



CAMPAIGN FOR

MERCURY FREE DENTISTRY

A PROJECT OF CONSUMERS FOR DENTAL CHOICE

Information on the Benefits of Non-Mercury Alternatives to Dental Amalgam

Submitted by Consumers for Dental Choice, United States

Surveys show that approximately half of dentists in the United States never use dental amalgam, demonstrating that non-mercury alternatives are available.¹ Our organization works with these dentists, whose diverse practices demonstrate that non-mercury alternatives are feasible to treat all patients – including individuals with extensive caries, children with disabilities, and lower-income people. Using non-mercury alternatives offers many health and environmental benefits – and eliminates the risks of dental amalgam. Below are three examples of recent research that show dental amalgam poses even more risks than previously known.

A. Evidence That Dental Amalgam’s Elemental Mercury is Converting to Methylmercury in the Human Body

Below are examples of evidence showing that dental amalgam’s elemental mercury can convert to methylmercury in the human body – a harm that could be avoided by the use of non-mercury alternatives to amalgam.

A.1. Scientific evidence demonstrates that bacteria found in the human oral cavity and gut commensal can methylate mercury:

- *Stone, M.E., et al. 2002. “Determination of Methyl Mercury in Dental-Unit Wastewater.” [Dental Materials 19:675-679. DCN 02836.](#)*
“SRB [sulfate reducing bacteria] are known to populate the oral cavity of healthy patients as well as patients with periodontal disease [22,23]. A recently published report [24] correlates MMHg levels in human mouths to the number of Hg containing restorations present, suggesting methylation may occur in the oral cavity. An earlier paper demonstrated the methylation of inorganic Hg by oral streptococci in vitro [25]. SRB in the oral cavity may provide a mechanism by which dental wastewater is ‘inoculated’ with these bacteria.”²
- *Heintze, U., et al, 1983. Methylation of mercury from dental amalgam and mercuric chloride by oral streptococci in vitro. [Scand. J. Dent. Res. 91, 150–152.](#)*
In this study, “Methylmercury was found in the bacterial cells of all four tested strains when they had grown in the presence of HgCl₂ or corrosion products of amalgam (Table I). When cultured in the HgCl₂ in>th, the concentration of methylmercury was larger with the streptococcal strains than with C. cochlearium T-2..... Thus, the results indicate the possibility of a microbial methylation of inorganic mercury from amalgam restorations in the mouth, as the oral streptococci studied are common in the dental plaque.”³

A.2. Recent studies confirm that methylmercury in the human body is associated with dental amalgam:

- *Yin et al., Associations of blood mercury, inorganic mercury, methylmercury and bisphenol A with dental surface restorations in the U.S. population, NHANES 2003–2004 and 2010–2012, Ecotoxicity and Environmental Safety (2016):*

Yin et al. “found that dental surface restorations significantly contributed to the blood concentrations of THg and IHg in both periods of study, as well as MeHg in 2011–2012, after adjusting covariates such as age, education, race/ethnicity, gender, smoking, and fish consumption history.” The researchers noted that “significant correlation between the blood level of mercury and dental restoration raises major concerns about potential mercury exposure.” The study also noted that “Elevated mercury in urine usually indicates exposure to an elemental or inorganic source of mercury, while elevated mercury in blood usually indicates exposure to organic mercury or recent exposure to a high level of elemental mercury vapor. However, our current study found that THg, MeHg, and IHg significantly increased with the number of the DSRs after the adjustment of covariates. It is well established that inorganic mercury is released into circulation from amalgam restorations (Lorscheider et al., 1995); it is also widely believed that the only source of the organic form, methyl mercury, is from fish in the diet. However, accumulating evidence demonstrates that human oral or gut commensal bacteria can methylate mercury (Edwards and McBride, 1975; Ekstrom et al., 2003; Heintze et al., 1983; Kucharzyk et al., 2015; Yu et al., 2013). Leistevuo et al. found a correlation between the total amalgam surfaces and organic mercury in saliva, suggesting both methylating and nonmethylating bacteria can enhance the formation of toxic methylmercury (Leistevuo et al., 2001).”⁴

- *Leistevuo, J., et al., 2001. Dental amalgam fillings and the amount of organic mercury in human saliva. Caries Res 35, 163–166.*

This study “found that the amalgam group had significantly higher amounts of both organic and inorganic mercury in paraffin-stimulated saliva samples than the nonamalgam control groups.... Our results are compatible with the hypothesis that dental amalgam fillings, in addition to being a major source of inorganic mercury, are also a continuous source of organic mercury.... In the light of these results, bacteria in the oral environment could be among the major sources of organic mercury in human saliva. Interestingly, the frequency of fish eating was lowest in the amalgam group, indicating that fish eating does not explain the observed differences.”⁵

- *William A Sellars, Rodney Sllars, Lian Liang & Jack D. Hefley (1996) Methyl Mercury in Dental Amalgams in the Human Mouth, Journal of Nutritional & Environmental Medicine, 6:1, 33-36, DOI: 10.3109/13590849608999133*

“We report the presence of methyl mercury from the analysis of three samples of restorations associated with dental amalgam. We believe this to be the first finding of methyl mercury in the human mouth. Although the amounts found are small (4.0, 5.3 and 37.3 ng per sample), any measurable amount of methyl mercury contributes to the total body's burden of mercury.”⁶

A.3. Government reports agree that methylmercury in the human body is associated with dental amalgam:

- *EPA, Health Services Industry Detailed Report: Dental Amalgam (August 2008), <https://www.epa.gov/sites/production/files/2015-06/documents/dental-amalgam-study-2008.pdf>*

“Researchers have concluded that sulfate-reducing bacteria are responsible for the presence of methylmercury in dental wastewater. However, it is not clear whether methylation occurs in the patient’s mouth or in the discharge stream.”⁷

- *European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), Final opinion on the safety of dental amalgam and alternative dental restoration materials for patients and users (29 April 2015), http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_046.pdf, pp.13, 24:* SCENIHR’s opinion summarizes the concerns about the stability of amalgam’s mercury in the human body: “Once released into saliva, inorganic mercury might be methylated by bacteria in the periodontal pocket and gastrointestinal tract, but the rate is not clear (Langendijk *et al.*, 2001, Leistevuo *et al.*, 2002, van der Hoeven *et al.*, 2007).... Indeed, species involved in environmental mercury methylation are present in the human gut (Gibson *et al.*, 1993), and limited evidence supports the notion that human faecal and oral microorganisms can generate methyl mercury from inorganic mercury (Edwards and McBride, 1975; Leistevuo *et al.*, 2001).”⁸

A.4. Several of these studies noted that the additional exposure to methylmercury from amalgam is particularly concerning for vulnerable populations, like fetuses, infants, and young children:

- *Yin et al., Associations of blood mercury, inorganic mercury, methylmercury and bisphenol A with dental surface restorations in the U.S. population, NHANES 2003–2004 and 2010–2012, Ecotoxicity and Environmental Safety (2016):* This study noted that “certain subpopulations with inherited genetic variability, along with special populations like fetuses or children, may exhibit more vulnerability to mercury levels lower than these threshold levels.”⁹
- *Leistevuo, J., et al., 2001. Dental amalgam fillings and the amount of organic mercury in human saliva. Caries Res 35, 163–166.* This study concluded that “Our results are compatible with the hypothesis that dental amalgam fillings, in addition to being a major source of inorganic mercury, are also a continuous source of organic mercury. Organic mercury, such as methyl mercury, is considered more toxic than the inorganic forms [WHO, 1991; Goyer, 1996]. From 90% to almost 100% of it is absorbed from the gastrointestinal tract, whereas the absorption of inorganic mercury is only 5-10% [WHO, 1990, 1991]. As a consequence, smaller doses of organic mercury are relatively more dangerous. Organic mercury targets are in particular the central nervous system, and prenatal life [WHO, 1990].”

B. Evidence That Dental Amalgam Poses a Risk to Vulnerable Populations

Below are examples of evidence showing that dental amalgam poses a risk to vulnerable populations – a harm that could be avoided by the use of non-mercury alternatives to amalgam.

B.1. Studies show that some people already exceed the dose associated with reference exposure level to mercury established by the U.S. EPA

- *Richardson et. al., Mercury exposure and risks from dental amalgam in the US population, post-2000, Sci Total Environ. 2011 Sep 15;409(20):4257-68, <http://www.ncbi.nlm.nih.gov/pubmed/21782213>:
One of the most recent studies is the 2011 Richardson study which concluded “Based on the least conservative of the scenarios evaluated, it was estimated that some 67.2 million Americans would exceed the Hg dose associated with the reference exposure level (REL) of 0.3 µg/m(3) established by the US Environmental Protection Agency; and 122.3 million Americans would exceed the dose associated with the REL of 0.03 µg/m(3) established by the California Environmental Protection Agency. Exposure estimates are consistent with previous estimates presented by Health Canada in 1995, and amount to 0.2 to 0.4 µg/day per amalgam-filled tooth surface, or 0.5 to 1 µg/day/amalgam-filled tooth, depending on age and other factors.”¹⁰*

B.2. More studies raising concerns about dental amalgam use in vulnerable populations have emerged:

- *Bjorkman L, Lygre GB, Haug K, Skjærven R (2018) Perinatal death and exposure to dental amalgam fillings during pregnancy in the population-based MoBa cohort. PLoS ONE 13(12): e0208803. <https://doi.org/10.1371/journal.pone.0208803>:
“The results from this study support the hypothesis of increased risk of perinatal mortality of children born by women with many amalgam fillings. Mothers with more than 12 teeth filled with amalgam had an adjusted OR [odds ratio] of 2.34. Using the advantage of the prospective cohort design and the OR as an estimate of the relative risk, we used a standard epidemiologic formula to calculate the attributable fraction [49]. We estimated that among mothers with more than 12 teeth filled with amalgam, 57% of the cases were attributable to amalgam. This estimate is based on the assumptions that there is a causal relationship and that the estimated adjusted OR is unbiased [49]. Since the OR was relatively modest, it cannot be ruled out that residual or unknown confounding could change the estimate. However, the association between perinatal mortality and exposure to amalgam is supported by studies on occupational exposed dental personnel. In addition, the gradual decrease over time in several countries of both the use of amalgam as restorative material and the incidence rates for perinatal mortality provides further support to the hypothesis of an association.”¹¹*
- *Rahime Bedir Findik, Huseyin Tugrul Celik, Ali Ozgur Ersoy, Yasemin Tasci, Ozlem Moraloglu, and Jale Karakaya, Mercury concentration in maternal serum, cord blood, and placenta in patients with amalgam dental fillings: effects on fetal biometric measurements, J Matern Fetal Neonatal Med (2016), https://www.researchgate.net/profile/Huseyin_Celik/publication/295686928_Mercury_concentration_in_maternal_serum_cord_blood_and_placenta_in_patients_with_amalgam_dental_fillings_effects_on_fetal_biometric_measurements/links/5ac8859d4585151e80a57417/Mercury-concentration-in-maternal-serum-cord-blood-and-placenta-in-patients-with-amalgam-dental-fillings-effects-on-fetal-biometric-measurements.pdf:
“The mean mercury levels in the serum, cord blood, and placental tissues of all of the patients were 0.385 ± 0.7, 0.4 ± 0.3, and 1.15 ± 0.8 mg/L, respectively. In the group with dental amalgams, the mean serum mercury level and mean cord blood mercury level were significantly higher than those of the control group (p ¼ 0.006; p ¼ 0.01, respectively).....In conclusion, in the present study, mercury levels in maternal and fetal blood were found to be higher in women with amalgam fillings than in those without them. These high levels do not seem to influence the fetal biometric measurements, but there is a lack of evidence for follow up. Considering that high mercury levels in the mother lead to adverse consequences by accumulating in fetal tissues, the safety of amalgam*

fillings in pregnancy should be reevaluated. In addition, it appears prudent to postpone amalgam filling and removal procedures until the period after pregnancy, even after lactation.”¹²

- *Norouzi, E., Bahramifar, N. & Ghasempouri, S.M., Effect of teeth amalgam on mercury levels in the colostrums human milk in Lenjan, Environ Monit Assess (2012) 184: 375.*
<https://doi.org/10.1007/s10661-011-1974-1>,
https://www.researchgate.net/profile/Seyed_Mahmoud_Ghasempouri/publication/51052927_Effect_of_teeth_amalgam_on_mercury_levels_in_the_colostrums_human_milk_in_Lenjan/links/00463522eee955d586000000/Effect-of-teeth-amalgam-on-mercury-levels-in-the-colostrums-human-milk-in-Lenjan.pdf

As explained in the abstract, “The result of this study also showed a positive correlation of mercury milk levels with the number of teeth fillings of the mother ($p < 0.05, r = 0.755$). The estimated weekly intake of mercury of a breastfed infant in this study was, in some cases, higher than provisional tolerance weekly intake recommended by FAO/WHO, which pose a threat to their health.”¹³

- *James S. Woods et. al., Modification of neurobehavioral effects of mercury by a genetic polymorphism of coproporphyrinogen oxidase in children, NEUROTOXICOLOGY AND TERATOLOGY 34 (2012), 513-521*

Woods et. al. (2012), noting that children are particularly susceptible to mercury’s neurotoxic effect, found “significant adverse effects on neurobehavioral functions associated with chronic Hg exposure [from amalgam] and the CPOX4 genetic variant among children, with effects manifested predominantly among boys. These findings are the first to describe a genetic polymorphism that modifies the effects of Hg exposure on neurobehavioral functions in children.” As the researchers explained, “These findings have important public health implications....These observations suggest potential adverse neurobehavioral effects of Hg among boys with the CPOX4 variant who fall within the top 10% of subjects sampled within that survey for Hg exposure.”¹⁴

C. Evidence That Dental Amalgam Use Results in Adverse Environmental Health Effects

Below are examples of evidence that dental amalgam use results in adverse environmental health effects over the course of its lifecycle, especially via its contribution to methylmercury exposure – harms that could be avoided by the use of non-mercury alternatives to amalgam.

C.1. Dental fillings constitute one of the largest intentional uses of mercury in products in the United States:

- *U.S. Geological Survey, Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States (2013), p.1, 26, https://pubs.usgs.gov/sir/2013/5137/pdf/sir2013-5137.pdf:*

Dentistry is the largest use of mercury in the United States, accounting for between 35% and 57% of all domestic mercury used in 2010.¹⁵ As explained in a U.S. Geological Survey report, “In 2010, the three leading end-use sectors were dental amalgam (accounting for between 35 and 57 percent of consumption), electrical and electronic instrumentation (29 percent of consumption), and batteries (8 percent of consumption)....Dental amalgam constituted the largest amount of mercury in use in the United States. One study reported about 290 t of mercury in dental amalgam was estimated to be contained in human mouths, an estimated 30 t of mercury amalgam was treated as waste, 28.5 t of mercury amalgam was released to the environment, 6 t of amalgam was recycled, and 3.5 t was treated and stored in landfills in 2009....The use of mercury in dental amalgam has been a source of growing concern and government investigation. Dental amalgam represents one of the leading uses

of mercury in the United States at about 18 to 30 t annually and constitutes the largest amount of mercury in use in the United States. In 2009, an estimated 28.5 t of dental amalgam was released into the environment, 6 t was recycled, and 3.5 t was treated and stored in hazardous waste landfills (Cain and others, 2007; Concorde East/West Sprl, 2012). Principal sources of mercury-bearing dental waste include water sent to municipal waste treatment facilities, solid material collected in amalgam separators and recycled, and amalgam fillings contained in the bodies of deceased persons.”¹⁶

C.2. Dental amalgam’s mercury pollutes water via dental clinic releases and human waste:

- EPA, EPA Will Propose Rule to Protect Waterways by Reducing Mercury from Dental Offices (2010), https://archive.epa.gov/epapages/newsroom_archive/newsreleases/a640db2ebad201cd852577ab00634848.html:
“Approximately 50 percent of mercury entering local waste treatment plants comes from dental amalgam waste.”¹⁷
- U.S. Geological Survey, *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States (2013)*, p.23 (see Figure 7), <https://pubs.usgs.gov/sir/2013/5137/pdf/sir2013-5137.pdf>:
Figure 7 shows 6 metric tons of mercury from dental waste traps and filters going to municipal solid waste, 8 metric tons going to municipal wastewater, and only 6 metric tons going of dental waste in separators going to recycle in the United States.¹⁸
- Association of Metropolitan Sewerage Agencies. 2000. *Evaluation of domestic sources of mercury*. Washington, DC: National Association of Clean Water Agencies, pp 10-11, <https://www2.nacwa.org/images/stories/public/mercury.pdf?phpMyAdmin=PM8UfvMmlxx8xqqT LrO9xE0mDg0>:
“Using the mean mercury domestic wastewater concentration of 138 ng/L, this loading from feces and urine could account for 83% of the total domestic loading. Considering the variability in domestic waste concentrations and uncertainties in the percentage of the population with amalgam fillings, this percentage could be higher or lower than this estimate, but this source of mercury is certainly significant.”¹⁹

C.3. Dental amalgam’s mercury pollutes air via cremation, dental clinic emissions, and sludge incineration:

- OSPAR Commission, *Overview assessment of implementation reports on OSPAR Recommendation 2003/4 on controlling the dispersal of mercury from crematoria (2011)*, http://www.ospar.org/documents/dbase/publications/p00532/p00532_rec_2003-4_overview_report.pdf:
“OSPAR has taken a number of measures to reduce discharges, emissions and losses of mercury from point and diffuse sources and identified crematoria as a significant source for releases of mercury, especially from dental amalgam from human remains.”²⁰
- KA Ritchie et. al., *Mercury vapour levels in dental practices and body mercury levels of dentists and controls*, *BRITISH DENTAL JOURNAL* Volume 197 No. 10 November 27 2004, <http://www.nature.com/bdj/journal/v197/n10/pdf/4811831a.pdf>:
“One hundred and twenty two (67.8%) of the 180 surgeries visited had environmental mercury measurements in one or more areas above the Occupational Exposure Standard (OES) set by the Health and Safety Executive.”²¹

- *Mark E. Stone, Mark E. Cohen, Brad A. Debban, Mercury vapor levels in exhaust air from dental vacuum systems, Dental Materials 23 (2007) 527–532, <http://www.mercuryexposure.info/environment/release-pathways/direct-air-exhaust/item/download/180>:
“Hg vapor release to the atmosphere from dental vacuums can be substantial and can exceed human exposure limits.”²²*
- *U.S. Geological Survey, Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States (2013), p.23:*
“Some dental amalgam settles out as a component of sewage sludge accumulated at municipal wastewater treatment plants. The EPA finalized rules in February 2011 that would reduce air emissions for mercury and eight other air pollutants from publically owned incinerators that burn sewage sludge to limit the release of dental mercury into the environment.”²³
- *Lars D. Hylander & Michael E. Goodsite, Environmental Costs of Mercury Pollution, Science of the Total Environment 368 (2006) 352-370, <http://www.aikencolon.com/assets/images/pdfs/Nikro/MercuryVacuum/STOTENbestpaper.pdf>:
Hylander et. al. (2006) found that “Mercury emissions from crematoria are one of the largest air pollution sources in many countries and several crematoria are being equipped with flue gas cleaning technology with associated, high costs (Table 3). The technology cannot recover all Hg in the flue gases, and a certain pollution level of Hg will still occur.”²⁴*

C.4. Dental amalgam’s mercury pollutes land via landfills, burials, and fertilizer:

- *U.S. Geological Survey, Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States (2013), p.23 (see Figure 7), <https://pubs.usgs.gov/sir/2013/5137/pdf/sir2013-5137.pdf>:
Figure 7 shows 3 metric tons of dental mercury from biomedical waste going into landfills and 5 metric tons of dental mercury from hazardous waste going into landfills.²⁵ It also shows that 5 metric tons of dental mercury in deceased persons who are buried ends up soil.²⁶*
- *A Cain, S Disch, C Twaroski, J Reindl and CR Case, Substance Flow Analysis of Mercury Intentionally Used in Products in the United States, Journal of Industrial Ecology, Volume 11, Number 3, copyright Massachusetts Institute of Technology, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.564.4140&rep=rep1&type=pdf>:
This study discussed the land application of wastewater treatment plant biosolids, “which are related primarily to amalgam fillings.”²⁷*

C.5. Dental amalgam’s elemental mercury can convert to methylmercury in the environment, where it can contaminate the fish that people eat, and damage the developing neurological systems of children even before they are born:

- *Stone, M. E., Cohen, M. E., Liang, L., and Pang, P. (2003). Determination of methyl mercury in dental-unit wastewater. Dent Mater 19, 675-9:*
“While the environmental significance of mercury (Hg) release from the dental practice has become an important issue [1–3], it has often at times been dismissed with the assumption that the Hg in dental amalgam is unavailable for uptake by biologic organisms, i.e. that Hg is in the form of intermetallic compounds [4] and therefore not bioavailable. Our supposition is that biologically

available species of Hg, specifically monomethyl mercury (MMHg), may be resident in dental-unit wastewater. In an attempt to resolve this issue, the concentrations of both total Hg and MMHg were measured in dental-unit wastewater samples obtained from three separate locations over 18 months.....To our knowledge, this is the first time MMHg has been reported in dental-unit wastewater, and this report establishes the existence of bioavailable Hg species in the wastewater effluent from dental treatment facilities. MMHg was found to be present, in important concentrations, in dental wastewater from three locations in two different treatment facilities from sampling over the 18-month study period. The highest concentrations of MMHg were found to be present in the holding tanks of the 107 and 30-chair clinics (Table 1). Lower, but still environmentally significant concentrations of MMHg were measured at the dental chair. The amount of MMHg is low in comparison to total Hg, (Table 1), yet noteworthy when the toxicity of MMHg is considered. The concentration of MMHg in dental wastewater samples is orders of magnitude greater than in environmental samples (Table 2).²⁸

- *EPA, EPA Will Propose Rule to Protect Waterways by Reducing Mercury from Dental Offices (2010)*,
https://archive.epa.gov/epapages/newsroom_archive/newsreleases/a640db2ebad201cd852577ab00634848.html:
“Approximately 50 percent of mercury entering local waste treatment plants comes from dental amalgam waste. Once deposited, certain microorganisms can change elemental mercury into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish. Fish and shellfish are the main sources of methylmercury exposure to humans. Methylmercury can damage children’s developing brains and nervous systems even before they are born.”²⁹
- *SCHER, Opinion on Environmental Risks and Indirect Health Effects of Mercury from Dental Amalgam (2014)*,
http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_165.pdf,
page 4:
The European Commission’s Scientific Committee on Health and Environmental Risks has confirmed that dental amalgam in the environment can methylate (forming the most toxic form of mercury, methylmercury), that as a result “the acceptable level in fish is exceeded” under some circumstances, and thus there is “a risk for secondary poisoning due to methylation.”³⁰
- *European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), Final opinion on the safety of dental amalgam and alternative dental restoration materials for patients and users (29 April 2015)*,
http://ec.europa.eu/health/scientific_committees/emerging/docs/scenih_r_o_046.pdf, p.42:
The European Union’s Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) acknowledged that “It is recognised that mercury, which is the major metallic element used in dental amalgam, does constitute a toxicological risk, with reasonably well-defined characteristics for the major forms of exposure. The reduction in use of mercury in human activity would be beneficial, both for the general decrease in human exposure and from environmental considerations.”³¹

Using non-mercury alternatives to dental amalgam offers the health and environmental benefits associated with eliminating the harm of amalgam’s elemental mercury converting to methylmercury in the human body, putting vulnerable populations at risk, and creating adverse environmental health effects.

- ¹ U.S. EPA, *Health services industry detailed study* (August 2008).
- ² Stone, M.E., et al. 2002. "Determination of Methyl Mercury in Dental-Unit Wastewater." *Dental Materials* 19:675-679. DCN 02836.
- ³ Heintze, U., et al., 1983. Methylation of mercury from dental amalgam and mercuric chloride by oral streptococci in vitro. *Scand. J. Dent. Res.* 91, 150–152.
- ⁴ Yin et. al., *Associations of blood mercury, inorganic mercury, methylmercury and bisphenol A with dental surface restorations in the U.S. population, NHANES 2003–2004 and 2010–2012, Ecotoxicity and Environmental Safety* (2016)
- ⁵ Leistevo, J., et al., 2001. Dental amalgam fillings and the amount of organic mercury in human saliva. *Caries Res* 35, 163–166.
- ⁶ William A Sellars, Rodney Sllars, Lian Liang & Jack D. Hefley (1996) Methyl Mercury in Dental Amalgams in the Human Mouth, *Journal of Nutritional & Environmental Medicine*, 6:1, 33-36, DOI: 10.3109/13590849608999133
- ⁷ EPA, *Health Services Industry Detailed Report: Dental Amalgam* (August 2008), <https://www.epa.gov/sites/production/files/2015-06/documents/dental-amalgam-study-2008.pdf>
- ⁸ European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), *Final opinion on the safety of dental amalgam and alternative dental restoration materials for patients and users* (29 April 2015), http://ec.europa.eu/health/scientific_committees/emerging/docs/scenih_r_o_046.pdf, pp.13, 24
- ⁹ Yin et. al., *Associations of blood mercury, inorganic mercury, methylmercury and bisphenol A with dental surface restorations in the U.S. population, NHANES 2003–2004 and 2010–2012, Ecotoxicity and Environmental Safety* (2016)
- ¹⁰ Richardson et. al., *Mercury exposure and risks from dental amalgam in the US population, post-2000*, *Sci Total Environ.* 2011 Sep 15;409(20):4257-68, <http://www.ncbi.nlm.nih.gov/pubmed/21782213>
- ¹¹ Bjorkman L, Lygre GB, Haug K, Skjærven R (2018) Perinatal death and exposure to dental amalgam fillings during pregnancy in the population-based MoBa cohort. *PLoS ONE* 13(12): e0208803. <https://doi.org/10.1371/journal.pone.0208803>
- ¹² Rahime Bedir Findik, Huseyin Tugrul Celik, Ali Ozgur Ersoy, Yasemin Tasci, Ozlem Moraloglu, and Jale Karakaya, *Mercury concentration in maternal serum, cord blood, and placenta in patients with amalgam dental fillings: effects on fetal biometric measurements*, *J Matern Fetal Neonatal Med* (2016), https://www.researchgate.net/profile/Huseyin_Celik/publication/295686928_Mercury_concentration_in_maternal_serum_cord_blood_and_placenta_in_patients_with_amalgam_dental_fillings_effects_on_fetal_biometric_measurements/links/5ac8859d4585151e80a57417/Mercury-concentration-in-maternal-serum-cord-blood-and-placenta-in-patients-with-amalgam-dental-fillings-effects-on-fetal-biometric-measurements.pdf
- ¹³ Norouzi, E., Bahramifar, N. & Ghasempouri, S.M., *Effect of teeth amalgam on mercury levels in the colostrums human milk in Lenjan*, *Environ Monit Assess* (2012) 184: 375. <https://doi.org/10.1007/s10661-011-1974-1>, https://www.researchgate.net/profile/Seyed_Mahmoud_Ghasempouri/publication/51052927_Effect_of_teeth_amalgam_on_mercury_levels_in_the_colostrums_human_milk_in_Lenjan/links/00463522eee955d586000000/Effect-of-teeth-amalgam-on-mercury-levels-in-the-colostrums-human-milk-in-Lenjan.pdf
- ¹⁴ James S. Woods et. al., *Modification of neurobehavioral effects of mercury by a genetic polymorphism of coproporphyrinogen oxidase in children*, *NEUROTOXICOLOGY AND TERATOLOGY* 34 (2012), 513-521.
- ¹⁵ U.S. Geological Survey, *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States* (2013), p.1, 26
- ¹⁶ U.S. Geological Survey, *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States* (2013), p.1, 26
- ¹⁷ EPA, *EPA Will Propose Rule to Protect Waterways by Reducing Mercury from Dental Offices* (2010), https://archive.epa.gov/epapages/newsroom_archive/newsreleases/a640db2ebad201cd852577ab00634848.html
- ¹⁸ U.S. Geological Survey, *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States*(2013), p.23 (see Figure 7)
- ¹⁹ Association of Metropolitan Sewerage Agencies. 2000. *Evaluation of domestic sources of mercury*. Washington, DC: National Association of Clean Water Agencies, pp 10-11, <https://www2.nacwa.org/images/stories/public/mercury.pdf?phpMyAdmin=PM8UfvMmlxx8xqLrO9xE0mDg0> ("this source of mercury is certainly significant").
- ²⁰ OSPAR Commission, *Overview assessment of implementation reports on OSPAR Recommendation 2003/4 on controlling the dispersal of mercury from crematoria* (2011), http://www.ospar.org/documents/dbase/publications/p00532/p00532_rec_2003-4_overview_report.pdf ("OSPAR has taken a number of measures to reduce discharges, emissions and losses of mercury from point and diffuse sources and identified crematoria as a significant source for releases of mercury, especially from dental amalgam from human remains.")
- ²¹ E.g., KA Ritchie et. al., *Mercury vapour levels in dental practices and body mercury levels of dentists and controls*, *BRITISH DENTAL JOURNAL* Volume 197 No. 10 November 27 2004, <http://www.nature.com/bdj/journal/v197/n10/pdf/4811831a.pdf> ("One hundred and twenty two (67.8%) of the 180 surgeries visited had environmental mercury measurements in one or more areas above the Occupational Exposure Standard (OES) set by the Health and Safety Executive.")
- ²² E.g., Mark E. Stone, Mark E. Cohen, Brad A. Debban, *Mercury vapor levels in exhaust air from dental vacuum systems*, *Dental Materials* 23 (2007) 527–532, <http://www.mercuryexposure.info/environment/release-pathways/direct-air-exhaust/item/download/180> ("Hg vapor release to the atmosphere from dental vacuums can be substantial and can exceed human exposure limits.")
- ²³ U.S. Geological Survey, *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States*(2013), p.23 ("Some dental amalgam settles out as a component of sewage sludge accumulated at municipal wastewater treatment plants. The EPA finalized rules in February 2011 that would reduce air emissions for mercury and eight other air pollutants from publically owned incinerators that burn sewage sludge to limit the release of dental mercury into the environment.")
- ²⁴ Lars D. Hylander & Michael E. Goodsite, *Environmental Costs of Mercury Pollution*, *Science of the Total Environment* 368 (2006) 352-370, <http://www.aikencolon.com/assets/images/pdfs/Nikro/MercuryVacuum/STOTENbestpaper.pdf>
- ²⁵ U.S. Geological Survey, *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States*(2013), p.23 (see Figure 7)
- ²⁶ U.S. Geological Survey, *Changing Patterns in the Use, Recycling, and Material Substitution of Mercury in the United States*(2013), p.23 (see Figure 7)
- ²⁷ A Cain, S Disch, C Twaroski, J Reindl and CR Case, *Substance Flow Analysis of Mercury Intentionally Used in Products in the United States*, *Journal of Industrial Ecology*, Volume 11, Number 3, copyright Massachusetts Institute of Technology and Yale University.

²⁸ Stone, M. E., Cohen, M. E., Liang, L., and Pang, P. (2003). Determination of methyl mercury in dental-unit wastewater. *Dent Mater* 19, 675-9

²⁹ EPA, *EPA Will Propose Rule to Protect Waterways by Reducing Mercury from Dental Offices* (2010), https://archive.epa.gov/epapages/newsroom_archive/newsreleases/a640db2ebad201cd852577ab00634848.html

³⁰ SCHER, *Opinion on Environmental Risks and Indirect Health Effects of Mercury from Dental Amalgam* (2014), http://ec.europa.eu/health/scientific_committees/environmental_risks/docs/scher_o_165.pdf, page 4

³¹ European Commission Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR), *Final opinion on the safety of dental amalgam and alternative dental restoration materials for patients and users* (29 April 2015), http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_046.pdf, p.42