

# Neurotoxic effects of mercury exposure for dental workers - A literature review

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## Abstract

This aim of this review is to estimate neurotoxic effects of mercury exposure among dental personnel. The electronic search in the database PubMed revealed 15 papers that investigated relationship between mercury occupational hazard and neurologic and psychological effects in dental professionals. Based on the studies reviewed could be concluded that chronic exposure to mercury might have central nervous system effects.

## Introduction

Dental amalgams fillings are used for more than 150 years due to low cost, ease of application, strength, and durability [1]. Dental amalgam is made by reaction (amalgamation) between liquid mercury and metal alloy powders (silver, tin, copper, zinc). Mercury, which makes up about 50% of the compound, is used to bind the metals together and to provide a strong, hard, durable filling.

Concern for appearance, environmental pollution, health, and the availability of improved, reliable, composite materials have diminished the use of amalgam restorations [2]. In particular, concerns about the toxicity of mercury have made its use increasingly controversial [3]. Mercury's toxic effects in humans include: damage to the brain, kidneys, immune and reproductive system [4]. Mercury can be absorbed through the skin and mucous membranes, but 80% of mercury vapour absorption occurs through the lungs [5] and then entering into bloodstream. Following distribution by blood circulation, mercury enters and remains in certain tissues and primary target organs of concern are the central nervous system and kidneys [6]. Therefore, the earliest signs of subclinical intoxication of mercury can appear on the target organs [7,8].

People who are handling mercury are at risk and dental personnel are ones of professionals who are working with mercury. Numerous studies reveal high concentration of mercury in blood, hair, nails and urine of dental staff [9-12]. The purpose of this article is to review neurotoxic effects of mercury exposure for dental personnel.

## Material and method

The present review includes studies about dental workers exposed to mercury and evaluation of personnel's health (Table 1).

## Results

The electronic search in the database PubMed provided a total number of 288 titles that were considered potentially relevant. In the second phase of study selection, only 33 articles were sampled and checked for correlation between chronic exposure to mercury and effects on central nervous system (CNS). Subsequently 15 papers were reviewed for possible effects of occupational exposure of mercury on CNS among dental staff (Table 2).

## Discussion

The revised paper investigated different possible consequences of chronic exposure to mercury; the first 33 articles investigated correlation between chronic exposure of low dose of mercury and health effects. 15 papers examined effects on nervous central system, and others try to establish possible correlation between chronic mercury exposure and allergic contact dermatitis, immunological effects, pituitary function, skeletal muscle abnormalities, pregnancy outcome, blood pressure or melanoma.

The classic symptoms associated with exposure to elemental mercury vapour (Hg<sub>0</sub>) and methylmercury (MeHg) involve CNS [13]. Neurotoxicity of mercury associated with occupational exposure where known from Middle Eve among mirror makers [14] and hat makers

**Table 1.** Search strategy.

Study group	Dental workers
Condition	Exposure to mercury
Outcome	Health effects related to chronic mercury exposure. Neurotoxicity correlated to chronic mercury exposure
Search combination	"mercury dental workers": 81 hits, "mercury dental personnel": 121 hits, "mercury dental staff": 86 hits
Database search	Electronic PubMed
Selection criteria phase one	-Inclusion criteria: Studies about consequences of mercury exposure for dental workers, published in English -Exclusion criteria: Studies in languages other than English, others professionals exposed to mercury than dental workers
Selection criteria phase two	-Inclusion criteria: Studies about consequences of mercury exposure on central nervous system -Exclusion criteria: Studies about other consequences of mercury exposure than on central nervous system

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**Key words:** mercury exposure, neurotoxicity, dental personnel

**Received:** March 10, 2017; **Accepted:** March 23, 2017; **Published:** March 27, 2017

**Table 2.** Summary of studies about neurotoxic effects of mercury exposure for dental workers.

Reference	Objective	Batch	Type of investigation	Findings	Conclusions
Uzzell <i>et al.</i> 1986 [17]	To measure the effects of chronic low-level exposure to inorganic mercury, the neuropsychological performances.	13 female dental auxiliary workers	Battery test: Recurrent Figures, SCL-90-R, WAIS, Rey's AVL, PASAT, BGT, Grooved Pegboard, and Finger Tapping tests.	Workers with elevated mercury levels scored significantly less well on the Recurrent Figures, and SCL-90-R.	Chronic subtoxic levels of inorganic mercury appear to produce mild changes in short-term nonverbal recall and heightened distress generally, and particularly in categories of obsessive compulsion, anxiety and psychoticism, without alterations in general intellectual functioning, attention, verbal recall, and motor skills.
Nilsson <i>et al.</i> 1990 [18]	Evaluation of four symptoms known to be connected with mercury exposure.	505 dental workers	Questionnaire focused on four symptoms: loss of appetite, tremor, insomnia and anxiety	The prevalence of any of the four symptoms investigated in the groups of exposed personnel and controls as low, less than or equal to 11%.	No increase in the prevalence of symptoms could be detected in relation to mercury concentrations in urine.
Glina <i>et al.</i> 1997 [19]	Evaluation of health status of dental staff exposed to mercury.	8 dental workers	Evaluation of health status: anamnesis, clinical and battery test: WMS, Leon Walther Mechanics Aptitude Test, Toulouse Picron Concentrated Attention Test, WAIS.	Symptoms related to the neurological condition (headache, cramps, paraesthesia, tremor, dizziness, muscle weakness, forgetfulness and difficulty concentrating) and the psychic condition (irritability, nervousness, depression and insomnia) were mentioned.	Prevalence of symptoms from lesions to the central nervous system; central nervous system signs; and mild-to-moderate chronic poisoning was found in 62.5% of workers.
Bittner <i>et al.</i> 1998 [20]	Evaluation the sensitivities of five psychomotor tasks.	230 dental workers	Battery test: IHST; Finger Tapping: The One-Hole Test; NES SRT; and Hand Tremor.	Significant associations were found for the IHST factor, followed by finger tapping, which was relatively meager and insignificant.	Results indicated remarkable differences in the effects of relative level of Hg0 on psychomotor performance.
Echeverria <i>et al.</i> 1998 [21]	Evaluation of potential CNS toxicity associated with handling Hg-containing amalgam materials.	37 dental workers	Battery test NES.	Adverse behavioural effects (alterations in mood, reduction in speed and accuracy in motor function, and subtle losses in memory and visuospatial cognitive skills) associated with low Hg0 exposures.	Subtle preclinical effects on symptoms, mood, motor function, and cognition were found associated with Hg body burden.
Urban <i>et al.</i> 1999 [22]	Neurological, visual evoked potentials (VEP) and electroneurography examinations on three groups of workers.	36 dental workers	Neurological examination.	The exposure of dental professionals was mild. Symptoms and signs of micromercurialism were observed only in the group with the highest exposure to Hg.	The combination of a decrease in sural nerve conduction velocity and an abnormality of VEP seems to be a characteristic pattern of electrophysiological changes in persons exposed to mercury vapours.
Ritchie <i>et al.</i> 2002 [23]	Finding the effect of chronic exposure to mercury on health and cognitive functioning.	180 dentists	Questionnaire.	Dentists were significantly more likely than control subjects to have had disorders of the kidney and memory disturbance. These symptoms were not significantly associated with urinary mercury concentration.	Several differences in health and cognitive functioning between dentists and controls were found. These differences could not be directly attributed to their exposure to mercury.
Aydin <i>et al.</i> 2003 [24]	To evaluate possible adverse effects on the CNS in dental personnel.	43 dental workers	Battery test and questionnaire: WMS-R, VTMP, SCL-90-R, BDI.	Urinary concentration of Hg had an inverse relationship with logical memory and total retention score, and a positive relationship with increased scores of anxiety and psychoticism.	These results may represent long-term consequences of low Hg exposure.
Moen <i>et al.</i> 2008 [25]	To compare the occurrence of neurological symptoms among dental assistants.	73 dental assistants	Questionnaire.	The dental assistants reported significant higher occurrence of neurological symptoms; psychosomatic symptoms, problems with memory, concentration, fatigue and sleep disturbance, but not for mood.	There is a possibility that the higher occurrence of neurological symptoms among the dental assistants may be related to their previous work exposure to mercury amalgam fillings.
Hilt <i>et al.</i> 2009 [26]	Correlation between mercury exposure and cognitive effects.	608 dental assistants	Questionnaire.	Dental assistants reported more cognitive symptoms than the controls	The occurrence of cognitive malfunction may be moderately increased in dental assistants.
Thygesen <i>et al.</i> 2011 [27]	To compare hospital admissions due to neurological and renal diseases between dental staff and control.	5371 dentists and 33 858 dental assistants	Records of hospital admission.	For neurological diseases, no association was observed for dental assistants, while for dentists an increasing risk for periods with less mercury exposure was observed. Among dental assistants, a negative association between employment length and risk of neurological disease was observed.	Occupational exposure to mercury does not increase the risk of hospital admissions for neurological, Parkinson's or renal diseases.
Hilt <i>et al.</i> 2011 [28]	Prevalence of symptoms consistent with neurological and/or cognitive malfunction in dentists.	406 dentists	Questionnaire.	The dentists reported no more cognitive symptoms than the controls.	Norwegian dentists do not report more cognitive and neurological symptoms than controls from the general population.
Sletvold <i>et al.</i> 2012 [29]	To find late developed disturbances in cognitive function of dental personnel with previous exposure to metallic mercury.	91 female dental workers	Battery test and questionnaire. WAIS, Finger Tapping Test, short-term memory, working memory, executive function, mental flexibility, verbal and visual long-term memory.	The only relationship that was statistically significant was between the previously measured urine mercury values and visual long-term memory,	The neuropsychological findings indicative of subsequent cognitive injuries are difficult to find in groups of otherwise healthy dental personnel with previous occupational exposure to mercury.
Naimi-Akbar <i>et al.</i> 2012 [30]	To investigate cognitive function among offspring of women working in dentistry at the time of their pregnancy.	3546	Four test: two linguistics, one for spatial recognition and one for technical comprehension.	The sons of dental workers had similar or higher cognitive function test results compared to their matched cohorts.	There is no evidence of poorer cognitive function among male offspring of female dentists or dental nurses.

Vähäsarja <i>et al.</i> 2016 [31]	To investigate whether potential in utero exposure to mercury might have affected the development of nervous system of the sons of female dental personnel.	12110	National registers.	There is no elevated risk for neurological disease, epilepsy or intellectual disability among the sons of dental personnel	The current use of dental amalgam should not represent an elevated risk for neurological disease or intellectual disability among the offspring of dental personnel.
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[15]. Signs of long term exposure to mercury include: emotional instability, cognitive and memory loss, shyness, speech problems and ataxia [16], known as "mad hatter's disease".

Dentists and dental assistants are among professionals exposed to Hg<sub>0</sub> due to dealing with amalgam fillings and MeHg from their own amalgam fillings. This review includes 13 studies about possible CNS effects of chronic exposure to mercury [17-29] and 2 studies about possible CNS effects on offspring of female dental professionals exposed to mercury during pregnancy [30,31]. All the papers compare a group of dental workers exposed to mercury proved by blood and/or urine tests with a control group.

Assessment of CNS effects was done using battery tests and/or questionnaires or analysed of individual hospital records. Tests evaluate neuropsychological activity within the following domains: motor function, short-term memory, working memory, executive function, mental flexibility, visual and verbal long-term memory.

The papers reviewed give contradictory evidence depending on year and type of investigation.

Uzzell and Oller [17] used Recurrent Figures, SCL-90-R (Symptom Checklist 90 revised), WAIS (Wechsler Adult Intelligence Scale), Rey's AVL (Rey-Auditory Verbal Learning), PASAT (Paced Auditory Serial Addition Test), BGT (Bender-Gestalt Test), Grooved Pegboard, and Finger Tapping tests for evaluation of neuropsychological performances of 13 female dental assistants and found mild changes.

Bittner, *et al.* [20] performed also psychomotor five tests: Intentional Hand Steadiness Test (IHST); Finger Tapping; The One-Hole Test; NES Simple Reaction Time (SRT); and Hand Tremor and determined a significant associations between the IHST and Hg<sub>0</sub> level.

Other study from 1998 [21] associated questionnaire with Neurobehavioral Evaluation System (NES) tests on 49 dental workers and discovered subtle alterations of motor, memory and cognitive skills. The same association was done by Aydin, *et al.* [24] and established a positive relationship with increased scores of anxiety and psychoticism using SCL-90-R test in a group of 43 dental workers. Sletvold, *et al.* [29] discovered a statistically significant relationship between measured urine mercury level and visual long-term memory based on evaluation of 91 female dental workers by questionnaire and neuropsychological tests.

Questionnaire based studies [18,23,25,26,28] could assess more dental workers than previously mention studies and generally concluded that symptoms of CNS could not be related with chronic mercury exposure, but dental assistants seems to have more cognitive symptoms than dentist [25,26,28] possible because dental assistants are more exposed than dentists. Glina, *et al.* [19] based on 8 questionnaires reported neurological and psychic effects.

Studies done before 2010 revealed associations between CNS symptoms and chronic mercury exposure, except study conducted Nilson, *et al.* in 1990. Studies that used different battery tests for neuropsychological examination noticed a significant correlation between CNS symptoms and chronic mercury exposure. In contrast,

studies based only on questionnaire found moderate or no link between neurological symptoms and occupational exposure.

Studies from 2011 do not associate neurological symptoms with chronic mercury exposure. This is related with regulations in amalgam use, occupational health training in handling dental amalgam and improvement in working conditions, especially improvement of ventilation, because inhalation of vapour is the main route for exposure in dental workers. All these measures reduced mercury exposure. In 1991 World Dental Federation [32] recognized that "a potential health risk to oral health personnel from mercury exposure exists if working conditions are not properly organised" and "application of proper mercury hygienic requirements together with monitoring of mercury vapours in the work environment in dental clinics will significantly reduce mercury exposure".

When compared with other mercury exposed workers, dental professionals' exposure was mild, no signs of micromercurialism were revealed, but a shortening of visual evoked potentials (VEP) latency was discovered in all groups [22] and this is associated with cerebral cortex activity. This is the only study that correlate exposure to mercury vapours with a certain test, namely VEP. Unfortunately, the relationship between VEP, chronic mercury exposure and dental professionals has not been investigated further, but VEP latency was correlated with mercury exposure due to food contamination [33].

Although the neurophysiological tests revealed an association between chronic mercury exposure and CNS findings among dental professionals, there is not a specific test to show this and also no specific CNS symptom. .

More recent studies made different correlation between occupational mercury exposure and CNS effects. Thygesen, *et al.* [27] compare hospital admissions due to neurological and renal diseases among dental workers and a control group and could not establish a positive relationship.

Naimi, *et al.* [30] and Vähäsarja, *et al.* [31] investigated the relationship between mercury exposure during pregnancy and cognitive function, respectively risk of neurological disease among offspring of dental workers. This is in accordance with previous findings, which suggested that placenta and foetal membranes might serve as a protection for the foetus against mercury exposure [34].

Occupational exposure is different from mercury exposure due to amalgam fillings, because amalgam aged for two years did not release mercury [35]. Different studies tried to correlate mercury eliminated from dental amalgam fillings with diverse health effects. A study from 1988 [36] aimed to investigate whether fatigue, a CNS effect, is related to the number of tooth surfaces of amalgam or to other factors and concluded that other factors (psychosocial factors and the frequency of sick-leave in respiratory diseases) rather than the release of mercury from dental amalgam could explain the symptoms of fatigue. Bates, *et al.* [37] performed a retrospective cohort study and examined associations with medical diagnostic categories, particularly disorders of the nervous system and kidney with mercury exposure from amalgam fillings. They concluded that there is a limited evidence of an

association between amalgam and disease.

Despite of controversy amalgam is still used worldwide for dental fillings because is durable and affordable [38] and in posterior teeth amalgam restorations have a better longevity and less number of secondary caries when compared to colour-tooth restorations [39].

## Conclusion

As this review has shown, earlier studies associate chronic exposure to mercury with CNS effects and later studies could not relate neuropsychological symptoms with mercury chronic exposure in dental professionals. Studies that used different neuropsychological tests noticed a significant correlation between CNS symptoms and chronic mercury exposure, but studies based only on questionnaire found moderate or no link between neurological symptoms and occupational exposure. There is not a specific neurophysiological test characteristic to chronic mercury exposure, only VEP latency is characteristic to mercury vapours exposure.

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