

# Health Effects from Dental Personnel Exposure to Mercury Vapor from Dental Amalgam

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Dental offices are known to be one of the largest users of inorganic mercury. It is well documented that dentists and dental personnel who work with amalgam are chronically exposed to mercury vapor, which accumulates in their bodies to much higher levels than for most non-occupationally exposed. Adverse health effects of this exposure, including neurological effects, have also been well documented that affect most dentists and dental assistants, with measurable effects among those in the lowest levels of exposure. Mercury levels of dental personnel average at least 2 times that of controls for hair, urine, toenails, and for blood. A Lebanese study found 25 % of dentists had hair mercury levels over 5 ppm and 8% had level over 10 ppm.

Sweden, which proposed to ban use of mercury in fillings, is the country with the most exposure and health effects studies regarding amalgam, and urine levels in dental professionals from Swedish and European studies ranged from 0.8 to 30.1 ug/L with study averages from 3.7 to 6.2 ug/L. The Swedish safety guideline for mercury in urine is 5.6 nmol Hg/nmol (11.6 ug/L). Study averages for other countries ranged from 3.2 to 15 microgram/liter (ug/L). A large survey of dentists at the Norwegian Dental Association's meeting found that the mean mercury level in 1986 was 7.8 ug/L with approx. 16% above 13.6ug/L, and for 1987 found an average of 8.6 ug/L with approx. 15% above 15.8 ug/L, with women having higher levels than men in general. A U.S. national sample of dentists provided by the American Dental Association had an average of 5.2 ug/L. In that large sample of dentists, 10% of dentists had urine mercury levels over 10.4 ug/L and 1% had levels over 33.4ug/L, indicating daily exposure levels of over 100 ug/day. Another large U.S. study had an average mercury level in urine of dentists of 3.2 ug/L.

Researchers from the University of Washington School of Dentistry and Department of Chemistry tested a sample of dentists at an annual ADA meeting. The study found that the dentists had a significant body burden of mercury, and the group with higher levels of mercury had significantly more adverse health conditions than the group with lower exposure. The increased effects in the group with more mercury exposure included mood disturbances, memory deficits, fatigue, confusion, anxiety, and delay in simple reaction time. A Norwegian study compared the occurrence of neurological symptoms among dental assistants likely to be exposed to mercury from work with dental filling material, compared to similar health personnel with no such exposure. The dental assistants reported significant higher occurrence of neurological symptoms; psychosomatic symptoms, problems with memory, concentration, fatigue and sleep disturbance. Another study of a group of 194 U.S. male dentists with mean urine mercury level of 3.3 ug/L and 233 female dental assistants with mean urine mercury level of 2.0 ug/L considered effects of polymorphism in brain-derived neurotrophic factor(BDNF) or a

polymorphism in blood heme (CPOX4) as well as mercury level. The study found significant effects of mercury level on nine measures of neurological deficits for the dentists and on eight measures of neurological deficits for dental assistants, as well as a significant difference relating to BDNF and to CPOX4.

Large studies of U.S. dentists and dental assistants have found that mercury level in urine is significantly associated with neurological dysfunction using several different measures, but that among a population with low level mercury exposure those with a polymorphism in blood heme (CPOX4) or to a polymorphism in neurofactor (BDNF) or to a functional single nucleotide polymorphism (Val158Met) in the gene encoding the catecholamine catabolic enzyme catechol O-methyltransferase (COMT) were more susceptible to neurological effects or deficits. An association in a population with low level mercury exposure between such polymorphisms and mood disorders was found only for female dental assistants. The associations between a polymorphism of the serotonin transporter gene (5-HTTLPR), dental mercury exposure, and self-reported symptoms were evaluated among 157 male dentists and 84 female dental assistants. The findings suggest that within this restricted population of mercury exposed workers, increased symptoms of depression, anxiety, and memory are associated with the 5-HTTLPR polymorphism among both males and females.

Mercury excretion levels were found to have a positive correlation with the number of amalgams placed or replaced per week, the number of amalgams polished each week, and with the number of fillings in the dentist. In one study, each filling was found to increase mercury in the urine, though the relationship was nonlinear and increased more with larger number of fillings. Much higher accumulated body burden levels in dental personnel were found based on challenge tests than for controls, with excretion levels after a dose of a chelator as high as 10 times the corresponding levels for controls. Autopsy studies have found similar high body accumulation in dental workers, with levels in pituitary gland and thyroid over 10 times controls and levels in renal cortex 7 times controls. Autopsies of former dental staff found levels of mercury in the pituitary gland averaged as high as 4,040 ppb. They also found much higher levels in the brain occipital cortex (as high as 300 ppb), renal cortex (as high as 2110 ppb), and thyroid (as high as 28,000 ppb). In general dental assistants and women dental workers showed higher levels of mercury than male dentists.

Mercury levels in blood of dental professionals ranged from 0.6 to 57 ug/L, with study averages ranging from 1.34 to 9.8 ug/L. A review of several studies of mercury level in hair or nails of dentists and dental workers found median levels were 50 to 300% more than those of controls. Dentists have been found to have elevated skeletal mercury levels, which has been found to be a factor in osteoporosis, as well as mercury retention and kidney effects that tend to cause lower measured levels of mercury in urine tests. A group of dental students taking a course involving work with amalgam had their urine tested before and after the course was over. Allergy tests given to another group of dental students found 44% of them were allergic to mercury. Studies have found that the longer time exposed, the more likely to be allergic and the more effects. One study found that over a 4 year period of dental school, the sensitivity rate increased 5-fold to over 10%. Another group of dental students had similar results, while

another group of dental student showed compromised immune systems compared to medical students. The total lymphocyte count, total T cell numbers (CD3), T helper/ inducer (CD4+CD8-), and T suppressor/cytotoxic (CD4-CD8+) numbers were significantly elevated in the dental students compared to the matched control group. Similar results have been seen in other studies as well.

More than 10,000 dental assistants were exposed to extremely high concentrations of mercury fumes while working with amalgam in dental offices during the 60's, 70's, 80's, and early 90's. 25% of them report they often or very often have neurological problems. They have been compared with a group of nurses of the same age. Dental assistants scored much higher than nurses on 4 health problems:

- Tremor/shaking;
- Heart and lung problems;
- Depression; and
- Lack of memory/memory failure.

Urinary porphyrin profiles were found to be an excellent biomarker of level of body mercury level and mercury damage neurological effects, with coproporphyrin significantly higher in those with higher mercury exposure and urine levels. Coproporphyrin levels have a higher correlation with symptoms and body mercury levels as tested by challenge test, but care should be taken regarding challenge tests as the high levels of mercury released can cause serious health effects in some, especially those who still have amalgam fillings or high accumulations of mercury. Screening test that are less burdensome and less expensive are now available as first morning void urine samples have been found to be highly correlations to 24 hour urine test for mercury level or porphyrins.

The average dental office exposure affects the body mercury level at least as much as the workers on fillings, with several studies finding levels approximately the same as having 19 amalgam fillings. Many surveys have been made of office exposure levels. The level of mercury at breathing point in offices measured ranged from 0.7 to over 300 micrograms per cubic meter (ug/M<sup>3</sup>). The average levels in offices with reasonable controls ranged from 1.5 to 3.6 ug/M<sup>3</sup>, but even in Sweden which has had more office environmental controls than others spot levels of over 150 ug/M<sup>3</sup> were found in 8 offices. Another study found spot readings as high as 200 ug/M<sup>3</sup> in offices with few controls that only used saliva extractor. OSHA surveys find 6-16% of U.S. dental offices exceed the OSHA dental office standard of 50 ug/M<sup>3</sup>, and residual levels in equipment sterilizers often exceed this level.

The German workplace mercury standard of 1 ug/M<sup>3</sup> is almost always exceeded. The U.S. ATSDR mercury vapor exposure MRL for chronic exposure is much lower, 0.2 ug/M<sup>3</sup> (giving approx. 4 ug/day exposure), similar to U.S. EPA and Health Canada guidelines. Thus most office mercury levels were found to far exceed the U.S. guidelines for chronic mercury exposures.

Use of high speed drill in removal or replacement has been found to create high volume of mercury vapor and respirable particles, and dental masks to only filter out about 40 % of such particles. Amalgam dust generated by high speed drilling is absorbed rapidly into the blood through the lungs and major organs such as the heart receive a high dose within minutes. This produces high levels of exposure to patient and dental staff. Use of water spray, high velocity evacuation, and rubber dams reduce exposure to patient and dental staff significantly, as seen in previous discussion. In addition to these measures researchers also advise all dental staff should wear face masks and patients be supplied with outside air. Some studies note that carpeting and rugs in dental offices should be avoided as it is a major repository of mercury. For office's using an aspirator, mercury vapor concentrations of ten times the current occupational exposure limit of 25 microg/M3 were recorded after 20 minutes of continuous aspirator operation. A build-up of amalgam contamination within the internal corrugated tubing of the aspirator was found to be the main source of mercury vapor emissions followed by particulate amalgam trapped within the vacuum motor. As the vacuum motor heated up with run time, mercury vapor emissions increased. It was found that the bacterial air exhaust filter (designed to clean the contaminated waste air entering the surgery) offered no protection to mercury vapor. Use of such measures along with a Clean-Up™ aspirator tip was found to reduce exposure to patient and staff approximately 90%.

Dentists were found to score significantly worse than a comparable control group on neurobehavioral tests of motor speed, visual scanning, and visiomotor coordination, concentration, verbal memory, visual memory, and emotional/mood tests. Test performance was found to be proportional to exposure/body levels of mercury. Significant adverse neurobehavioral effects were found even for dental personnel receiving low exposure levels (less than 4 ug/l Hg in urine). This study was for dental personnel having mercury excretion levels below the 10th percentile of the overall dental population. Such levels are also common among the general population of non- dental personnel with several fillings. This study used a new methodology which used standard urine mercury levels as a measure of recent exposure, and urine levels after chelation with a chemical, DMPS, to measure body burden mercury levels. 30% of dentists with more than average exposure were found to have neuropathies and visigraphic dysfunction. Mercury exposure has been found to often cause disability in dental workers.

A large study at a Scottish University found dentists had higher levels of mercury in their bodies, compared with a sample group of academics. Researchers obtained urine, hair, and nail samples from 180 dentists in the west of Scotland and 180 academics from the University of Glasgow. Levels of mercury were four times higher on average among dentists compared with academics. The levels were found to be strongly associated with the number of hours worked, the number of fillings handled, and the number of fillings they had themselves. There was evidence the increased mercury exposure results in adverse effects. Dentists were ten times more likely to have sought medical treatment for kidney disorders and three times more likely to have experienced fertility problems. There were also more than twice as likely to have suffered from memory disturbances. These are all problems known from other studies to be related to mercury exposure. (Note: Some discussions of study findings, such as this, make it

clear that many critics of such study findings do not understand the well documented fact that effects of mercury are not strictly dose related and depend on susceptibility as well as dose. A significant portion of the population are more immune reactive or have less system ability to detoxify and excrete mercury than others. The fact that some aren't significantly affected by levels that disable others has been used inappropriately as an argument against accepting consistent significant findings.)

Chelators, like DMPS, have been found after a fast to release mercury from cells in tissue to be available for excretion. This method was found to give enhanced precision and power to the results of the tests and correlations. Even at the low levels of exposure of the subjects of this study, there were clear demonstrated differences in test scores involving memory, mood, and motor skills related to the level of exposure pre- and post-chelation. Those with higher levels of mercury had deficits in memory, mood, and motor function compared to those with lower exposure levels. The plotted test results gave no indication of an existing threshold below which effects were not measurable. Mood scores including anger were found to correlate more strongly with pre-chelation urine mercury levels; while toxicity symptoms, concentration, memory (vocabulary, word), and motor function correlated more strongly with post-chelation mercury levels. Another study using DMPS challenge test found over twenty times higher mercury excretion in dentists than in controls, indicating high body burden of mercury compared to controls.

Many dentists have been documented to suffer from mercury poisoning other than the documented neurological effects, such as chronic fatigue, muscle pains, stomach problems, tremors, motor effects, immune reactivity, contact dermatitis etc. One of the common effects of chronic mercury exposure is chronic fatigue due to immune system overload and activation. Many studies have found this occurs frequently in dentists and dental staff along with other related symptoms- lack of ability to concentrate, chronic muscular pain, burnout, etc. In a group of dentists and dental workers suffering from extreme fatigue and tested by the immune test MELISA, 50% had autoimmune reaction to inorganic mercury and immune reactions to other metals used in dentistry were also common. Tests of controls did not find such immune reactions common. In another study nearly 50 % of dental staff in a group tested had positive autoimmune ANA titers compared to less than 1 % of the general population.

One dentist with severe symptoms similar to ALS improved after treatment for mercury poisoning, and another with Parkinson's disease recovered after reduction of exposure and chelation. Similar cases among those with other occupational exposure have been seen. A survey of over 60,000 U.S. dentists and dental assistants with chronic exposure to mercury vapor and anesthetics found increased health problems compared to controls, including significantly higher liver, kidney, and neurological diseases. A recent study in Scotland found similar results. Other studies reviewed found increased rates of brain cancer and allergies and lupus. Swedish male dentists were found to have an elevated standardized mortality ratio compared to other male academic groups. Dental workers and other workers exposed to mercury vapor were found to have a shortening of visual evoked potential latency and a decrease in amplitude, with magnitudes correlated with urine excretion levels. Dentists were

also found to have a high incidence of radicular muscular neuralgia and peripheral sensory degradation. In one study of dentists and dental assistants, 50% reported significant irritability, 46% arthritic pains, and 45% headaches, while another study found selective atrophy of muscle fiber in women dental workers, and in a third study, significant between-group differences were found in current health symptom experience and reproductive health, especially early hysterectomy experience. Reporting of Occupational Overuse Syndrome was strongly positively correlated with years of work.

In a study in Brazil, 62% of dental workers had urine mercury levels over 10 mg/L, and indications of mild to moderate mercury poisoning in 62% of workers. The most common problems were related to the central nervous system. Recent studies in Turkey found the dental staff group had higher whole blood (B-Hg) and urine (U-Hg) Hg levels than the control group. The mean B-Hg value was 2.18 nmol/l, and U-Hg was 1.17 nmol/mmol creatinine. U-Hg had an inverse relationship with logical memory (in WMS-R test) and total retention score (in VTMP test), and a positive relationship with increased scores of Anxiety and Psychoticism (in SCL-90-R). Dentists mercury levels in urine were 3 times higher than controls.

Both dental hygienists and patients get high doses of mercury vapor when dental hygienists polish or use ultrasonic scalers on amalgam surfaces. Use of hydrogen peroxide or other bleaching agents for teeth whitening in dental office or home bleaching products also results in significant increases in release of mercury by amalgams. Pregnant women or pregnant hygienist especially should avoid these practices during pregnancy or while nursing since maternal mercury exposure has been shown to affect the fetus and to be related to birth defects, SIDS, etc. Amalgam has been shown to be the main source of mercury in most infants and breast milk, which often contain higher mercury levels than in the mother's blood. Because of high documented exposure levels when amalgam fillings are brushed, dental hygienists are advised not to polish dental amalgams when cleaning teeth. Face masks worn by dental workers filter out only about 40% of small dislodged amalgam particles from drilling or polishing and very little mercury vapor. Dental staff members have been found to have significantly higher prevalence of eye problems, conjunctivitis, atopic dermatitis, and contact urticarial. Finnish dental staff have the highest occupational risk of contact dermatitis with 71% affected over time with plastics, rubber, and mercury the most common causes of sensitization.

Korean dental technicians have a high incidence of contact dermatitis, with dental metals the most common sensitizers. Over 25% had contact dermatitis with over 10% sensitive to 5 metals, chromium, mercury, nickel, cobalt, and palladium. Another study found a high prevalence of extrapyramidal signs and symptoms (tremor) in a group of male dental technicians working in a state technical high school in Rome.

An epidemiological survey conducted in Lithuania on women working in dental offices (where Hg concentrations were < 80 ug/M<sup>3</sup>) had increased incidence of spontaneous abortions and breast pathologies that were directly related to the length of time on the job. A large U.S. survey also found higher spontaneous abortion rate among dental assistants and wives of dentists, and two other studies found an increased risk of spontaneous abortions and other pregnancy complications among women working in dental surgeries. A study of dentist and

dental assistants in the Netherlands found 50% higher rates of spontaneous abortions, stillbirths, and congenital defects than for the control group, with unusually high occurrence of spina bifida. A study in Poland also found a significant positive association between mercury levels and occurrence of reproductive failures and menstrual cycle disorders, and concluded dental work to be an occupational hazard with respect to reproductive processes. Body burden increases with time and older dentists have median mercury urine levels about 4 times those of controls, as well as higher brain and body burdens, and poor performance on memory tests. Some older dentists have mercury levels in some parts of the brain as much as 80 times higher than normal levels. Dentists and dental personnel experience significantly higher levels of neurological, memory, musculoskeletal, visiomotor, mood, and behavioral problems, which increase with years of exposure. Even dental personnel with relatively low exposure (urine Hg < 4 ug/l) were found to have significant neurological effects and was found to be correlated with body burden of mercury. Most studies find dentists have increased levels of irritability and tension, high rates of drug dependency and disability due to psychological problems, and higher suicide rates than the general white population, but one study found rates in same range as doctors. Female dental technicians who work with amalgam tend to have increased menstrual disturbances, significantly reduced fertility and lowered probability of conception, increased spontaneous abortions, and their children have significantly lower average IQ compared to the general population. Populations with only slightly increased levels of mercury in hair had decreases in academic ability. Effects are directly related to length of time on the job. The level of mercury excreted in urine is significantly higher for female dental assistants than dentists due to biological factors. Several dental assistants have been diagnosed with mercury toxicity, and some have died of related health effects. From the medical register of births since 1967 in Norway, it can be seen that dental nurse/assistants have a clearly increased risk of having a deformed child or spontaneous abortions. Female dentists have increased rates of spontaneous abortion and perinatal mortality, compared to controls. A study in Poland found a much higher incidence of birth defects among female dentist and dental assistants than normal. A chronically ill dental nurse diagnosed with mercury sensitivity recovered after replacement of fillings and changing jobs, and a female dentist recovered from Parkinson's after mercury detox. Some studies have found increased risk of lung, kidney, brain, skin melanoma, and CNS system cancers among dental workers. Studies have reported that inorganic mercury induces immunosuppression by decreasing the production of thymus gland hormone (thymulin) and causes other systemic immune effects. A recent study found that dentists and dental nurses have increased mercury exposure compared to controls and reduced thymus function. Plus, many homes of dentists have been found to have high levels of mercury contamination used by dentists bringing mercury home on shoes and clothes. Nationwide, the dental industry is the third largest user of mercury, using over 45 tons of mercury per year, and most of this mercury eventually ends up in the environment. Amalgam from dental offices is by far the largest contributor of mercury into sewers and sewer plants, with mercury from replaced amalgam fillings and crown bases the largest source. As much as 10% of prepared new amalgam becomes waste. This mercury also accumulates in building sewer pipes and septic tanks or drain fields where used, creating toxic liabilities. Unlike most European countries and Canada, which have much more stringent regulation of mercury that

requires amalgam separators in dental offices, the U.S. does not, and most dental offices do not have them. The discharge into sewers at a dental office per dentist using amalgam without amalgam separators is between 270 and 570 milligrams per day. For the U.S. with approximately 170,000 dentists working with amalgam, this would be approximately 16,000 kg/yr (or slightly over 16 tons/year of mercury) into sewers and thus into streams, lakes, bays, and sewer sludge. In Canada, the annual amount discharged is about 2 tons per year, with portions ending up in waters/fish, some in landfills and cropland, and in air emissions. A study in Michigan estimated that dental mercury is responsible for approximately 14% of mercury discharged to streams. An EPA study found that dental office waste were responsible for similar levels of mercury in lakes, bays, and streams in other areas throughout the U.S. A Canadian study found similar levels of mercury contribution from dental offices into lakes and streams, and surveys of dental office disposal practices found the majority violated disposal regulations, and dangerous levels of mercury are accumulating in pipes and septic tanks from many offices. The total discharge into sewers from dental amalgam at individual homes and businesses is almost as large as that from dental offices, since the average person with amalgam fillings excretes in body waste approximately 100 micrograms per day of mercury. This has also been confirmed by medical labs, such as Doctors Data Lab in Chicago and Biospectron in Sweden, which do thousands of stool tests per year and is consistent with studies measuring levels in residential sewers by municipalities. In the U.S. this would amount to approximately 7,300 kilograms per year into sewers or over eight tons per year. Thus the amount of mercury being excreted from dental amalgam is more than enough to cause dangerous levels of mercury in fish in most U.S. streams into which sewers empty. Studies by Oak Ridge National Laboratory and other studies have confirmed high levels of mercury in sewers and sewer sludge. According to an EPA study the majority of U.S. sewerage plants cannot meet the new EPA guideline for mercury discharge into waterways that was designed to prevent bioaccumulation in fish and wildlife due to household sewer mercury levels. Over three tons of mercury flows into the Chesapeake Bay annually from sewer plants, with numerous resulting fish consumption advisories for that area and similar for other areas. The EPA discharge rule had been reduced due to a National Academy of Sciences report of July 2000 that found that even small levels of mercury in fish result in unacceptable risks of birth defects and developmental effects in infants.

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