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Original Article

Occurrence of Cognitive and Neurological Symptoms in Norwegian Dentists

Bjørn HILT[1,2], Kristin SVENDSEN[3], Tore SYVERSEN[4], Oddfrid AAS[1] and Torgunn QVENILD[1]

[1]Department of Occupational Medicine, St. Olav's University Hospital, [2]Department of Public Health and General Practice Faculty of Medicine, [3]Department of Industrial Economics and Technology Management, [4]Department of Neuroscience Faculty of Medicine, Norwegian University of Science and Technology, Trondheim, Norway

Objectives: Previous investigations have presented some evidence of late cognitive effects in dental personnel exposed to metallic mercury. We wanted to examine if Norwegian dentists have an increased prevalence of symptoms consistent with neurological and/or cognitive malfunction.

Methods: The study group consisted of 406 dentists from central Norway and 217 controls from the general population, all under the age of 70. They had responded to a standardised postal questionnaire (Euroquest) inquiring about seven symptoms in regard to neurology, psychosomatics, memory, concentration, mood, sleep disturbances, and fatigue. A score was calculated for each symptom based on 4 to 15 single questions scored on a scale from 1 (seldom or never) to 4 (very often).

Results: The dentists and controls had a participation rate of 57.2 % and 42.9 % respectively. The dentists reported no more cognitive symptoms than the controls, with low average symptom scores from 1.16 for neurological symptoms in males to 1.73 for fatigue in females. Corresponding figures for the controls were 1.22 and 1.77. There were a total of 1.2 % of the dentists and 1.8 % of the controls who reported having three or more of the seven symptoms "often" or more frequently.

Conclusion: Norwegian dentists do not report more cognitive and neurological symptoms than controls from the general population.

Key Words: Cognitive function, Dental health care, Occupation, Metallic mercury, Euroquest

Introduction

Dentists have long been exposed to metallic mercury when handling amalgam for teeth restoration. The degree of exposure has varied with the extent of the use, work performance and the properties of the physical environment [1].

Two recent reviews, including meta-analyses of several studies of exposure to metallic mercury in mostly industrial settings, have concluded that long term exposure to metallic mercury vapour with urine levels above 500 nmol/litre can lead to chronic cognitive effects, while there is more doubt as to whether exposures below this level can lead to similar long term effects [2,3]. During the last 25 years, several studies have raised some concern by showing that both dentists and other dental personnel have had an increased prevalence of symptoms of cognitive malfunction [4-7], some have shown cognitive impairments in neuropsychological investigations [8-10], and some have reported both symptoms and neuropsychological findings [11-14]. One recent study with neuropsychological investigations of possible long term effects in dental personnel did not, however, show any such effects [15].

It has repeatedly been shown that exposure to metallic mercury results in psychological and cognitive effects. The milder form, characterised by weakness, fatigue, psychological disturbances, and asthenia, is termed micromercurialism, while the more severe form of intoxication, which entails psychotic

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Correspondence to: Bjørn HILT
Department of Occupational Medicine, St. Olav's University Hospital
Postbox 3250 Sluppen, N-7006 Trondheim, Norway
Tel: +47-72571407/+47-90069490, **Fax:** +47-72571347
E-mail: bjorn.hilt@stolav.no

symptoms, is known as erethism [16,17].

In order to monitor mercury exposure, the National Institute of Occupational Health in Norway offered a voluntary monitoring of mercury levels in urine for dental personnel from 1955 to 2000 with a total of 4,030 samples analysed from 2,028 persons. The samples were analysed by cold vapour flameless atomic absorption spectrophotometry with the results given in nmol/litre [18,19]. In 1,565 samples from 788 dentists, the mean values showed a steady decrease from 252 (range 83-528) nmol/litre in the nineteen-fifties to 24 (range 13-57) nmol/litre in the nineteen-nineties. The highest level found in a dentist was 760 nmol/litre. It was measured in the early seventies. From all the measurements, 5.2% showed values above 300 nmol/litre. These were all before 1985 [19].

In Norway, the preliminary publication of the results from a small study of cognitive problems in 41 dental assistants [6], and a television programme broadcasted in 2005 raised public concern by indicating that chronic metallic mercury intoxication and cognitive injuries were common in dental personnel. After that, the government ministry responsible for labour protection initiated research on the topic. In a previous publication we have shown that female dental assistants had a slightly increased prevalence of cognitive complaints compared to a control group [7]. Of seven symptom groups investigated by means of a standardized questionnaire called Euroquest [20], the most prevalent symptoms in terms of having them often or more frequently among the dental assistants were feeling of fatigue with 13.6%, problems with memory with 12.6%, and sleep disturbances with 7.2%.

The aim of this study was to see whether Norwegian dentists have an increased prevalence of symptoms consistent with neurological and/or cognitive malfunction.

Materials and Methods

We asked at the offices of the dental health care authorities in the three counties More and Romsdal, South-Trondelag, and North-Trondelag in Central Norway for lists of all dental personnel known to have worked in the region. In that way we identified 2,247 dental workers of whom 790 were dentists and, thus were candidates to be included in this study.

All the identified dental workers were invited to participate in the study by filling out a postal primary questionnaire on more general topics and by answering a second questionnaire relating to their work career and working conditions including their first employment in dental health care and the length of employment. They were asked to return both questionnaires in a prepaid envelope together with their written consent to participate. More details on our inquiry about working conditions in Norwegian dental health care, and the results thereof, are described at more length in another publication [1]. In addition, all the addressed dentists were asked for written permission to access any results of their urine mercury levels held at the National Institute of Occupational Health.

To form a control group, the Norwegian Central Bureau of Statistics randomly chose 1,500 persons from the same counties with a categorical matching for the whole group for sex and age within 5-year groups. In order to be included in the study, the control subjects had not to have been engaged in dental health care, and had to have worked outside their homes for more than five years after 1960. The control group was invited and asked to fill out and submit the primary questionnaire in the same way as the dental personnel.

In addition to inquiring about some general information such as age, education, some life style issues, and a few health questions, the first questionnaire comprised a Norwegian version of the standardised European questionnaire called "Euroquest" which has been designed to monitor cognitive symptoms in subjects exposed to neurotoxic substances [21]. We used the parts of this questionnaire which inquire about mood, memory, ability to concentrate, sleep disturbances, neurological symptoms, psychosomatic symptoms, and fatigue. There are 5 to 15 separate questions for each of these seven symptom groups. Each of these can be answered with the alternatives "seldom or never", "now and then", "often" or "very often" with designated values from 1 to 4 respectively. In order to have a valid answer for each symptom, it was required that two thirds of the questions included in that particular symptom had been answered. A score was calculated for each symptom as the mean of the values for the particular questions included.

Statistical analysis

Statistical analyses were performed using PASW Statistics version 17.0 for Windows (SPSS Inc., Chicago, IL, USA). We presented the outcome variables as the mean scores for each symptom group, the sum of symptom scores, and the prevalence of subjects who reported having more than three symptoms "often" or more frequently stratified by sex and 10-year age groups. Statistical significance was assessed by use of the chi square test and student's t-test.

Ethical considerations

The study was approved by the ethical committee for medical research in Central Norway, and had a licence for collecting personal data from the Norwegian Social Science Data Services. The authors declare that there are no conflicts of interest.

Table 1. Background variables for the participating dental assistants and controls

Variables		Dentists	Controls
Number of participants		406	217
Sex (% female)		42.6	76
Age in yrs, Mean (SD)		52.1 (12.4)	48.4 (10.8)
Years of professional work, Mean (SD)		26.3 (12.6)	24.0 (10.5)
Married/cohabiting (% of the participants)		81.5	77.4
Smoking habits (% of the participants)	Yes, daily	6	13
	Yes, now and then	5	7.4
	Ex-smoker	24.3	27.8
	Never smoker	64.7	51.8
Use of alcohol last year (% of the participants)	Yes, every week	49.1	33.8
	Yes, more seldom	43.4	53.7
	No use	7.4	12.5
Amalgam in own teeth (% of the participants)	Yes	83.5	91.7
	Number of surfaces, mean (SD)	8.7 (5.2)	9.8 (5.2)
Current diseases (% of the participants)	Diabetes mellitus	1.2	1.8
	Arterial hypertension	11.8	9.7

SD: standard deviation.

Results

Out of the 790 identified dentists who were asked to participate, 452 (57.2%) responded. Of these, 46 were excluded because they were over the age of 70, which left us with 406 dentists for the analysis. From the 1,500 who had been selected for the control group, there were 690 who participated and fulfilled the criteria for inclusion and 583 of these were under the age of 70. For a valid comparison with the dentists, only the 217 control persons who held a university degree were included in this study. Table 1 shows background variables and some information on life style issues for the participating dentists and the control group.

In regard to occupational activities, the average duration of occupational work for the female and male dentists was 21.8 and 29.7 years respectively. Fig. 1 shows that a greater share of the participating male dentists had started working before 1980 than was the case for the females. There were 28.1% of the female and 35.2% of the male dentists who reported having used copper amalgam.

For 118 of the participating dentists we had the results of previous urine mercury measurements available. The average

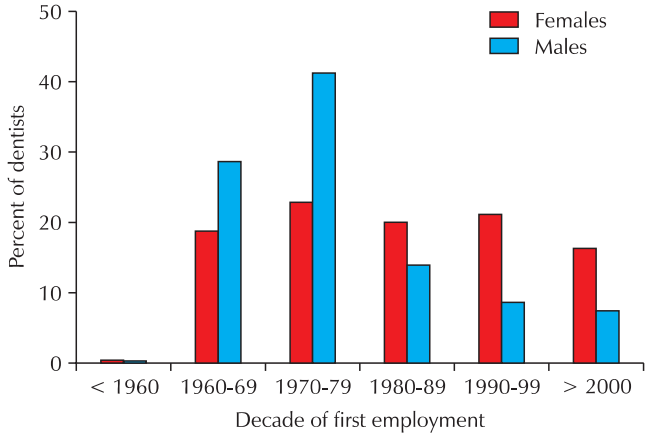

Fig. 1. The decade when starting work in dental health care for the 170 female and 231 male dentists who submitted such information.

of the individually maximum measured values showed urine mercury levels of 57.3 (SD 35.4, range 7-174) for females and 58.7 (SD 37.4, range 0-170) for males.

In Table 2 the mean scores for each symptom group in the Euroquest questionnaire are presented for the dentists and the controls, stratified for sex. Most symptom scores are nearer

Table 2. Mean scores for seven symptom groups from the Euroquest questionnaire reported by 406 dentists and 217 controls

Symptoms	Dentists				Controls			
	Male		Female		Male		Female	
	Valid answers	Mean symptom score (SD)	Valid answers	Mean symptom score (SD)	Valid answers	Mean symptom score (SD)	Valid answers	Mean symptom score (SD)
Mood	232	1.35 (0.37)	172	1.47 (0.49)	51	1.47 (0.43)	164	1.49 (0.42)
Memory	232	1.60 (0.50)	173	1.69 (0.58)	52	1.68 (0.57)	165	1.71 (0.62)
Ability to concentrate	231	1.38 (0.45)	172	1.44 (0.51)	52	1.47 (0.52)	165	1.51 (0.47)
Sleep disturbances	231	1.49 (0.40)	172	1.47 (0.47)	52	1.55 (0.39)	165	1.51 (0.50)
Neurological symptoms	231	1.16 (0.28)	172	1.19 (0.28)	52	1.22 (0.32)	164	1.25 (0.34)
Psychosomatic symptoms	231	1.23 (0.25)	171	1.37 (0.38)	51	1.30 (0.29)	163	1.41 (0.31)
Fatigue	231	1.51 (0.53)	171	1.73 (0.61)	52	1.61 (0.56)	165	1.77 (0.65)

SD: standard deviation.

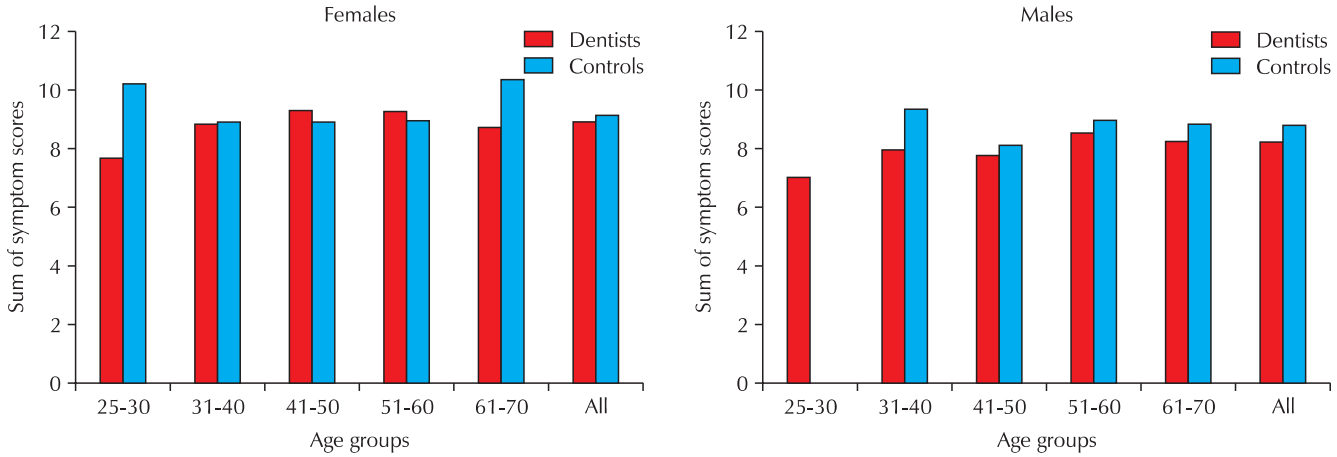

Fig. 2. Mean sum of symptom scores stratified for age in 171 female and 231 male dentists and 163 female and 51 male controls.

to the value one ("seldom or never") than the value two ("now and then") and there is little difference between the dentists and the controls. Fig. 2 shows the sum of the seven symptom scores for the dentists and the controls by age. Only the female dentists between 41 and 60 years had slightly higher sum scores than the controls. Table 3 shows the sum scores for dentists who had started their dental career before and after 1990, stratified for sex.

As the mean scores for each symptom turned out to be low, we also made a categorisation by looking at the prevalence of subjects with three symptoms occurring "often" (value 3) or more frequently. This was done on the assumption that subjects who had three or more of the seven symptoms often or more frequently could be those who could, to some extent,

Table 3. Sum of symptom Euroquest scores for dentists who had started working in dental health care before and after 1990

	First employment in dental health care					
	Before 1990			After 1990		
	n	Mean	SD	n	Mean	SD
Female	106	8.87	2.05	64	8.73	2.48
Male	194	8.31	2.02	37	7.80	1.55
All	300	8.51	2.05	101	8.38	2.22

SD: standard deviation.

suffer from or were disabled by their symptoms. Among the female dentists and the controls there were 5 out of 173 (2.9%) and 3 out of 165 (1.8%), respectively who had three or more symptoms often or more frequently. The corresponding figures for males were 0 out of 233 and 1 out of 52. None of these differences were statistically significant. An attempt to stratify this analysis by age groups gave too small figures for any meaningful comparison to be made.

Discussion

The first international studies dating from the early 1980's indicated possible neurological and cognitive effects in dentists related to exposure to mercury in dental health care [8]. Later, both dentists and other dental personnel have been studied with the emphasis on symptoms [4-7], neuropsychological function [8-10] or both [11-15]. There are no previous studies of the occurrence of symptoms or cognitive function in Norwegian dentists. From our investigations of dental assistants we have previously assessed that the prevalence of possibly work-related cognitive symptoms among them is between 0.4% and 2.8%, dependent on the severity [7]. From the previous questionnaire survey and from the urine values from the dentists who participated in the present study, we have also shown that dentists in Norwegian dental health care had relatively low mercury exposures, and probably had less than dental assistants who were the ones who prepared the amalgam for use [1]. This was also evident from the previously published results from urine-mercury measurements in Norwegian dental personnel where the dentists had lower and more stable values than dental assistants through all years from the nineteen seventies through the nineteen nineties [19].

The results of the present study show that Norwegian dentists do not report more cognitive symptoms than comparable controls. However, with an assumed prevalence ratio for serious cognitive complaints (at least four Euroquest symptoms out of seven "often" or more frequently) of 2.8 (0.9 vs. 2.5%) which was the case for dental assistants and controls in our previous study [7], the statistical power at a 5% level to detect such an increase among the dentists in the present material would be only 38%. Therefore, it cannot be ruled out that low statistical power can explain the negative results. Regrettably, the low prevalence of symptoms was not known when the study was planned.

Both for the dentists and the control group, the study was hampered by a relatively low participation rate. This could cause bias in both directions. It might be that the non-responders from both groups, as often is the case, were less healthy than the responders, and thus, the real occurrence of symptoms in both groups could have been underscored. The present study was carried out about one year after a television programme that brought the connection of mercury exposure in dental offices and possible health effects into the public agenda. This may also have influenced both the quantity and quality of the response to our questionnaire, but probably not by underscoring a possible effect. As the outcome in terms of cognitive disturbances was rare, it is important that the tool used to assess the outcome has sufficient specificity. As both sufficient specificity and sensitivity is reasonable to expect from the Euroquest questionnaire [20-22], the negative results are probably not a bias resulting from undifferential misclassification.

Uncontrolled confounding may have some impact on the results of the present study. The group of dentists and the controls were different in regard to sex distribution and the number of own amalgam fillings. The dentists also smoked less, but drank slightly more alcohol than the controls. With regard to sex, our stratified analysis in Table 2 did not reveal any differences in cognitive symptoms between the groups irrespective of sex. Apart from information on the occurrence of diabetes mellitus and arterial hypertension, we lacked data on other potential confounders such as drug abuse, mental illness, other cardiovascular diseases, and previous head injuries, but had little reason to assume that these were unevenly distributed between dentists and controls.

In the study we included dentists with their first employment beyond 2000 who had obviously been less exposed to mercury than those who started dental work in the nineteen sixties and seventies. The analysis of symptoms in dentists who had started their career before 1990, when the old methods of amalgam preparation was about to be phased out, compared to those who had started after that year, was done to see if there were differences between the two groups. If there had been more symptoms in those who had started early, age would certainly have been a possible confounding factor, but, as there were no differences, this was not considered important.

Only one of the previous studies on the occurrence of symptoms in dental personnel had made use of the same standardised Euroquest questionnaire [6] that we used in the present study. It is therefore difficult to relate our results to the results of others, except to the recently published Norwegian study and our own study of dental assistants that also made use of Euroquest and reported higher symptom scores in dental assistants than in our dentists [6,7]. A shortcoming in the use of Euroquest is that there are no reliable reference values available yet, and thus, we do not know the occurrence of symptoms in a larger "normal" population. Table 4 gives a short summary

Table 4. Mean Euroquest scores for symptom domains reported in previous studies

Age and Euroquest symptom domain	Study of dental asistants [7]		Solvent exposed cohort [23]*		
	Female dental assistants n=608	Controls† n=425	Exposed men n=180	Non-exposed men n=387	Female references† n=201
Mean age	51.7 (9.7)	49.4 (10.8)	38.3 (7.31)	39.8 (9.34)	39.7 (10.95)
Mood	1.71 (0.56)	1.62 (0.54)	1.49 (0.32)	1.47 (0.31)	1.56 (0.29)
Memory	1.99 (0.72)	1.79 (0.63)	1.49 (0.32)	1.47 (0.31)	1.56 (0.29)
Concentration	1.76 (0.63)	1.58 (0.52)	1.46 (0.38)	1.45 (0.39)	1.55 (0.36)
Sleep disturbances	1.81 (0.63)	1.66 (0.6)	1.5 (0.33)	1.49 (0.29)	1.52 (0.29)
Neurological symptoms	1.49 (0.49)	1.35 (0.4)	1.26 (0.22)	1.22 (0.2)	1.23 (0.2)
Psychosomatic symptoms	1.59 (0.56)	1.5 (0.41)	1.33 (0.24)	1.29 (0.21)	1.37 (0.23)
Fatigue	2.06 (0.5)	1.87 (0.69)	1.55 (0.33)	1.49 (0.34)	1.59 (0.31)

*Values adjusted to an applicable scale.
†From the general population.

of results from earlier investigations where Euroquest scores were reported in a way that is comparable with the results of the present study. This again raises some questions as to whether these results are comparable. In our previous study of dental assistants [7] the controls had higher symptom scores than the controls in the present study. This is probably because the controls used in the previous study constituted a representative sample of the general population while only subjects with a university degree were used as controls for the dentists. As for the French study that reported Euroquest symptoms in a comparable way [23], female controls from the general population had Euroquest scores that were fairly in line with the scores in our female dentists and controls, but here, the possibility of cultural differences should also be taken into account.

The aim of this study was to elucidate whether Norwegian dentists with previous occupational exposure to metallic mercury have an increased prevalence of symptoms consistent with cognitive malfunction. We can conclude that Norwegian dentists do not report more cognitive symptoms than controls from the general population.

Conflict of Interest

There are no known conflicts of interest for any of the authors that could in any way have influenced this work.

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