [1-3,9,10]. Amalgam restorations are known as the most important source of mercury [11]. Exposure to mercury in dental offices can be resulted from accidental spills [10,12,13], amalgam preparations [3,9] teeth restorations with amalgam [3,5,9], removal of old amalgam restorations [1,3,5,13,14], polishing of amalgam restorations [1,9], contaminated amalgam capsules [5,12], leakage of amalgam capsules while amalgamation [5], expelling excess mercury with hands [3,13], mechanical amalgamators [13,14], ultrasonic condensers [5,13], not using high vacuum suction when removing old amalgam restorations, and using dry sterilization [1,13]. Mercury vapor arising from the floor may also be the most important cause of contamination [15]. The most important factors which may affect the body mercury level in dentists are method of amalgam mixing, type of amalgam used, number of amalgam restorations done per day, working hours per week [4,16], work experience, and office's age [16]. The most common ways through which mercury can enter the body are respiratory system, digestive system, and skin [9,17]. Respiratory tracts absorbs about 80% of the inhaled mercury vapor [5,9,10,14,18]. The mercury then is distributed by blood circulation to a number of key organs such as liver, heart muscle, oral tissues, and brain [19,20]. Exposure to mercury may lead to various conditions including autoimmune system disorders [21,22], renal dysfunction [6,21-23], infertility [22,24], negative effect on fetus [22,25-27], neuro-behavioral problems [27], cardiac dysfunction [28], multiple sclerosis [19], Alzheimer [21,29,30] destructive effects on central and peripheral neural system [6,21,25,31], acute respiratory insufficiency, dermatitis, dementia, nausea, vomiting, diarrhea abdominal pain, hematuria, conjunctivitis, necrotizing bronchitis, pneumonia, pulmonary edema, metal fume fever, neuropsychotic disorders, ocular disease, and oral problems [31]. Therefore, it is critical to determine mercury level in individuals having direct occupational exposure to this toxic element and to investigate the methods for minimizing blood mercury and its harmful effects on the body.

**Table 1.** Factors investigated as the determinants of blood mercury levels among dentists of Hamadan city (n=43).

| Variable Source | Mean | Min | Max | SD |
|---|---|---|---|---|
| **Age (year)** | 37.3 | 27 | 73 | 9.6 |
| **Working experience (year)** | 11.02 | 1.5 | 46 | 9.11 |
| **Average working hours in the office** | 5.7 | 0 | 14 | 6 |
| **Average working hours in the clinic** | 3.4 | 0.5 | 8 | 1.6 |
| **Number of amalgam restorations per day** | 4 | 0 | 8 | 1.9 |
| **Number of amalgam removals per week** | 4.7 | 0 | 17 | 4.2 |
| **Offices age (year)** | 8.59 | 1 | 45 | 1.95 |
| **Interval between cleanings of amalgamator (day)** | 11.88 | 0 | 180 | 28.44 |
| **Interval between cleaning of Unit Basin (day)** | 2.8 | 0.5 | 10 | 2.52 |
| **Size of the working room ($m^2$)** | 20.33 | 1.5 | 40 | 9.47 |
| **Interval between cleanings of the offices floor (day)** | 1.17 | 0 | 7 | 1.07 |

SD= Standard Deviation

The purpose of the present study was to determine blood mercury level (BML) in dentists practicing in Hamadan city using cold vapor atomic absorption method, and to investigate some of its determinants.

## MATERIALS AND METHODS

This cross sectional study was done on all dental practitioners of Hamadan (n=43). Based on the most important effective factors on BML mentioned in several articles, a questionnaire was prepared. Then a list of all active dentists in Hamadan was taken from the Medical Council.

The questionnaires were personally handed among all the dentists except surgeons and orthodontists who do not use amalgam and have low exposure to mercury. Participants were explained and asked to complete an informed consent and the questionnaire that included

**Table 2.** Blood mercury levels according to some related variables in dental practitioners of Hamadan city (n=43).

| Variables | | Mean(µg /l) | SD (µg /l) | P-value |
|---|---|---|---|---|
| **Sex** | female | 5.13 | 0.95 | 0.001 |
| | male | 6.73 | 1.20 | |
| **Age (years)** | > 37 | 6.48 | 1.1 | 0.838 |
| | ≤ 37 | 6.39 | 1.41 | |
| **Working in a clinic besides their offices** | Yes | 6.67 | 1.37 | 0.337 |
| | No | 6.27 | 1.27 | |
| **Using dry sterilization (fur)** | Yes | 7.15 | 1.1 | 0.036 |
| | No | 6.11 | 1.23 | |
| **Using diamond bur for removing amalgam** | Yes | 6.57 | 1.37 | 0.223 |
| | No | 5.93 | 0.95 | |
| **Who polished amalgam regularly** | Yes | 5.95 | 1.18 | 0.011 |
| | No | 6.99 | 1.30 | |
| **Amalgamator in working room** | Yes | 6.51 | 1.38 | 0.665 |
| | No | 6.23 | 1.10 | |
| **Working hours per day** | > 5.5 | 6.89 | 1.09 | 0.021 |
| | ≤ 5.5 | 5.06 | 1.39 | |
| **Number of amalgam restorations per day** | > 4 | 7.32 | 1.16 | 0.000 |
| | ≤ 4 | 5.73 | 0.969 | |
| **Fish meals per week** | > 1.1 | 6.59 | 1.36 | 0.283 |
| | ≤ 1.1 | 6.10 | 1.18 | |
| **Interval between cleaning of amalgamator (day)** | > 11.5 | 6.08 | 1.43 | 0.311 |
| | ≤ 11.5 | 6.57 | 1.28 | |
| **Work experience** | > 11 | 6.67 | 1.1 | 0.427 |
| | ≤ 11 | 6.33 | 1.42 | |
| **Office age (year)** | > 8.5 | 6.91 | 0.95 | 0.138 |
| | ≤ 8.5 | 6.24 | 1.44 | |
| **Amalgam removal per week** | > 4.5 | 6.72 | 1.32 | 0.278 |
| | ≤ 4.5 | 6.26 | 1.31 | |
| **Size of office (meter)** | > 20 | 6.50 | 1.23 | 0.854 |
| | ≤ 20 | 6.42 | 1.38 | |

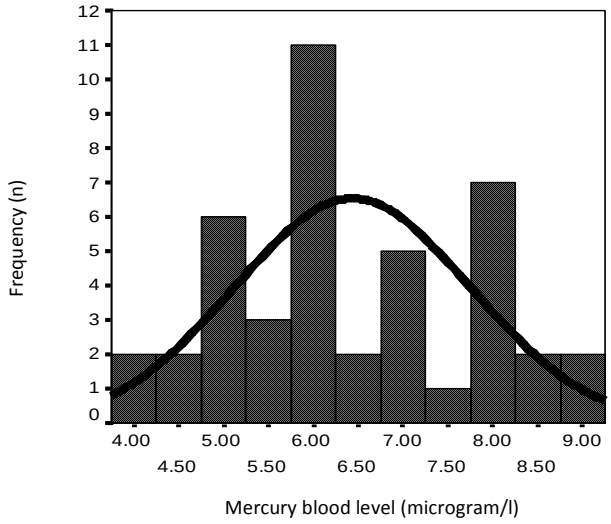


**Fig 1.** Histogram of blood mercury levels among dentists of Hamadan city (n=43).

questions on demographics and factors affecting BMLs. From each participant, 5 cc of venous blood was taken and stored in lidded preheparinized collection tubes. For preparing the samples, 0.5 cc from each blood sample was poured in a tube. Then 5 ml concentrated $H_2O_2$ (Hydrogen peroxide) and 3 ml concentrated $H_2SO_4$ (sulfuric acid) were added to the tube for oxidation. For converting all forms of the present mercury (Hg) in the sample to mercury ions ($Hg_2^+$), 0.5 ml $KMnO_4$ (potassium permanganate) 5% w/v was added. At the end some $HONH_3Cl$ (Hydrochloride Hydroxide Amine) 12% w/v was added to remove the excess permanganate and decolorize the purple samples.

A cold vapor atomic absorption analyzer system VAV-440 (Thermo Jarrell Ash Co. SH-22 Model, Franklin, Massachusetts, USA) was used to measure mercury. The device was calibrated and prepared, and the samples were poured in its bottle. In this step the device added 0.5 ml $SnCl_2$ (tin chloride) 5% w/v in HCl 25% w/v to the samples. This solution vaporizes present mercury in the samples (neutral atomic vapor) and guides this vapor to the absorption cell by argon gas available in the device. Finally, BML was measured by comparing the amount of the samples absorption with the calibration curve at 253.7 nm resonance line.

The findings were evaluated statistically using SPSS for windows version 13 (SPSS Inc., USA). Pearson correlation analysis and regression models were used to assess the relationship between BML and other variables. Results were considered significant when P value $< 0.05$.

## RESULTS

The average BML of the dentists was 6.43 µg/l with SD=1.31, a minimum of 4.15, and a maximum of 8.93 (Fig 1). Corresponded figure among men (35 individuals) was 6.73 µg/l and among women (8 individuals) was 5.13 µg/l (Table 1).

Dentists working in a clinic in addition to their private offices and those using dry sterilization (fur) had higher BML than the others. Higher BML was also apparently in association with increase in working hours per day (Fig 2), in number of amalgam restorations per day (Fig 3), in number of amalgam removals per week, and in office's age.

Higher BML was detected among dentists having more fishmeals per week, among older dentists, and among those with longer work experience. BML was also higher among dentists using diamond bur for removing amalgam, those using powder/mercury amalgamator with mercury reservoir, and those who triturate amalgam in person. On the other hand, lower BML was found among the dentists who polished amalgam regularly. Cleaning unit basin regularly and working in a larger office room was not associated with lower BML.

Lower BML was noticed among the dentists keeping their amalgamators outside the working rooms and those who more frequently had their amalgamator and the office's floor cleaned. Regarding the type of air ventilation, using fan, window, and air conditioning, re-

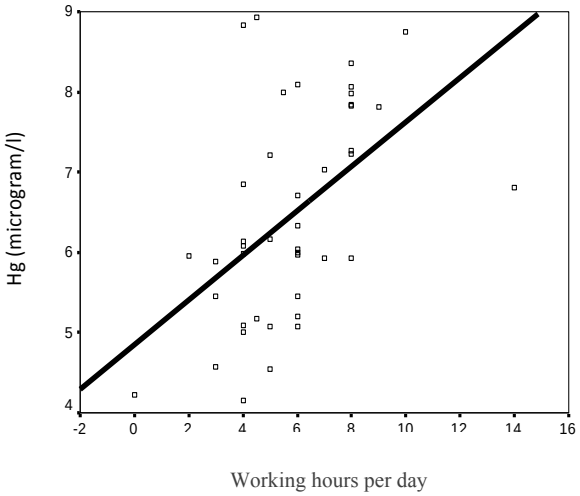


**Fig 2.** Scatter diagram of blood mercury levels according to the average working hours per day among dentists of Hamadan city (n=43).

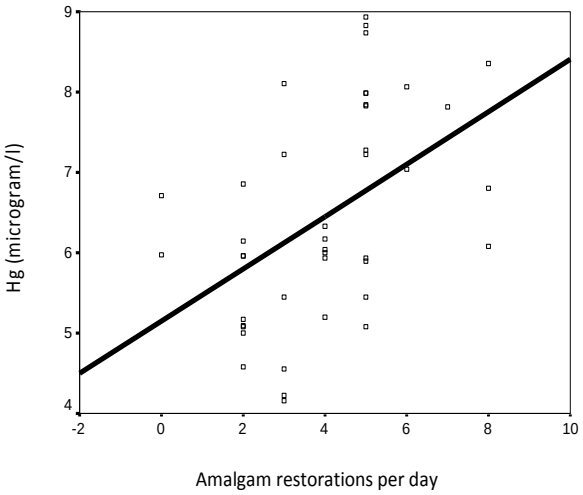


**Fig 3**. Scatter diagram of blood mercury levels according to the number of amalgam restorations performed per day among dentists of Hamadan city (n=43).

spectively, was associated with lower BML.

BML was lower among dentists whose office's floors were of ceramic and mosaic compared to those working in offices with stony floor. Highest BML was detected among the dentists who used nylon floorings in the office. Higher BML was also detected among dentist working in offices with walls covered with dye, chalk and wallpaper compared to those working in offices with ceramic-covered wall.

None of the above mentioned differences were statistically significant except for differences related to gender, regular amalgam polishing, using dry sterilization, working hours, and the number of amalgam restorations per day (Table 2). Pearson correlation analysis revealed that working hours and the number of amalgam restorations per day were significantly correlated with BML (P<0.001 and P=0.002, respectively). Correlation coefficient (r) between BML and these two factors were 0.529, and 0.474, respectively. Simple linear regression analysis of all investigated variables showed that only average working hours in the office and the number of amalgam restorations per day were significantly associated with BML (P=0.001, P=0.002).

## DISCUSSION

In the present study, Cold Vapor Atomic Absorption method was used to measure BML, which is one of the priciest methods. This method has been used in many previous studies [3,4,12,32].

Average BML among participants of the present study was 6.43 µg/l, SD=1.31. Previous studies on this subject have shown various results. In a research done by Muller in 1988, in Denmark, BML of 130 dentists was measured and in 40% of them, this concentration was over 5 µg/l [4]. In another study performed by Chang et al [12] in 1992, the average BML in dentists was 5 µg/l and in another study it was 8.2 µg/l [16]. This variation is not unusual since BML is affected by various factors including geographical locations and diets. Safe BML is determined in each region according to its ecological conditions. For example, BML in normal volunteers living in Tehran has been reported to be 8.48, SD=4.42, in Buyat Bay (Jakarta) 8.0, in Czech Republic 6.8, in Madeira (Portugal) 15, in Lisbon (Portugal) 18, and in New York 2.73 µg/l [19]. A maximum of 3 µg/l has been determined as allowable BML [2].

In our study, male dentists had higher BML, which may be due to their longer working hours and their higher number of patients. In a study performed in 2005 on mercury urinary level of Turkish dentists, this concentration was also higher in males than females, and the difference was statistically significant [3]. The present study showed insignificant higher BML in older dentists, those with more working experience, and those having more fish-meals. Previous studies also have shown higher MBL among dentists with longer working experience [13,16] and those with more frequent use of fish meals per week [4,12]. Similar to our research, the relation between the dentists' BML and age in a previous study was not statistically significant [3]. Möller-Madsen et al [4] reported that age, sex, number of amalgam restorations per week, and method of amalgam mixing were not associated with BML among dentists, and the only related factor was frequent use of fish meals per week [4]. This factor has been noted by many of the previous studies [1,2,5,4,25]. After having fish, methyl mercury is easily absorbed by the body; but it is expelled much slower than other forms of metallic and mineral mercury after absorption. Thus, this substance tends to accumulate in some of the organs such as liver, kidney, and brain [1]. A research on environmental and occupational sources of exposures to mercury identified amalgam restoration as the main source of exposure to inorganic mercury and fish as the main source of exposure to methyl mercury [3]. World Health Organization has also estimated that having seafoods once a week increases urinary mercury level 2-8 times [2].

In the present study, using powdered amalgam-alloy and amalgamator with mercury reservoir were associated with higher BML although the difference was not statistically significant. This maybe due to the fact that, using powdered amalgam alloy and amalgamator with mercury reservoir increase the probability of skin exposure and accidental spellings, which in turn, increase BML [12]. That is why using amalgam capsules are recommended [1]. Even when using amalgam capsules, due to the high frequency of mixing some substances rich of mercury can be driven out of the capsules and distributed by 6-12 feet further [1].

In the present study, insignificant higher BML was noticed among dentists who filled powdered amalgamator in person. It can be as a result of more skin absorption and more inhalation of mercury vapor. The same result was found in Chang's et al study [12]; but in Battistone's et al study [16], no statistically significant difference existed between the dentists who filled the amalgamator themselves and those who had their assistants to do it. This diversity can be related to amalgam and amalgamator's type, which seem to be effective on BML of the dental staff's.

In the present study, BML was associated with increase in working hours per day [13,16]. Those working longer in a day are more exposed to mercury vapor in the working place. Thus, the amount of systemic mercury absorption increases in them [16]. On the other hand, those dentists do likely more amalgam restorations, which is a cause of higher BML itself. While removing amalgam, mercury-silver phase may melt. With an increase in the number of amalgam restorations per day and also in the number of amalgam removals per week, higher BML is noticed which may be a result of more mercury vapor's inhalation [1]. The same results have been found in the previous studied [12,16].

Battistone's et al [16] reported that higher BML was higher among dentist working in older offices compared to those working in newer offices; but in Karahalil et al study [3], as well as in the present study; this relation was not significant. In addition, dentists who used dry sterilization (fur) for sterilizing had higher BML. Several studies have reported higher mercury concentration when dry sterili-

zation is used [1,13].

$Ag_2Hg_3$ phase (Gamma one phase ), one of the products of reactions in amalgam, has a low melting point (127°C) and can change easily to liquid if the heat is not controlled during polishing amalgam. This causes more mercury vapor to be produced. This usually happens when a dentist polishes amalgam restorations without enough water and with high speed [1]. In the present study, contrary to what was expected, the dentists who polished amalgam regularly had lower BML. This may be due to other interventional factors, such as these dentists' more knowledge on mercury and its safety points.

Dentists using carbide burs for removing amalgam, in comparison with those using diamond burs, and those whose amalgamators were not in their working rooms, had lower BML, although the difference was not statistically significant. Diamond burs, according to the mentioned mechanism, produce more heat and Ag-Hg phase is melted and more mercury vapor is released [1]. Leakage from amalgam capsule during amalgamation may cause mercury vapor to be spread and air to be contaminated [2]. Consequently, those dentist keeping their amalgamator in another room inhale less mercury-contaminated air.

In the present study, no association existed between the size of the working room and the dentist's BML. Ventilation seems to be more important than the size of working room in mercury hygiene. It has been found in the previous studies that air conditioning in an office decreases BML efficiently [1,3,12]. Dentists are recommended to install suitable ventilation in their office according to various valid references [1,2,7].

In our study, no association existed between the type of flooring or the wall's covering and blood mercury. Researchers have shown that if a small drop of mercury contaminates the floor, the only practical way for decontamination is to change the flooring [1]. Therefore, the office flooring should not be absorbent and should not have any fissures and fractures [1]. Using high vacuum central suction while working with amalgam decreases mercury vapor in environment and therefore reduces systemic absorption [1,2,9]. In our study, only one participant used high vacuum suction. In a study performed by Pohl in 1955, it was found that when high vacuum suction was used in cutting amalgam, filling with amalgam, and polishing amalgam restorations, the mean mercury vapor inhaled by the dentists was 1-2 µg/l and this amount was increased when normal suction was used [9]. Since most of the participating dentists in this study had no distinct method for throwing away amalgam bits and amalgam excess, questions related to this were excluded. However, in various references, it has been mentioned that amalgam bits should be collected, stored in a closed container and be discarded separately [1,2,4,9,17]. One of the other questions being asked in the questionnaire was about mechanical ultrasonic condensers. This question was also excluded because none of the participants in this study used this device. Using these types of condensers can spread more mercury vapor. Therefore, it is recommended to use hand condensers for packing instead of these condensers [1,2].

The present study not only determined the BML in dental practitioners of Hamadan, but also investigated some of the determinants of BML, which should be taken into consideration in other experimental studies.

## CONCLUSION

This study showed that the BML of dental practitioners of Hamadan had a higher average and standard deviation than what has been previously mentioned for many of the dental personnel. Working hours and the number of amalgam restorations per day were significantly associated with increase in BML. With regard to the number of amalgam restorations

done in dental offices and clinics, especially in Iran, it seems that more emphasis should be placed on mercury hygiene and its related instructions.

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