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# DENTAL AMALGAM EXPOSURE AND URINARY MERCURY LEVELS IN DENTISTS

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ABSTRACT

Introduction: Amalgam has been used in dentistry for more than a century. Amalgam restorations are done widely across the world. The reason for its use is its desirable physical properties, such as good sealing strength, durability, and ease of use. It is a combination of metal powders (mainly silver, tin, and copper) and a mercury compound. The latter makes up about 50 per cent of the amalgam. This puts dental staff, including dentists and their assistants, in great risk of mercury poisoning.
Goal: The aim of this study is to measure urinary mercury content of dentists in Tabriz.
Material and Method: In this case-control study, 48 dentists in Tabriz were studied as a case group. Urine samples (20 ml) for the study were taken and mercury concentrations determined by atomic spectroscopy. Descriptive and analytical measures like t-test, and ANOVA were used and analysed by SPSS software (version 16) and α=0.05 was considered significant.
Results: The average urinary mercury content of dentists was 20.9±6.71 micrograms per litre. There was a significant correlation between the daily and weekly hours of work and urinary mercury content (p-value <0.01). However, the number of daily amalgam filling and replacement was not associated with urinary mercury content (p-value=0.51). There was a significant correlation between the used amalgam types (capsules or bulk) and urinary mercury level (p-value=0.015). However, the urinary mercury level had no significant correlation with the presence of amalgam waste, and air conditioning.
Conclusion: According to the study, urinary mercury levels were below the threshold in dentists, though its level was higher than that of the average citizen.



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## Introduction

The most common material used for dental restoration is amalgam. Its history goes back more than a century. The reason why amalgam is used in dentistry is its desirable physical properties such as favourable sealing strength, acceptably long life, and easy usage(1; 2) .It is a combination of the powders of several metals (mainly silver, tin, and copper) and mercury, which makes up about 50 per cent of its composition. If the metals of the periodic table are compared, mercury is the most dangerous metal after plutonium. It is the most toxic and dangerous metal on earth after the radioactive elements (1) .

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In recent years, amalgam has been used more cautiously because of the dangers of mercury poisoning. Its use in several countries was significantly reduced in the last decades of the 20th century.

Mercury plays an important role in triggering over 40 diseases, such as periodontal disease, immune system diseases, cardiovascular problems, and digestive and nervous system diseases(3; 4). Some studies have shown that mercury affects the heart, too. Mercury leads to the loss of glutathione(5), and due to its effect on lipids, leads to cardiovascular complications(6) .

Metallic mercury vapour may also increase the rate of miscarriages in women. As a side effect of mercury, they may also give birth to children with congenital diseases. Toxic substances may injure the sensitive reproductive system so that reproduction is either impossible or babies are born with congenital disorders. Mercury can also affect breast-fed babies(7,8) .

The potential for contamination and mercury poisoning in dental staff, including dentists and their assistants, is great. Dental personnel are most likely to be infected by inhalation of mercury vapour in their office. The body cannot absorb the metallic mercury and it is excreted through urine(9,10) .Since the short half-life of the mercury concentration in blood is about three days, urine tests are used to assess long-term exposure(11,12). Some studies suggest that the measurement of urinary mercury is the most practical and sensitive way to demonstrate occupational exposure to low-density inorganic mercury(13,2) .The rate of exposure to mercury depends on the exposure to the metallic mercury droplets and debris of amalgam particles in the workplace. The peak of this exposure is in private dental work, such as preparation, placement, and removal of amalgam restorations(14,15) .

The type of amalgamator, air conditioning, floor coverings, and standards of hygiene, such as washing and cleaning habits, and existence of shed droplets affect the rate of exposure(16,17) .Additionally, certain conditions of work (age of dentist, employment history, and number of teeth restored in a week) are other factors involved in the mercury intake of the body(18) .

It should be noted that the standard amount of urinary mercury in normal people with 1–5 micrograms per litre and for dentists with 1-6 micrograms per litre are considered to be normal(19,20) .

Studies show that the measurement of urinary mercury is the most practical and sensitive method to show occupational exposure to low-density inorganic mercury. Given that, this study aimed to determine the amount of urinary mercury of dentists in Tabriz and compare it with the control group by taking into account the role of factors such as race and genetics.

Emphasizing that the job security of dentists is effective in promoting the total level of public health, the study also aimed to inform the dentists who are at risk of mercury poisoning.

Material and Method

In this cross-sectional study, a list of all dentists was prepared in the city of Tabriz. Akbari et al.(21) calculated the sample size as 96, using a formula to calculate the sample size with a standard deviation of 2.7 and accuracy of 0.5.

$$n = \left[\frac{z_{\alpha/2}\sigma}{E}\right]^2 = (1.96*2.7/0.5)^2 = 96$$

In all, 48 general dentists were chosen in random, using the names and addresses listed at the Medical Council. The chosen dentists were all graduates aged between 27 and 55 years, had served in clinical practice for at least a year, with at least five half-day shifts (morning or evening) at the time of the test, and had not eaten seafood for at least a week before it.

In the control group, 48 people from the general population, aged between 27 and 55 years, with no occupational exposure to mercury or dental fillings with amalgam, and who referred to the Tabriz Faculty of Dentistry, were selected.

The samples (control and case group) were prepared with 20cc of urine in bottles of polyethylene. The sampling of the dentists' urine was done before they started the day's work midweek. The atomic absorption device made in the biochemtech analytical instrument CTA300 2006 factory in England was used to measure urinary mercury. It should be noted that the amount of mercury released per minute was recorded on the device's screen. The highest number was considered as the amount of mercury in the sample urine in micrograms per litre. The case and control groups were synchronized to eliminate the confounding effects of age and gender.

Statistical Methods

All demographic data was collected and the studied data were analyzed by IBM® SPSS® release 16.0.0.

Frequency statistical tests, frequency percentage, cumulative frequency, frequency distribution tables, and histograms and pie charts were used for descriptive statistical analysis of the studied population.

In inferential statistics, the analysis of variable and analysis of hypothesis (ANOVA and t-test) to compare the means, and the mean difference test were used for independent groups, the chi-square association test or the Fisher Exact Test was used to assess the association between the qualitative variables, and the linear regression was used to investigate the relationship between quantitative variables with each other, and they were statistically analyzed. In this study, the P value of less than 0.05 was considered to be statistically significant.

**Results**

Seventy-two people with a frequency of 76.6% were male and 22 people with a frequency of 23.4% were female

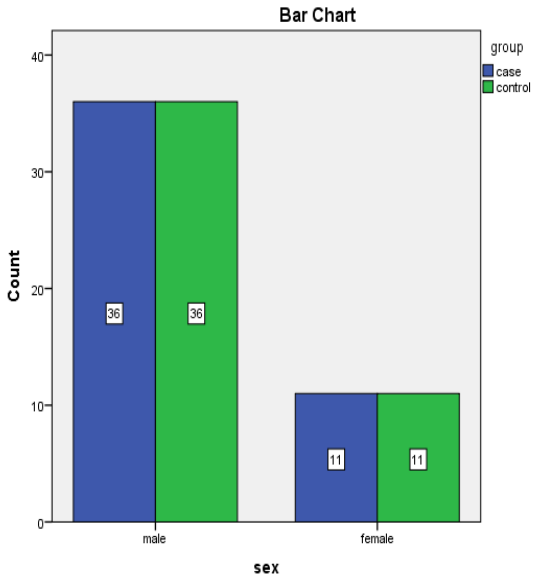
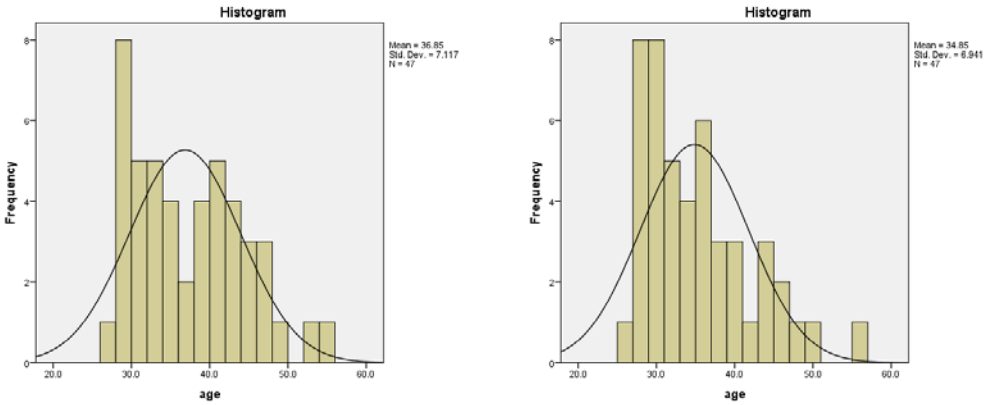



**Figure 1**. Sexual frequency of people in the studied groups

The mean age in the case group was $36.85 \pm 7.11$ with a median of 36 and mode of 28 in the range of 37 years (27–54). The mean age in the control group was $34.85 \pm 6.94$ with a median of 33 and mode of 28 in the range of 29 years (26–55). There was no significant difference between these two groups in term of age according to the statistical t test (p-value = 0.17).




Case group control group

The average urinary mercury levels in the case group and control group were $20.9 \pm 6.71$ and $2.57 \pm 1.02$ respectively. This was significantly higher in the case group, according to the statistical t-test (p-value<0.01).

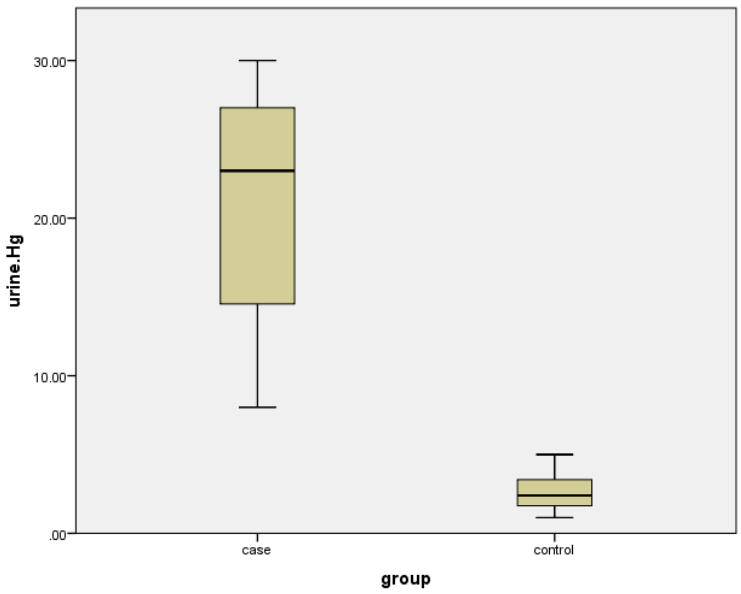



**Figure 4.** The urinary mercury levels in the people in each group

Sixteen dentists (34%) and 31 dentists (66%) used weighted amalgam and capsule amalgam respectively.

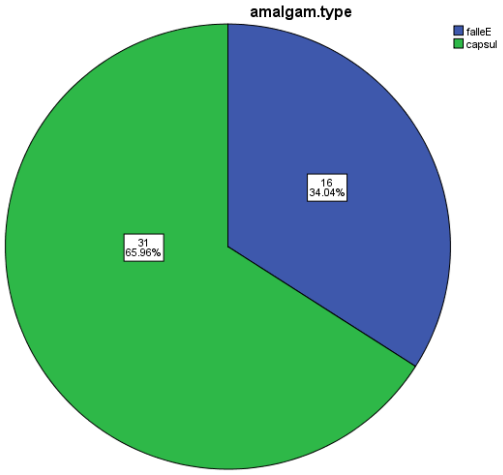
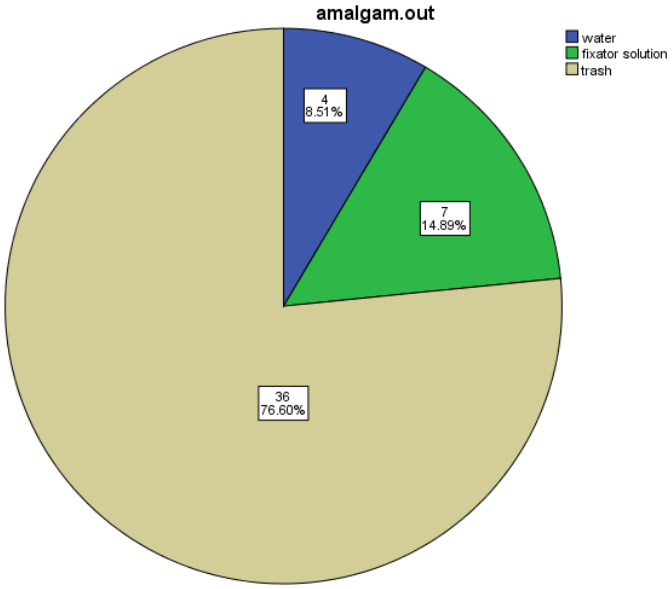



**Figure 5.** The frequency of amalgam type used by dentists

Four dentists (8.5%) wash off the additional amalgam in water, while seven dentists (14.9%) wash it off in the solution, and 36 (76.6%) dispose of it in the garbage.




Three dentists (6.4%) did not use a mask during work. Ten dentists (21.3%) used a fabric mask; 14 dentists (29.8%) used a two-layer mask, and 20 dentists (42.6%) used a paper mask.

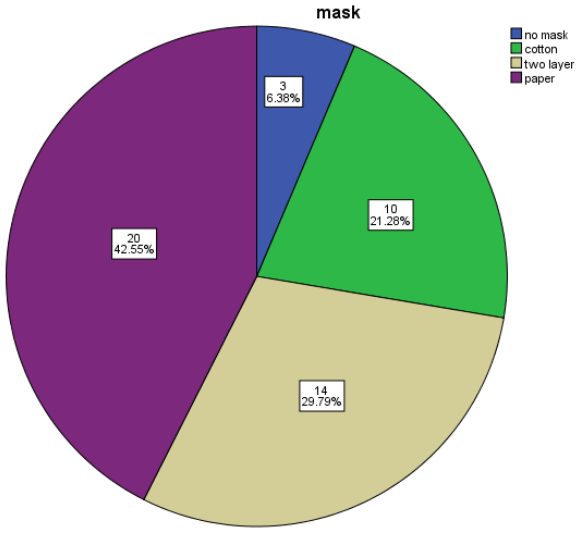



**Figure 8**. The frequency of mask type used by dentists

There was no air conditioning in 18 clinics (38.3%).

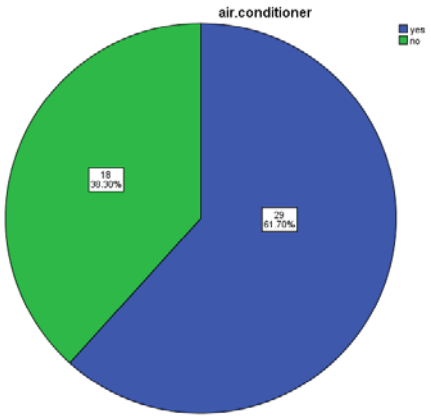



**Figure 9.** The frequency of air conditioning in the clinic

The average working hours of the dentists in a week was $35.13 \pm 10.51$ with a median of 35 and a mode of 30 in the range of 57 hours (15–72).

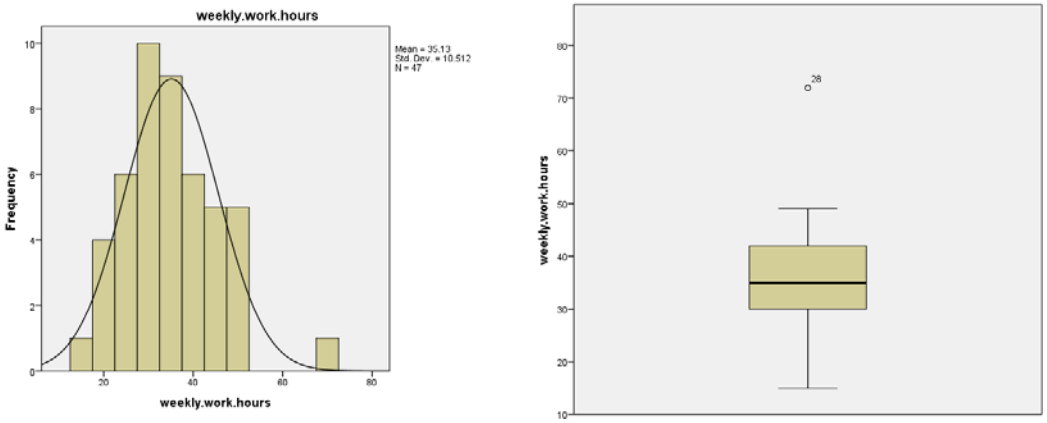



Figure10: Distribution of dentists' working hours per week

The average duration of the dentists' work hours was $9.84 \pm 7.18$ with a median of 10 and a mode of 2 in the range of 25.75 years (1.25–27).

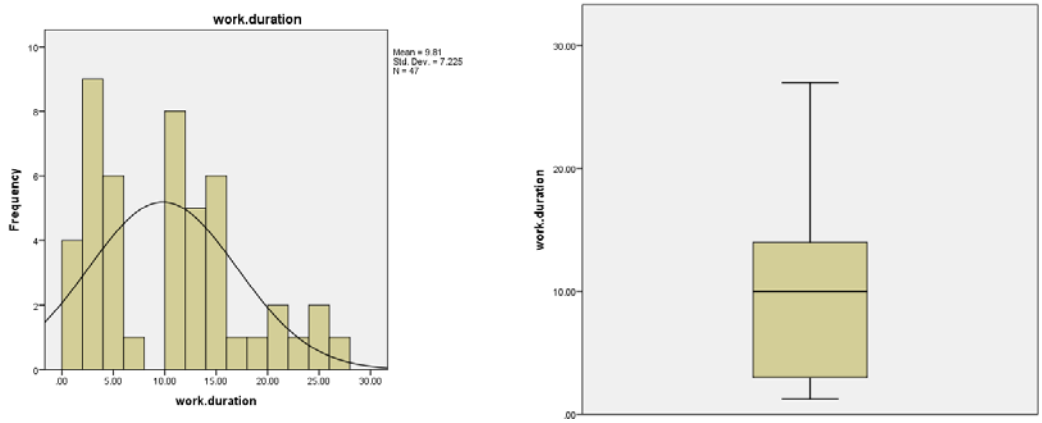



Figure 11: Distribution of dentists' working time (in years)

The work duration of the doctors was defined according to the number of 'working hours per day x the number of working days per week x 4 x 12 x years of work', and the mean hour was $16103.48 \pm 11647.7$ .

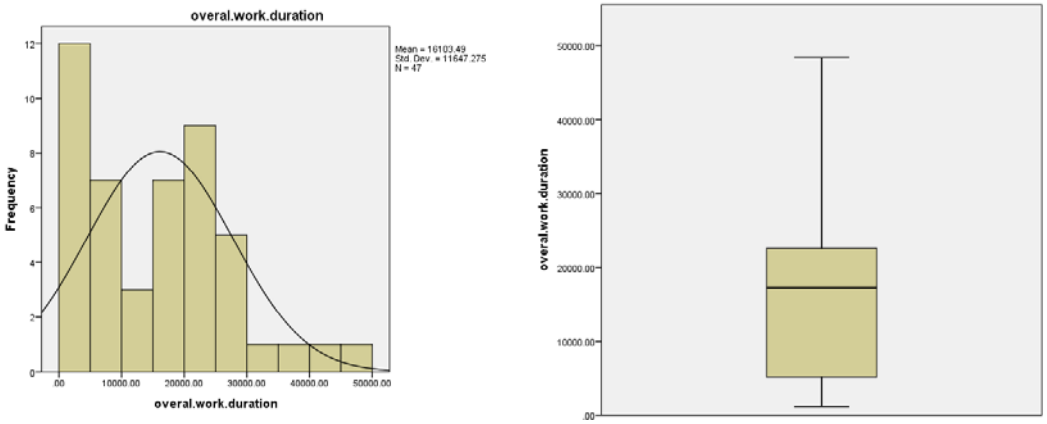



**Figure 13.** The distribution of dentists' working time (in hours)

No significant relationship was observed between the urinary mercury level and the number of amalgams used according to the Pearson's correlation test (p-value = 0.51).

A significant relationship was observed between the work duration and urinary mercury levels of dentists according to the linear regression method (p-value <0.01).

Table 1: The relationship between urinary mercury level and working time in hours

Dependent Variable: urine .Hg

| | Model Summary | | | | | Parameter Estimates | |
|---|---|---|---|---|---|---|---|
| Equation | R Square | F | df1 | df2 | Sig. | Constant | b1 |
| Linear | .320 | 21.208 | 1 | 45 | .000 | 15.653 | .000 |

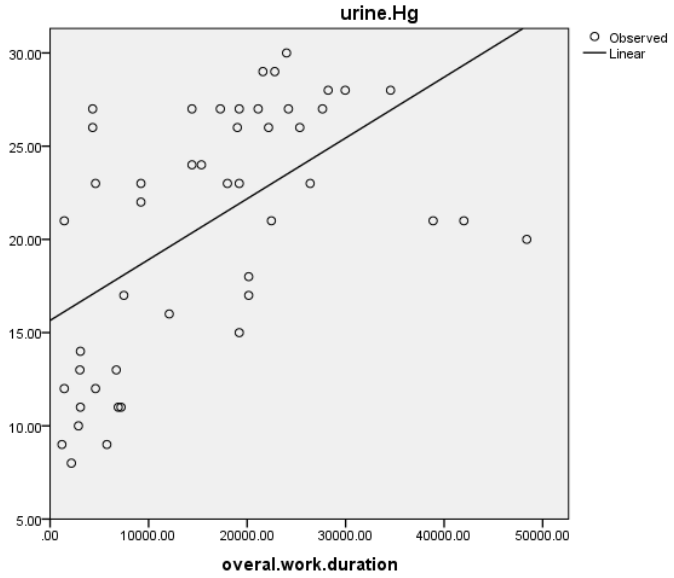



**Figure 18**. Dispersion of the level of urinary mercury according to working time in hours

No significant relationship was observed between the urinary mercury level and the type of the clinic according to the statistical t-test (p-value = 0.63).

A significant relationship was observed between the urinary mercury level and the amalgam type according to the statistical t-test (p-value = 0.015). The amount of urinary mercury in dentists who used a weighted amalgam(24.18±4.91 microgram/ litre) was greater than those who used the capsule type (19.21±6.95 microgram/ litre).

No significant difference was observed in the relationship between urinary mercury level and the type of amalgam disposal according to the statistical ANOVA test (p-value = 0.46).

No significant relationship was observed between urinary mercury level and the washing equipment according to the statistical t-test (p-value = 0.29).

A significant relationship was found between the urinary mercury level and the falling of mercury drops on the ground, according to the statistical t-test (p-value = 0.04). The mercury level was higher in the group with a history of falling mercury drops(23.26±4.07 microgram/ litre) compared with the group with no such history(19.3±7.68 microgram/ litre) .

No significant relationship was observed between urinary mercury level and the mercury-storing place, according to the statistical t-test (p-value = 0.15).

No significant relationship was observed between the urinary mercury level and ventilation, according to the statistical t-test (p-value = 0.17).

The relationship between mercury levels in urine and the type of mask used, according to the ANOVA test, was significant (p-value = 0.012). The urinary mercury level in the group using fabric and two-layered masks was lower than the groups using paper mask or no mask.

**Discussion**

The average urinary mercury level was(20.9±6.71 microgram/ litre) in the case group, and(2.57±1.02 microgram/ litre) in the control group, which means the level is significantly higher in the case group according to the statistical t-test (p- value <0.01).

A significant relationship was seen between the work duration in hours and the urinary level of mercury (p-value <0.01).

In the study by Tabatabai et al.(18) the mean of the dentists' urinary mercury was(3.1±3.95 microgram/ litre). There was a positive and significant correlation between working hours per day and urinary mercury level, and between working hours per week and urinary mercury level (p=0.006). According to the findings of this study, the mean of the dentists' urinary mercury level in Tehran was lower than the international standard limit (WHO-OSHA).

Golbabaei et al.(22) showed in a study that the amount of the dentists' urinary mercury was $0-99\mu g/lit$ with a mean of $57.2\pm36.4\mu g/lit$, which is very high compared with the result of the present study.

Majid Akbari et al. (2010) showed in a study in Mashhad that the mean of the urinary mercury levels present in the general dentist, specialists in restorative dentistry, and the control group were $9.26\pm2\mu g/lit$, $9.13\pm1.79\mu g/lit$, and

$1.84 \pm 1.73 \mu g / lit$ respectively. There was no significant difference in the concentration of urinary mercury in general dentists and specialists in restorative dentistry, while their urinary mercury concentration was significantly higher than that of the control group (P = 0.000 and P = 0.002 respectively).

M Neghab et al. (23) investigated the symptoms and urinary levels of mercury in dentists compared with physicians in Shiraz in 2011, and showed that the mercury level in the air has a direct correlation with the urinary level of the mercury. This amount in dentists $(3.22 mcg / l)$ is significantly higher than that of physicians $(1.83 mcg / l)$ (p-value=0.006).

Moris M Joselow et al. (1963) investigated the relationship between the excretion of mercury in dentists in their case-control study and concluded that there was a relationship between the urinary level of mercury and the environmental mercury pollution rate. Also, there is a direct relationship between the the rate of working hours and the urinary level of mercury(Joselow & Goldwater, 1967) .C Naleway et al. investigated the urinary level of mercury in 4,272 dentists between 1975 and 1983 in their analysis-descriptive study. The average urinary mercury level of these people was $14.2 \pm 25.4 mcg / l$. This study related the urinary mercury level with the history of work, the weekly working time, the type of ventilation, the type of amalgam used, and the number of working hours with amalgam(24) .

Oliveira et al. (2010) assessed the urinary mercury levels of patients and dental students exposed to the amalgam. There was a significant difference between the urinary mercury levels of the groups before and after exposure to the amalgam. The urinary mercury concentration was significantly higher for the students and patients' group before exposure (p = 0.0038) and after exposure ( p = 0.0045)(25) .

The mercury level measured in some studies is higher or lower than the results of this study. However, in most studies, this amount in dentists is significantly different from that in normal people. Although this amount is lower than the poisoning limit, the level is related to the working experience of dentists and their weekly working hours.

There are a lot of differences in the results of studies. Those can be induced by different methods of study or difference in the studied sample (blood, urine, and plasma) and unit of measurement (mcg/lit, nmol/lit). The results may be inconsistent even in the studies in which the same method or unit has been used. This difference might be due to insufficient knowledge of the factors that affect exposure to the mercury, the time taken, the environment, and the use of capsule amalgam in recent years. The difference in professional hygiene practices in the public and semi-public facilities, compared with private clinics, can be considered an important factor.

It seems that the work hours and experience are among the factors that have a direct impact on the mercury level in urine. But this relationship has not been observed in some studies(16), which may be due to the need for a minimum period of six months to create a sustainable level of mercury in the body and the mercury secretion in urine.

In this study, the total number of working hours was computed and used as a measure of the total hours of exposure in a dentist's lifetime.

A significant relationship was found between the urinary mercury level and the type of amalgam used (p-value = 0.015). The amount of urinary mercury in dentists who use the weighted type of amalgam $(24.18 \pm 4.91)$ was higher than those who use the capsule type $(19.21 \pm 6.95)$.

C Naleway et al.(24) investigated the urinary mercury level in 4,272 dentists between 1975 and 1983. This study related the amalgam type used to the number of amalgams used with urinary mercury level.

The study found that the use of capsule amalgams reduces the emission of mercury vapour in the workplace as well as the mercury entering the dental staff's body (26)ut other studies(27) did not achieve this relationship.

Skare et al.(4)reported that the use of capsule amalgams increases the rate of urinary mercury level(4). In the Rich et al. (27) study, there was no difference in the rate of urinary mercury level of dentists who used only wighted amalgams and those who used only capsules(27).

There was a significant relationship of urinary mercury level and a fallen drop of mercury (p-value = 0.04). The mercury level in a group with a history of falling drop $(23.26 \pm 4.07 \mu g / lit)$ was higher than a group with no history of falling drop $(19.3 \pm 7.68 \mu g / lit)$.

Thus, environmental contamination and poisoning of people can be prevented by exercising caution when using amalgam.

Although it seems that factors such as the method of discarding amalgam waste, storing crude amalgam, the location of the sterilizator, the type of flooring, and the presence or absence of ventilation and its type influence the release rate of mercury vapour, and as a result, the amount of urinary mercury in dentists. In this study, no statistically significant relationship was found between these factors and the amount of urinary mercury of dentists.

There was a significant relationship between the urinary mercury level and the type of mask used (p-value=0.012). The level in the group using fabric or two-layered masks was less than that in the group using paper mask or no mask.

This demonstrates the lack of a protective effect of paper masks compared with fabric and two-layered masks. No significant difference was observed between the group using paper mask and the group who used no mask.

**Conclusion**

The average levels of urinary mercury in the case group and the control group were $20.9 \pm 6.71 \mu g / lit$ and $2.57 \pm 1.02 \mu g / lit$ respectively. The level is significantly higher in the case group. A significant relationship was found between the work duration in hours and the urinary level of mercury.

A significant relationship was observed between the urinary mercury level and the type of the amalgam used. The level was higher in dentists who used a weighted amalgam $(24.18 \pm 4.91 \mu g / lit)$ than in those who used the capsule type $(19.21 \pm 6.95 \mu g / lit)$.

There was a significant relationship between urinary mercury level and a fallen drop of mercury (p-value = 0.04). The mercury level in the group with a history of a fallen drop $(23.26 \pm 4.07 \mu g / lit)$ was higher than the group with no such history $(19.3 \pm 7.68 \mu g / lit)$.

No significant relationship was found between urinary mercury level and the number of amalgams used, the type of clinic, the method of amalgam disposal, washing equipment, storage of mercury, and ventilation.

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