Mercury excretion and occupational exposure of dental personnel

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Abstract – At the annual congresses of the Norwegian Dental Association in 1986 and 1987 surveys were conducted to assess the significance of potential sources of mercury exposure. Morning urine samples and questionnaires were collected from 672 participants in 1986 and 273 participants in 1987. The mean values of the urinary mercury excretion were 39 nmol/L (SD=29) in 1986, and 43 nmol/L (SD=36) in 1987. The excretion values were correlated to the answers on questionnaires supplied from each participant. The data was analyzed using ANOVA, multiple classification analyses, and Pearson correlation. The correlations between environment and practice characteristics and the mercury excretion values reconfirm in general results from previous investigations. In addition, the data indicate that urinary mercury excretion may be gender dependent and that the restorative status of the participants contribute to the daily mercury exposure. Moreover, the excretion correlates not only to the number of placed restorations per week, but also to the number of polished and replaced amalgam restorations per week. Participants working in environments with wooden floors had significantly higher mean mercury values than other dental personnel. Elevated mercury values were also observed for participants working in clinics with installed amalgam separators or other filtering devices. The possibility that the storage of collected scrap amalgam and mercury from the filtering devices increases the mercury vapor in the work environment warrants further investigation.

Key words: adverse effects; amalgam; dentists; urine

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The relationship between mercury exposure and the urinary mercury excretion was assessed in a survey on Norwegian dental personnel conducted in 1986 (1). In general, the findings corroborated previous surveys on mercury exposure of dental personnel (2). However, some unexpected observations on the relationship between urinary mercury excretion and clinical practice characteristics were made. The urinary mercury levels were elevated in the samples from some participants working in environments with strict mercury hygiene regimes and optimal office equipment. The high levels could not be related to contributions from the diet or the dental status of the participants. This could signify that possible exposure sources in the dental clinic remained to be identified. Furthermore, variations in the urinary mercury values could be related to gender and to the dental status of the participants. It was possible that the findings were the results of mere statistical coincidence, or influenced by a bias in the selection of Norwegian dental personnel. The survey was therefore repeated in 1987 in order to control for the potential interactions, and to gain a better basis for interpretation of the observations.

Materials and methods

The methodology was identical in 1986 and in 1987. All participants at the annual meetings of the Norwegian Dental Association in 1986 and 1987 were invited to take part in an assessment of their occupational mercury exposure. A 25 mL plastic container and a questionnaire consisting of questions related to personal and environmental characteristics were supplied prior to the meeting. The questionnaire and methodology were derived largely from the Health Assessment Program conducted at the annual sessions of the American Dental Association (3). The questionnaires and urine samples were collected at the annual meetings. The participants had been instructed to provide morning urine samples to reduce the effects of daily fluctuation of excreted mercury (4). All samples were immediately refrigerated to -4°C, and kept cool until 1 h before analysis, which was performed at room temperature.

The mercury concentrations in the urine were determined within 2 weeks by a direct cold vapor method (5) by means of a modified LDC mercury monitor model 1205. Control urine samples containing 250 nmol/L were added to the test series at intervals for calibration of the apparatus. The precision has been reported elsewhere (6). The detection limit is below 1 nmol/L. The test series were analyzed twice when possible. The specific gravity of urine was measured by weighing for adjustments of the mercury values to the urinary concentrations (7). The urinary mercury values used in this report are in the SI unit: nmol/L (5 nmol/L = 1 μg/L).

An analysis of variance was applied to detect any differences between the samples from 1986 and from 1987. The statistical relationships between the urinary mercury and the variables in the questionnaire was determined with the Eta coefficient for the ordinal and nominal variables, and the Pearson correlation coefficient for the interval variables. A multiple classification analysis (MCA analysis) was in addition used for some of the variables to assess the relationship while compensating for possible inter-variable effects. Differences between the subgroups of each variable were compared with Student-Newman/Keuls test at the 0.05 significance level for a one-way analysis of variance (ANOVA). The statistical analyses were performed for each sample and on a pooled sample.

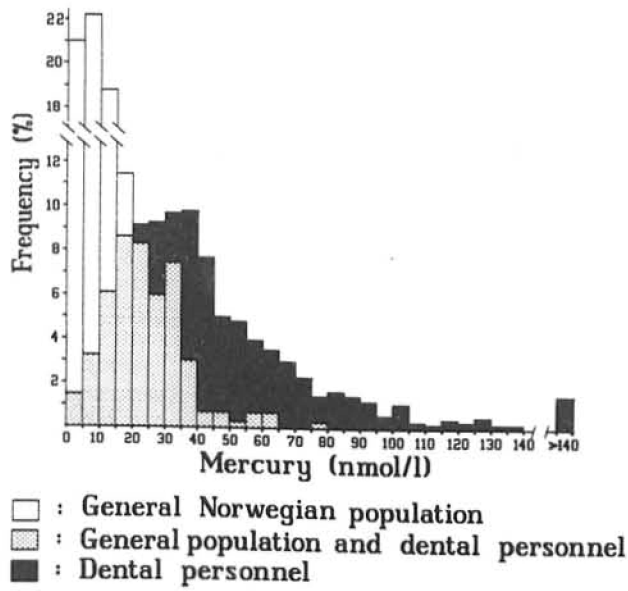

Fig. 1. Distribution of urinary mercury levels from Norwegian dental personnel ($n=945$), matched with values of a sample of the general population in Norway ($n=146$).

Results

The survey included 672 individuals from 1200 delegates at the National Dental Association meeting in 1986. The survey in 1987 included 96 repeating participants and 177 new individuals from 560 delegates. Of the 849 individuals, 92% were dentists ($n=782$). These dentists represent approximately 20% of all active dentists in Norway. The mean age was 43 yr (SD=10), varying from 22 to 75 yr. The mean length of the work experience was 17 yr (SD=10), varying between 0 yr and 52 yr. 68% of the participants were males. The demographic configuration of the dentists' subgroup in the two samples was similar to the gender and mean age distribution and the geographic distribution of Norwegian dentists (8).

The mean urinary mercury value for the 1986 sample was 39 nmol/L (SD=29) in 1986, and 43 nmol/L (SD=36) in 1987. Compared to previous measurements (Table 1), these values seemed to be good population estimates of the urinary mercury excretion from Norwegian dental personnel. The distribution of the urinary mercury levels in the two samples is matched with the values of a sample of the general population in Norway in Fig. 1. Of the participants 5% had mercury levels greater than 100 nmol/L.

The relationship between the environment and practice characteristics and the mercury excretion values observed in the 1986 study (1) was in general confirmed in the sample from the meeting in 1987 (Table 2). The two samples were therefore pooled for the subsequent analyses to gain a better basis for the statistical interpretation of the observations. The mean mercury value was lower for the female (40 nmol/L) than for the male participants (44 nmol/L). The mean of the female dentists decreased to 38 nmol/L after excluding a subset of female dental assistants with high mercury levels. This gender difference was statistically significant ($P<0.05$) for the mean values.

The number of practice hours per week correlates at the $P<0.001$ level with $r=0.18$. A breakdown of the mercury values by practice hours per week and gender show a dissimilar pattern in urinary mercury levels for the male and female participants (Fig. 2).

The total and the number of occlusal amalgam restorations of the respondents correlate at the $P<0.001$ level, with $r=0.14$ (Fig. 3). Neither the length of work experience nor the years in the current office facility correlate with the urinary mercury levels, but the participants with less than 5 yr experience had a significantly higher mean mercury value in comparison with the other participants ($P<0.05$). The age of the participant correlates at the $P<0.05$ significance level with $r=0.05$.

The participants were identified as dentists, students, hygienists, assistants, or specialists. The mean urinary mercury values differed among the work categories ($P<0.001$) (Fig. 4). Dentists in private practice had a higher mean mercury value than dentists employed by the na-

Table 1. Mean urinary mercury values measured on Norwegian dental personnel in different counties (include all employees in the public dental health service in the county), and individual cases from the whole country (volunteers and individual samples)

County	Year	*n*	Personnel type	Mean nmol/L	Percentage with <100 nmol/L
Oslo	1973	32	Dentist	90	80%
		33	Assistants	140	60%
S. Tröndelag	1976	43	All	80	90%
Oslo	1976	24	Dentist	50	90%
N. Hordaland	1979	14	All	50	85%
N. Hordaland	1980	22	All	45	95%
N. Hordaland	1981	19	All	30	95%
Oppland	1981	59	All	38	86%
Möre	1981	96	All	40	85%
Hordaland	1985	214	All	38	93%
Norway	1974	106	All		60%
Norway	1975	74	All	100	50%
Norway	1982	239	All	43	90%
Norway (Sample 1)	1986	672	All*	39	96%
Norway (Sample 2)	1987	273	All*	43	94%

* Mostly dentists.

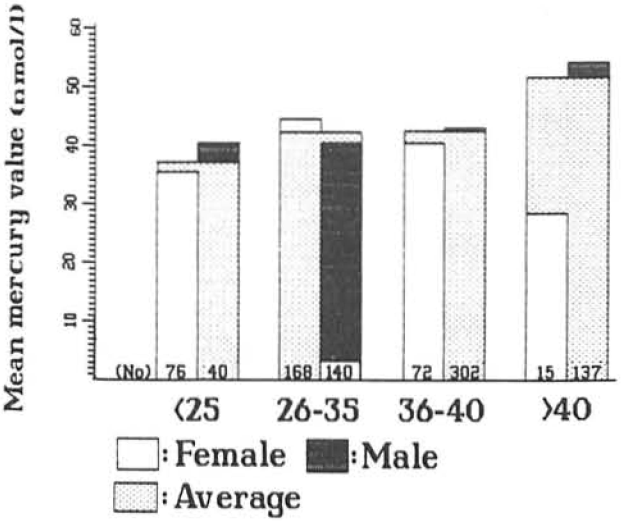

Fig. 2. Urinary mercury levels by number of hours of practice in clinic each week, and by gender.

Table 2. Significance of different environment and practice characteristics on the urinary mercury excretion values observed in 1986 study (column 1). Measured by analysis of variance of subgroups, multiple classification analysis of the variance to correct for intervariable correlation, and on canonical correlations. Identical measurements for the variables in the sample from 1987 (column 2)

Variables	1986	1987
Participant characteristics		
Geographic location	–	–
Personnel category	++	++
No. restorations	++	+
No. occlusal restorations	++	+
Gender	+	–
Work experience in same clinic	+	–
Age	–	+
Work experience in years	–	–
Previous control of urinary mercury	–	–
Eating/drinking habits during work	+	–
Weight	–	–
Smoking	–	–
Weekly fish consumption	–	–
Working environment		
Floor covering	++	++
Daily/weekly cleaning procedures	+	+
Volume of clinic	+	–
No. of employees	–	–
No. of clinicians sharing clinic	–	–
Ventilation system	+	–
Age of clinic	–	–
Volume of office	–	–
Heating system	–	–
Working characteristics		
Hours work per week	+	–
No. polished restoration per week	++	+
No. new placed restorations per week	++	+
No. removed restorations per week	++	+
Installed amalgam separator on unit	+	+
Method for triturating amalgam	–	–
Method for condensing amalgam	–	–
Storage of waste amalgam products	–	–
Installed vacuum ejector on unit	–	–

–, no effect. +, slight effects. ++, strong effects.

tional dental health service. The MCA analysis ascribed this relationship to a combination of more practice hours, and an increased proportion of restorations placed per week by the private dentists.

The age of the clinic did not correlate with the urinary mercury levels. A weak correlation was found between the volume of the clinics, and the mercury levels ($P<0.05$, $r=0.06$). The type of heating did not seem to have any influence on the mean values, possibly because the survey was conducted in the late summer. The participants working in offices with central air conditioning had lower mean values than those working in offices without such units ($P<0.05$). The results indicated a relationship between the type of flooring and the urinary mercury (Fig. 5). Participants working in clinics with wooden floors had significantly higher values than the other groups ($P<0.05$). The method for cleaning the office floors did not influence the urinary mercury.

Fig. 6 shows the relationship between the prevalence of various amalgam procedures and the urinary mercury levels. The numbers of new restorations, replaced restorations, and polished restorations per week correlate at the $P<0.001$ level, with coefficients of $r=0.21$, $r=0.17$, and $r=0.17$. Several clinical variables failed to influence the urinary mercury levels: technique for triturating or condensing amalgam, type of alloy capsules, type of suction system on the unit, and procedures for disposing of used capsules, excess expressed mercury or carved amalgam, or removed old restorations. On the other hand, the participants with amalgam separators or other filtering devices connected to the units had elevated mean urinary mercury values ($P<0.05$) (Fig. 7).

Discussion

It is clear that dental personnel are exposed to small amounts of mercury vapor in their working environment (Fig. 1). Although the mean value of 40 nmol/L is measured on volunteers and mostly dentists, previous reports indicate similar estimates of the urinary mercury excretion for dental personnel (Table 1). A mean urinary mercury excretion of 40 nmol/L in Norwegian dentists is higher than that for Swedish dentists (20 nmol/L) (10), nearly identical to that in a recent study in Finland (38 nmol/L) (11), but

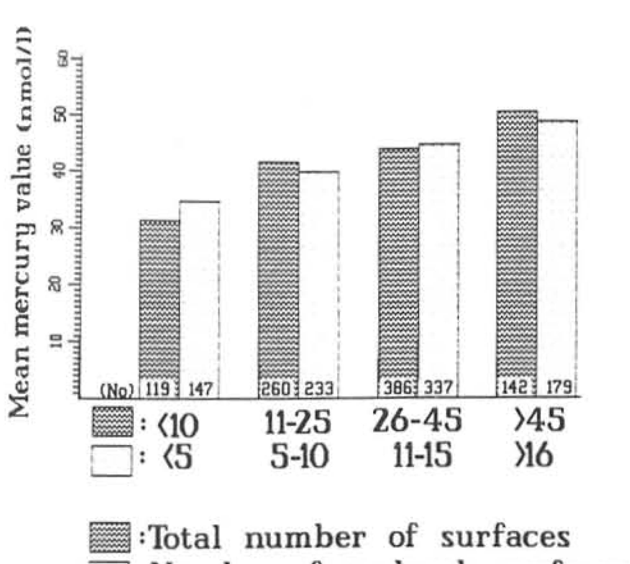

Fig. 3. Variation in mean urinary level by respondent's amalgam status.

lower than the values reported in an American study (70 nmol/L) (3). The relationship between the urinary mercury levels and several clinical variables corresponds in general to previous reports, and consequently only reconfirm the results in these studies. Some observations in the present study do, however, merit particular appraisal.

Males and females showed different urinary mercury levels at presumably increasing mercury exposures (Fig. 2). This difference could also be observed after an MCA analysis of the variance, which also considered other working characteristics. The urinary mercury values increased with the number of hours spent per week in the clinic for the whole group and for the male participants as expected, but not for the females. The mean values for the females remained relatively constant, and for the most part less than the male participants, especially at the higher exposures. There may be several explanations for this observation. It is possible that the mercury level in morning urine samples may not reflect the daily urinary mercury clearance for females as it does for males (12). Furthermore, urine samples from females may be more prone to bacterial contamination, which may have caused reduced mercury levels in the samples (13). There are also factors affecting the mercury excretion kinetics which were not assessed in the present study, e.g., smoking habits and alcohol consumption (14). The disparity may, on the other hand, signify that mercury excretion kinetics is gender variable. Previous investigators disagree about gender differences in urinary excretion in studies of unexposed population samples (15–17). This disagreement may partly be attributed to the erroneous comparison of creatinine-corrected urinary mercury values. Differences of mercury accumulated in hair have been reported, indicating separate excretory kinetics for males and females (18). Although the urinary excretion vary with gender, it remains to be solved whether this is due to less absorption in the lungs, dissimilar daily fluctuation of mercury in the urine, or an actual difference of urinary mercury excretion kinetics.

Since it was assumed that dental personnel could correctly assess their own dental status, the questionnaire included questions of the amalgam status of the respondent. Approximately 900 of the participants had supplied information on their dental status, and this represents the largest sample in the literature where the amalgam status correlates to the urinary mercury (Fig. 3). It is uncertain to what degree the abrasion of amalgam restorations contribute to the daily mercury burden of the body (19). The results do, however, support previous findings that there is an association between the amalgam status and the urinary mercury excretion (20, 21).

Several investigators have estimated the influence of the floor surface in the clinic on the urinary mercury. Although the conclusions vary in the different surveys, the authors concede that it is important to choose a surface that allows decontamination (2). Carpets in the dental clinic should therefore be avoided. The participants in this study working in clinics with carpets did not have an elevated mean urinary mercury value (Fig. 5). On the other hand, high values were observed for those working in clinics with wooden floors, presumably because of mercury accumulations in surface defects. Consequently, wooden floors in the dental clinic are not to be recommended.

The number of amalgam restorations placed per week is an indirect measure of the frequency of clinical procedures with exposure for mercury vapor (3). A correlation between this variable and the urinary mercury was therefore anticipated. A more unexpected finding was that the

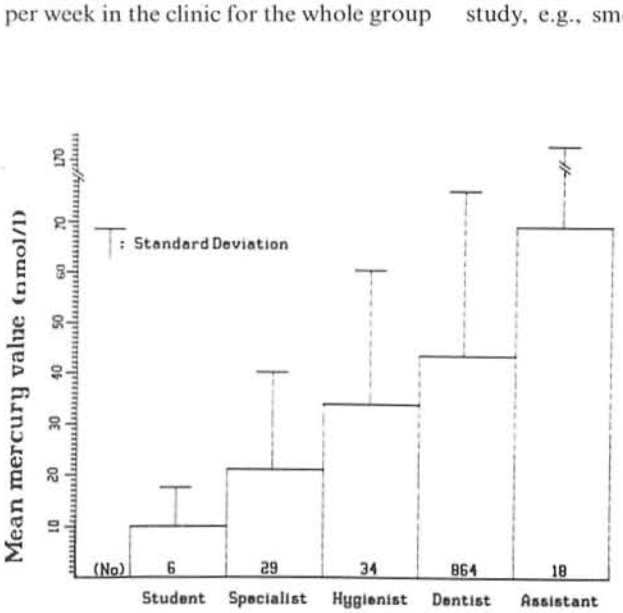

Fig. 4. Relationship between urinary mercury levels and dental personnel category.

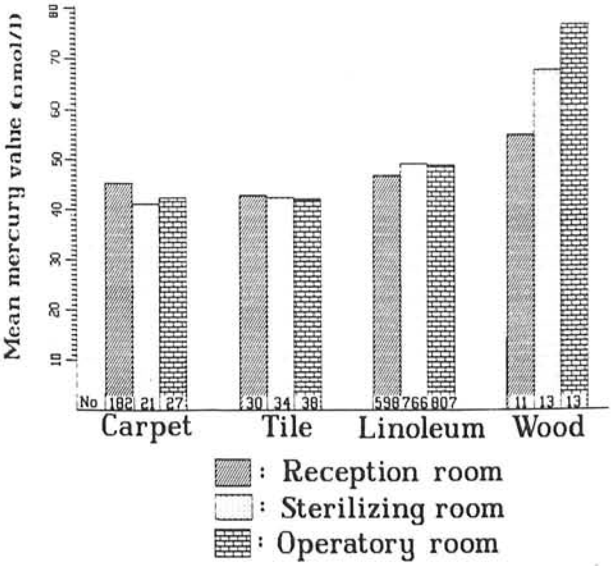

Fig. 5. Relationship between urinary mercury levels and floor covering.

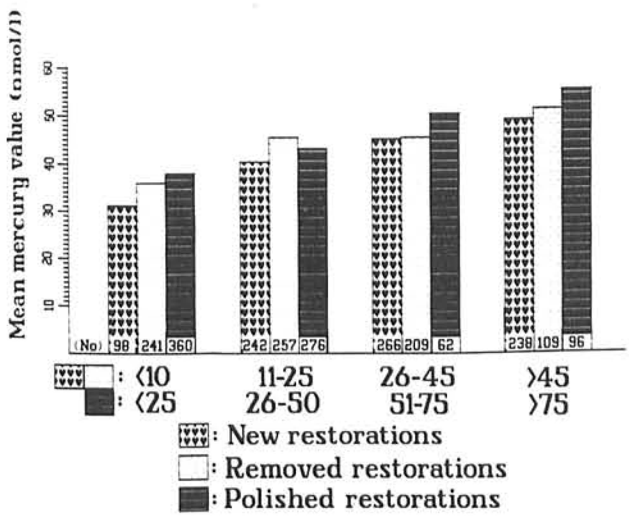

Fig. 6. Mean urinary mercury levels and number of operative procedures involving amalgam each week.

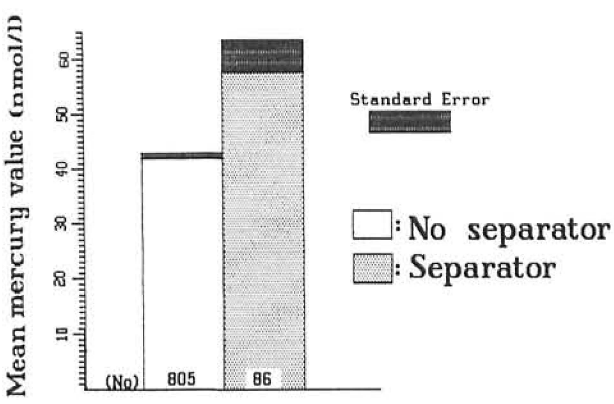

Fig. 7. Relationship between urinary mercury levels and use of amalgam separators or other filtering devices on the unit.

weekly numbers of replaced and polished amalgam restorations were also correlated with urinary mercury (Fig. 6). This was valid after the MCA analysis, which took the relationship between these three variables into account. It is possible that the increased values reflect the mercury vapor generated near the operative zone because of heat, and the production of solid particles (22).

The urinary mercury values were higher for the participants who reported that they had "separators" installed in their clinic (Fig. 7). The MCA analysis revealed that these participants did not differ from the others on any other clinical variables, e.g., the prevalence of weekly number of placed restorations. Since the questionnaire required the separator's product name, it became apparent that the "separators" were ordinary filters and few were true amalgam separators. The removal of heated amalgam debris from suction filters represents an exposure to mercury vapor and the exposure increases if the debris from the filters is discarded into the trash container and remains there for some time. Consequently, remote suction units with closed-system filters are advantageous to open assemblies with filters that require periodical rinsing. It is difficult to explain why personnel working in clinics with true amalgam separators had higher mercury levels than others. Possibly, there is a "concentration phenomenon" of mercury vapor in the work environment since the mercury and amalgam debris usually is accumulated and stored in the clinic before it is sent for recycling. The influence of storing contaminated debris in the clinic on the mercury vapor levels should therefore be investigated further.

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