

A COMPREHENSIVE REVIEW OF THE TOXIC EFFECTS OF MERCURY IN DENTAL AMALGAM FILLINGS ON THE ENVIRONMENT AND HUMAN HEALTH

The International Academy of Oral Medicine and Toxicology (www.iaomt.org)
2016 Update

“For medical reasons, amalgam should be eliminated in dental care as soon as possible.

This will confer gains in three respects.

The prevalence of side-effects from patients’ mercury exposure will decline;

occupational exposure to mercury can cease in dental care;

and one of our largest sources of mercury in the environment can be eliminated.”¹

--Dr. Maths Berlin, the Dental Material Commission of Sweden, 2003

About the IAOMT:

Representing a network of dental, medical, and research professionals with more than 750 members in North America and affiliated chapters in over fourteen other countries, the International Academy of Oral Medicine and Toxicology (IAOMT) has been researching the damage dental mercury inflicts on the environment and humans since the non-profit organization was created in 1984.

Brief Overview of Mercury Used in Dentistry:

Millions of dentists around the world routinely use dental amalgam as a filling material in decayed teeth. Often referred to as “silver fillings,” all dental amalgams actually consist of 45-55% metallic mercury.² Mercury is a known neurotoxin that can cause harm to humans, especially children, pregnant women, and fetuses. Furthermore, the use of dental amalgam results in substantial quantities of toxic mercury released annually into the environment. Once in the environment, mercury pollution damages animals, plants, and the entire ecosystem, while creating “hotspots that last for centuries.”³

According to the United States Environmental Protection Agency (EPA), there are currently over 1,000 tons of mercury in the mouths of Americans, which is more than half of all the mercury being used in the U.S. today.⁴ While amalgams are currently used for 45% of all direct dental restorations worldwide,⁵ articles published in the *Journal of the American Dental Association* have established that these mercury fillings are used on 51.0% of White/Caucasian Americans 53.4% of Black/African Americans, on 72.9% of American Indians/Alaska Natives/Asians/Pacific Islanders,⁶ and on more than 75% of posterior restorations for new recruits to the U.S. Navy and Marines.⁷

Controversy has surrounded the use of mercury in dentistry since the 1800’s, when the hazardous material was first widely introduced as a filling component. The American Society of Dental Surgeons, the predecessor to the American Dental Association (ADA), made its members pledge not to use mercury because of its known toxicity,⁸ and in more recent years, government officials, scientists, dentists, consumers, and many others have raised serious concerns about the threats dental mercury poses to humans and to the environment at large.

In 2013, the United Nations Environment Programme (UNEP)’s Intergovernmental Negotiating Committee formalized a global, legally-binding mercury treaty, which has now been signed by over 100 countries, including the U.S. Part of UNEP’s “Minamata Convention on Mercury” text includes initiatives with regards to dental mercury amalgam such as setting national objectives aimed at minimizing its use, promoting the use of cost-effective and clinically effective mercury-free alternatives for dental restoration, discouraging insurance policies and programs that favor dental amalgam use over mercury-free dental restoration, and promoting the use of best environmental practices in dental facilities to reduce releases of mercury and mercury compounds to water and land.⁹

Individual countries have likewise taken protective actions against this dental material. Norway banned dental amalgam in 2008,¹⁰ Sweden banned the use of dental amalgam for almost all purposes in 2009,¹¹ and Denmark, Estonia, Finland, and Italy, use it for less than 5% of tooth restorations.¹² Japan and Switzerland have also restricted or almost banned dental amalgam.¹³ France has recommended that alternative mercury-free dental materials be used for pregnant women, and Austria, Canada, Finland, and Germany have purposely reduced the use of dental amalgam fillings for pregnant women, children, and/or in patients with kidney problems.¹⁴

In spite of this international action, the U.S. Food and Drug Administration (FDA) “considers dental amalgam fillings safe for adults and children ages 6 and above.”¹⁵ However, details in the FDA’s public statements about dental amalgam on its website have changed over the years, including information about amalgam’s potentially harmful impact on pregnant women, fetuses, and children under the age of six. Due in part to concerns about this lack of protection, the IAOMT filed a lawsuit in 2014 against the FDA over its classification of dental mercury amalgam.¹⁶ As part of the case, the IAOMT secured an internal document from the FDA that had proposed restricting dental mercury amalgam use in pregnant and nursing women and children under the age of six, as well as individuals with mercury allergies and pre-existing kidney or neurological disease.¹⁷ Yet, allegedly for administrative reasons, the FDA communication (dated January 2012) was never released to the public.

Meanwhile, scientific studies continue to demonstrate that the mercury used in dentistry poses serious risks to the environment and public health.

Dental Amalgam Pollutes the Environment in a Variety of Ways:

Some 340 tonnes of mercury is used per year in dentistry, of which about 70-100 tonnes (i.e. 20- 30%) likely enters the solid waste stream.¹⁸
--United Nations Environment Programme (UNEP), *Global Mercury Assessment, 2013*

1) Wastewater from Dental Offices

According to the United States Geological Survey, in 2010, dental amalgam was the leading end-use sector of mercury in the U.S.¹⁹ The use of mercury for dental amalgam in the U.S. has been estimated at 35.2 tons per year,²⁰ and the discharge per dentist is an average of 250 milligrams per day (for an equivalent of 12 tons collectively released to the U.S. environment each year).²¹ This mercury pollution can obviously damage the environment, and indeed, a 2002 report from the New York Academy of Sciences found that over 40% of the mercury entering the New York/New Jersey harbor through wastewater was the result of discharges from dental offices.²²

Additionally, in a 2014 document, the U.S. EPA recognized that “dental offices are the largest source of mercury discharges to POTWs [publicly-owned treatment works], contributing about half of the mercury received by POTWs.”²³ This is dangerous because wastewater treatment facilities are designed to process human waste, not heavy metals. Thus, the mercury from dental discharges is separated out into sludge or biosolids.²⁴ The sludge is usually incinerated, which releases mercury pollution into the atmosphere,²⁵ and the biosolids are often used as fertilizer, which contaminates soil with mercury.²⁶

“Human waste is second only to direct release from dental offices as a contributor of dental mercury to wastewater plants (AMSA 2001).”²⁷
--Cited in Letter to the Editor by Larose & Basciano (IAOMT), *Journal of Dental Research, 2008*

2) Human Waste

Research has shown that amalgam fillings contribute to notable mercury levels in saliva, urine, and feces, and patients with dental amalgam excrete more than ten times more mercury in their feces than those without mercury fillings.²⁸ Based on figures provided in scientific studies, the IAOMT has estimated that in the U.S., this amounts to over eight tons of mercury being flushed out to sewers, streams, and lakes per year.²⁹ The same types of calculations were derived in Sweden in 1994, when researchers suggested that 100 kilograms (over 220 pounds) of mercury was being released to their country’s environment annually as a result of dental mercury excretion in feces and urine.³⁰

Considering that dental mercury is released in feces and urine,³¹ and methylmercury (such as that taken in from fish consumption), is also released in feces and urine,³² the impact of human waste containing various forms of mercury is a pertinent factor in water pollution.

*“Amalgam fillings not replaced before death will cause emissions to air, soil, and water upon cremation or burial.”³³
--Hylander & Goodsite, Science of the Total Environment, 2006*

3) Cremation and Burial

A 2013 assessment on mercury from UNEP reported: “Global emissions from use of mercury in dental amalgam resulting from cremation of human remains are estimated at 3.6 (0.9 – 11.9) tonnes in 2010.”³⁴ With this consequential amount of mercury being released, it is apparent that cremation of bodies with amalgam fillings adds to air emissions and deposition onto land and into waterways. To illustrate this point, in 1992, the IAOMT applied scientific data to calculate that the cremation of 320,372 bodies in the U.S. during the preceding year added an estimated 2,800 pounds of mercury emissions into the atmosphere.³⁵

Austria, Belgium, Germany, The Netherlands, Norway, Sweden, and Switzerland have applied measures to reduce pollution from cremations.³⁶ Although legislation has yet to be passed in the U.S.,³⁷ Colorado, Maine, Minnesota, and Vermont have attempted to achieve regulations that would make removing amalgam fillings before cremation mandatory.³⁸ Meanwhile, citizens in the U.S. have fought crematoriums in their neighborhoods by filing lawsuits³⁹ and initiating protests.⁴⁰

A variety of trends suggest that mercury releases from amalgam fillings in crematoriums will continue to increase.^{41 42} However, one alternative to cremation is a traditional burial, but burying an individual with amalgam fillings means that the mercury is deposited directly into the soil. This means that whether a person is cremated or buried, the mercury is released back to the environment.⁴³

*“Hg [mercury] vapor release to the atmosphere from dental vacuums can be substantial and can exceed human exposure limits.”⁴⁴
--Stone, Cohen, & Debban, Naval Institute for Dental and Biomedical Research, 2007*

4) Mercury Vapor

In offices with air/water separator tanks as part of the central vacuum system, mercury vapor has been found in air vented to the outside of the dental office.^{45 46} Dr. Paul G. Rubin of IAOMT has explained: “This mercury-containing material is discharged into waste streams via the dental office vacuum-pump system. This system also discharges large quantities of air, either into the atmosphere exterior to the office building or into the sewer system, depending on the type of equipment used.”⁴⁷

Indoor air can also be dangerously polluted as a result of dental mercury. A study published in 2014 conducted at 42 dental sites in 17 countries found that mercury levels within the clinics were above safe limits, leading the researchers to conclude: “At these sites, [the] public, in general, and the medical, paramedical staff and vulnerable population, in particular, are at most serious risk to health resulting from exposure to toxic and hazardous mercury.”⁴⁸

Furthermore, mercury particulate can be discharged from dental amalgam fillings, and vapor is continuously emitted from amalgam fillings,^{49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70} which means that people are directly exposed to the mercury in their mouths. The output of mercury vapor can be intensified by the number of fillings and other activities, such as chewing, teeth-grinding, and the consumption of hot liquids.^{71 72 73 74 75 76 77} Mercury is also known to be released during the placement, replacement, and removal of dental mercury amalgam fillings.^{78 79 80 81 82 83 84 85}

Human Health Risks of Mercury in Dental Amalgam:

“And I think that there really is perhaps no place for mercury in children.”⁸⁶

--Dr. Suresh Kotagal, pediatric neurologist at the Mayo Clinic; FDA Dental Products Panel, 2010

1) Pregnant Women and Children

Authorities have issued distinct warnings about mercury’s use in children and pregnant women. For example, a 2005 World Health Organization (WHO) report identified harmful effects of mercury exposure, including areas of risk specifically linked to mercury in fetuses and children: “Adverse health effects from mercury exposure can be: tremors, impaired vision and hearing, paralysis, insomnia, emotional instability, developmental deficits during fetal development, and attention deficit and developmental delays during childhood.”⁸⁷

Moreover, as stated earlier in this document, international legislation has warned of the clear and present danger that the mercury in dental amalgam fillings poses to pregnant women and children: In addition to the countries that have banned or drastically reduced the use of dental amalgam,^{88 89 90 91} France has recommended that alternative mercury-free dental materials be used for pregnant women, and Austria, Canada, Finland, and Germany have worked to reduce the use of dental amalgam fillings for pregnant women and children.⁹²

Also, 19 members of the U.S. Congress wrote a letter to the FDA in 2009 to express their concern about mercury used in amalgam fillings, with a focus on potential dangers to pregnant women and children,⁹³ and when Representative Diane Watson of California proposed a *Mercury Filling Disclosure and Prohibition Act* (H.R. 2101 {not enacted}), she explained: “It is, in fact, children who are at greatest risk from these fillings.”⁹⁴

In regards to fetal and infant risks from dental amalgam, research in this area has provided significant data associating the number of maternal amalgam fillings with mercury levels in cord blood,^{95 96} in the placenta,⁹⁷ in the kidneys^{98 99} and liver¹⁰⁰ of fetuses; in fetal hair;¹⁰¹ and in the brain¹⁰² and kidneys¹⁰³ of infants. Another trend in research about maternal amalgam fillings are studies that have found the mercury concentration in breast milk increases as the number of amalgam fillings in the mother increases.^{104 105 106 107}

Although two studies^{108 109} (commonly referred to as the “New England Children’s Amalgam Trial” and the “Casa Pia Children’s Amalgam Trial”) have repeatedly been used to defend the use of amalgam in children, other researchers have since demonstrated that factors such as long term effects, genetic predisposition, and measurement errors must be taken into account.^{110 111 112 113 114 115} Furthermore, researchers studying the same cohort (of the Children’s Amalgam Trials) have provided data that has identified potential risks to these subjects from mercury exposure based on gender,^{116 117 118} genetic predisposition,^{119 120 121} and even gum-chewing.¹²² Risk assessments have also explored designating safe levels for children, who are smaller and still developing,¹²³ especially since many dose levels are based on a one-size-fits-all scale for both children and adults.

In the meantime, scientific research continues to show that children are, in fact, at-risk for health impairments potentially caused by dental amalgam mercury fillings.^{124 125 126 127 128 129 130 131 132 133} In summary, authors of a study from 2011 cautioned: “Changes in dental practices involving amalgam, especially for children, are highly recommended in order to avoid unnecessary exposure to Hg [mercury].”¹³⁴

“Dental amalgam fillings are the primary source of mercury exposure for the general population (Skare, 1995; Health Canada, 1997).”¹³⁵

--Cited in paper published under the joint sponsorship of the United Nations Environment Programme, the International Labour Organization, and the World Health Organization, 2003

2) The General Population

An extensive number of research studies have thoroughly documented the human health risks associated with the use of dental amalgam. Scientific data from all over the world has investigated how the mercury in amalgam fillings can

relate to Alzheimer's disease,^{136 137 138} amyotrophic lateral sclerosis (Lou Gehrig's disease),¹³⁹ antibiotic resistance,¹⁴⁰
141 142 143 autism spectrum disorders,^{144 145 146} autoimmune disorders/immunodeficiency,^{147 148 149 150 151 152 153 154 155 156}
cardiovascular problems,^{157 158 159} chronic fatigue syndrome,^{160 161 162 163} hearing loss,¹⁶⁴ kidney disease,^{165 166 167 168}
169 170 171 172 multiple sclerosis,^{173 174 175 176} Parkinson's disease,^{177 178 179} reproductive dysfunction,^{180 181} and a myriad
of other health problems.¹⁸²

Researchers of a scientific review published in 2014 entitled "Evidence supporting a link between dental amalgams and chronic illness, fatigue, depression, anxiety, and suicide" resolved: "Thus, consideration of Hg [mercury] toxicity may be central to the effective clinical investigation of many chronic illnesses, particularly those involving fatigue and depression."¹⁸³

More essential details on factors relevant to mercury toxicity and the general population are provided below in the "Additional Considerations about Dental Amalgam and Human Health" section of this fact sheet.

*"Various countries are moving to limit the use of amalgam as a dental restorative material in order to protect dental patients from Hg [mercury] exposure. However, dentists' occupational exposure should also be considered as a justification for reduced amalgam use."*¹⁸⁴

Richardson, Human and Ecological Risk Assessment, 2003

3) Dentists and Dental Personnel

A plethora of scientific studies have demonstrated potential hazards of mercury in the workplace to dental workers,¹⁸⁵
186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 and dental students.
217 218 219 Another area that has received much attention is the possibility of reproductive hazards to female dental
personnel, including pregnancy risks, fertility issues, and menstrual cycle disorders.^{220 221 222 223 224 225}

In addition to the concerns about mercury levels in the dental office and the exposure of workers there, a variety of studies have called for protective measures to be taken in the dental office as a means of limiting mercury releases.²²⁶
227 228 229 230 231 232 233 234 235 236 237 A study led by Dr. Robin Warwick and published in 2013 clarified: "To maximize safety, dental schools should train students to remove amalgam only while using water spray and high volume suction."²³⁸ More on the importance of safe removal of amalgam fillings is provided in the "Safe Removal of Existing Amalgam Fillings" section of this fact sheet.

*"Provide pre-placement and periodic medical exams for those regularly exposed to mercury with emphasis directed to CNS-central nervous system, skin, lungs, liver, kidneys, and G.I. tract."*²³⁹

*--Material Safety Data Sheet (MSDS), Safe Handling and Use Section,
provided with dental amalgam product by Original D Wykle, 2002*

4) Additional Considerations about Dental Amalgam and Human Health

Reference Exposure Level (REL)

[REL is a term used to denote the exposure level defined by national and international regulatory agencies at which there is an expectation of *no negative health outcomes* within the population.]

In a 2005 document, the World Health Organization (WHO) explained: "Recent studies suggest that mercury may have no threshold below which some adverse effects do not occur."²⁴⁰ Reports from the WHO and Canada's federal department of health (Health Canada) have also concluded that mercury vapor from dental amalgam is the greatest source of human exposure to mercury in non-industrial settings.^{241 242} In 2003, the WHO reported: "Dental amalgam constitutes a potentially significant source of exposure to elemental mercury, with estimates of daily intake from amalgam restorations ranging from 1 to 27 ug[mcg]/day."²⁴³

Dangers of exposure to dental mercury have been validated by other sources. In 2003, Dr. G. Mark Richardson presented a chart to Health Canada summarizing seventeen separate estimates of mercury exposure due to amalgams

in adults. If the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk level (MRL) for non-occupational exposure in air standard is used, even one amalgam filling would expose the individual to more mercury than would be allowed by Dr. Richardson's proposed tolerable daily intake.²⁴⁴ Furthermore, in research published in 2011, Dr. Richardson reported that more than 67 million Americans aged two years and older exceed the intake of mercury vapor considered "safe" by the U.S. EPA due to the presence of dental amalgam fillings, whereas over 122 million Americans exceed the intake of mercury vapor considered "safe" by the California EPA due to their amalgam fillings.²⁴⁵

The issue of amalgam fillings contributing to human mercury exposures from fish consumption was reported in 2013 by the European Food Safety Authority (EFSA)'s Panel on Contaminants in the Food Chain (CONTAM). The EFSA Panel described the increased mercury danger from the combination of fish and dental amalgam: "The estimated exposure to inorganic mercury in Europe from the diet alone does not exceed the TWI [tolerable weekly intake]. Inhaled elemental mercury vapour from dental amalgam, which after absorption is converted to inorganic mercury, is an additional source that is likely to increase the internal inorganic mercury exposure; thus the TWI [tolerable weekly intake] might be exceeded."²⁴⁶

Methylmercury and Dental Amalgam

Bacteria in soil and water can convert inorganic mercury into methylmercury, which is considered by some researchers to be the most toxic form of mercury. When this form of the element is consumed by certain fish and shellfish, it impacts the entire food chain. Because of the health risks from this toxic contamination, pregnant women and children have been advised to restrict consumption of seafood that might contain elevated levels of methylmercury.^{247 248 249} The levels of methylmercury in waterbodies are thus an area of concern, and dental wastewater (discharges from dental offices) can contribute to these levels of methylmercury.²⁵⁰

The fish consumption advisories can assist consumers in avoiding *outside* sources of methylmercury; however, research has begun to explore how other forms of mercury might be altered into methylmercury *inside* the human body. In particular, several studies have documented the ability of mercury in the human system (such as that from amalgam fillings) to be transformed into methylmercury in the mouth^{251 252 253 254} and by specific strains of yeast and bacteria in the gut.²⁵⁵ In 2001, authors of a scientific study postulated: "Our results are compatible with the hypothesis that amalgam fillings may be a continuous source of organic mercury, which is more toxic than inorganic mercury, and almost completely absorbed by the human intestine."²⁵⁶ Over a decade later, researchers of a study published in 2015 identified the need for more accurate risk assessment in this area and stated: "Because humans are exposed to inorganic Hg [mercury] (from dental amalgams, food, and industrial pollutants), potential Hg [mercury] methylation by the human gut microbiome would have tremendous health implications."²⁵⁷

Genetic Predisposition

The issue of genetic predisposition to specific, adverse effects from mercury exposure has also been examined in several studies. For example, researchers have associated neurobehavioral consequences from mercury exposure with a specific genetic polymorphism. Moreover, the researchers of a study published in 2006 linked the polymorphism, CPOX4 (for coproporphyrinogen oxidase, exon 4), to decreased visuomotor speed and indicators of depression in dental professionals.²⁵⁸ Furthermore, the CPOX4 genetic variation was identified as a factor for neurobehavioral issues in a study of children with dental amalgams. The researchers noted, "...among boys, numerous significant interaction effects between CPOX4 and Hg [mercury] were observed spanning all 5 domains of neurobehavioral performance...These findings are the first to demonstrate genetic susceptibility to the adverse neurobehavioral effects of Hg [mercury] exposure in children."²⁵⁹

The ability of these specific genetic variants to negatively impact the body's reaction to dental mercury exposure has even achieved attention in the mainstream media. A January 5, 2016, article by Greg Gordon of McClatchy News included interviews with some of the researchers of the studies mentioned above. Markedly, Dr. James Woods stated: "Twenty-five percent to 50 percent of people have these (genetic variants)."²⁶⁰ In the same article, Dr. Diana

Echeverria discussed “a lifetime risk” of neurological damage related to this population, and she elaborated: “We’re not talking about a small risk.”²⁶¹

Another area of genetic susceptibility in relation to dental mercury risk that has merited attention is the APOE4 (Apolipoprotein E4) genetic variation. A 2006 study found a correlation between individuals with APOE4 and chronic mercury toxicity.²⁶² The same study found that removal of dental amalgam fillings resulted in “significant symptom reduction,” and one of the symptoms listed was memory loss. The symptom of memory loss is quite interesting, as APOE4 has also been associated with a higher risk for Alzheimer’s disease.^{263 264 265} Importantly, the authors of a study which found a connection between number of mercury fillings and neurotoxic effects for those with APOE genotype explained: “APO-E genotyping warrants investigation as a clinically useful biomarker for those at increased risk of neuropathology, including AD [Alzheimer’s disease], when subjected to long-term mercury exposures...An opportunity could now exist for primary health practitioners to help identify those at greater risk and possibly forestall subsequent neurological deterioration.”²⁶⁶

Research has also shown that dental mercury fillings can play a role in immune system problems for genetically predisposed patients. Whereas research on animals has established a connection between dental mercury and autoimmunity,^{267 268} research involving human subjects has confirmed that genetic susceptibility to reactions from dental mercury is potentially related to chronic fatigue syndrome,²⁶⁹ as well as amyotrophic lateral sclerosis, multiple sclerosis, and rheumatoid arthritis.²⁷⁰

In addition, scientific data has linked mercury and genetic traits to autism,^{271 272} chemical sensitivities,²⁷³ and Kawasaki’s disease,²⁷⁴ and research has also suggested that genetic transporters could be involved in the toxicokinetics of mercury.²⁷⁵ Other than CPOX4 and APOE, genetic traits that have been examined for association with health impairments caused by mercury exposure include BDNF (brain-derived neurotropic factor),^{276 277 278} metallothionein (MT) polymorphisms,^{279 280} catechol-O-methyltransferase (COMT) variants,²⁸¹ and MTHFR mutations and PON1 variants.²⁸² The authors of one of these studies concluded: “It is possible that elemental mercury may follow the history of lead, eventually being considered a neurotoxin at extremely low levels.”²⁸³

Mercury allergies

A 1993 study reported that 3.9% of healthy subjects tested positive for metal reactions in general.²⁸⁴ If this figure is applied to the current U.S. population, this would mean that dental metal allergies potentially impact as many as 12.5 million Americans. Also pertinent is that, in 1972, the North American Contact Dermatitis Group determined that 5-8% of the U.S. population specifically demonstrated allergy to mercury by skin patch testing,²⁸⁵ which would amount to approximately 21 million Americans today. Yet, these figures could be even higher because recent studies and reports tend to agree that metal allergies are on the rise.^{286 287}

Since most patients are not tested for mercury allergies prior to dental amalgam exposure, this means that millions of Americans are unknowingly allergic to the fillings in their mouths. A 2011 article by Hosoki and Nishigawa explained why dentists should be educated about this possible side effect: “Current data indicate that practicing dentists need to obtain further specialized knowledge about dental metal allergy in order to ensure the correct treatment of patients in their clinics.”²⁸⁸

Furthermore, ionization of metals appears to play a major role in allergies. While a “stable” metal is generally regarded as non-reactive, if ionization of the metal occurs, this can cause an allergic response. In the oral cavity, ionization can result from pH changes initiated by saliva and diet.²⁸⁹ The electrolytic conditions can also cause corrosion of the dental metals and generate electrical currents in a phenomenon known as oral galvanism.²⁹⁰ Not surprisingly, oral galvanism has been established as a factor in sensitivities to dental metals.²⁹¹ While the combination of mercury and gold has been recognized as the most common cause of dental galvanic corrosion, other metals used in dental restorations can similarly produce this effect.^{292 293 294}

However, one issue with calculating the number of patients suffering from a negative reaction to a metallic material is that the onset of symptoms can be delayed and therefore might not be associated with the exposure. Another issue is the wide-range of symptoms patients allergic to dental metals can exhibit.

Nonetheless, a gamut of health conditions has been linked to dental metal allergies. These include autoimmunity,²⁹⁵²⁹⁶ chronic fatigue syndrome,^{297 298 299} fibromyalgia,^{300 301} metallic pigmentation,³⁰² multiple chemical sensitivities,³⁰³³⁰⁴ multiple sclerosis,³⁰⁵ myalgic encephalitis,³⁰⁶ oral lichenoid lesions,^{307 308 309 310 311} orofacial granulomatosis,³¹² and even infertility in both women and men.³¹³

Co-existing Factors

Yet, even with the recognition that genetic susceptibility and metal allergies play a role in reactions to dental amalgam, research warns that there are most likely a variety of other factors tied into health risks of mercury.³¹⁴ As examples, in addition to genetic predisposition and metal allergies, the number of amalgam fillings in the mouth,^{315 316}^{317 318 319 320 321 322 323 324 325 326 327} gender,^{328 329 330 331 332} dental plaque,³³³ selenium levels,³³⁴ exposure to lead,^{335 336}^{337 338} and consumption of milk^{339 340} or alcohol³⁴¹ can play a role in each person's unique response to mercury.

"...it [is] apparent that dental mercury amalgam and all dental restorative materials should be assessed for safety and biocompatibility with special consideration for all populations and all known risk factors. This can also be applied to the evaluation of any health risk, especially because science continues to prove that each person has a unique and personalized set of reactions to substances taken into the human body."³⁴²

Kall, Just & Aschner (IAOMT),

*"What's the risk? Dental amalgam, mercury exposure, and human health risks throughout the lifespan,"
Book Chapter in Epigenetics, the Environment, and Children's Health across Lifespans, 2016*

Suggested Solutions to Mercury Risks Caused by Dental Amalgam:

Since some countries have successfully eliminated dental mercury, banning mercury from dentistry has already proven to be both feasible and economical. Regarding the worldwide phase-down on dental amalgam, a 2014 document from WHO and UNEP included the following statement: "The environmental impacts of dental amalgam can be sustainably avoided by phasing down the use of dental amalgam as a restorative material and switching to quality mercury-free alternatives."³⁴³ However, various considerations should be part of any effort to end the use of mercury in dental amalgam...

1) Amalgam Separators

Amalgam separators can successfully reduce the amount of mercury discharge in wastewater from dental offices.³⁴⁴³⁴⁵ In fact, a 2014 article about the issue written by mercury recyclers qualified: "Capture efficiency rates for mercury by amalgam separators range between 95-99%. If amalgam separators were ubiquitously installed in dental practices across the U.S., the estimated discharge of 6.5 tons of mercury to POTWs in the U.S. would be reduced to approximately 0.3 tons (Vandeven & McGinnis, 2005)."³⁴⁶

Because of this reality, the U.S. EPA has utilized measures in the Clean Water Act to develop standards for dental clinics to reduce mercury releases. While these standards have not yet been enacted, a 2014 document from the EPA described the proposed changes: "The proposal would require dental practices to comply with requirements for controlling the discharge of dental amalgam pollutants into POTWs based on the best available technology or best available control technology and Best Management Practices."³⁴⁷

Enforced standards that require amalgam separators are essential in stopping mercury from entering the environment, especially because voluntary initiatives have often been unsuccessful.³⁴⁸ However, even if standards are required, it would be helpful to likewise enforce maintenance requirements for amalgam separators, as the Royal College of Dental Surgeons has done in Ontario, Canada.³⁴⁹ It should also be remembered that amalgam separators only contribute to solving the problem of dental mercury in wastewater and not the additional burdens placed by amalgam fillings on the environment and human health.

2) Alternatives to Amalgam as a Filling Material

Alternatives to amalgam include composite resin, glass ionomer, porcelain, and gold, among other options. Most consumers choose direct composite fillings because the white coloring matches the tooth better and the cost is considered moderate.

In the past, a common argument against composite fillings was that they were not as durable as amalgam. However, recent studies have debunked this claim. Researchers of a study which was published in 2016 and conducted on over 76,000 patients for over ten years found that posterior amalgam fillings had a *higher* annual failure rate than composites.³⁵⁰ Two separate studies published in 2013 found that composite fillings performed as well as amalgam when comparing failure rates³⁵¹ and replacement filling rates.³⁵² Other research has offered similar findings: a study published in 2015 documented “good clinical performance” of composite resins over a 30-year evaluation,³⁵³ a meta-analysis published in 2014 noted “good survival” of posterior resin composite restorations,³⁵⁴ a study published in 2012 showed certain types of composite materials last as long as amalgam,³⁵⁵ and a study published in 2011 found “good clinical performance” of composites over a 22-year period.³⁵⁶

Composite fillings have also been criticized because some of them contain the controversial material bisphenol-A (BPA). Dentists have a variety of opinions about the safety of BPA and other types of bisphenol, such as Bis-GMA and Bis-DMA. Patients who are concerned about bisphenol-containing dental material often choose to speak with their dentists about using a material that does not contain the ingredient. For example, a product named Admira Fusion³⁵⁷/Admira Fusion X-tra³⁵⁸ released in January 2016 by the dental company VOCO is being touted as “the first purely ceramic-based restorative material”³⁵⁹ and does not contain Bis-GMA or BPA before or after it has been cured.

Another option for dental patients concerned about which mercury-free alternative to use as a filling material is to do their own research and/or take a dental biocompatibility test. If biological testing is used, a patient’s blood sample is sent to a laboratory where the serum is evaluated for the presence of IgG and IgM antibodies to the chemical ingredients used in dental products.³⁶⁰ The patient is then provided with a detailed list of which name-brand dental materials are safe for their use and which ones could result in a reaction. Two labs that currently offer this service are Biocomp Laboratories³⁶¹ and Clifford Consulting and Research.³⁶²

Also, in regards to dental allergies, Dr. Stejskal introduced the MELISA test in 1994. This is a modified version of the (Lymphocyte Transformation Test) LLT designed to test for metal sensitivity type IV delayed hypersensitivity to metals, including sensitivity to mercury.³⁶³ There is promising research that suggests in some cases, patients improve or are cured of their reactions after removal of the material suspected to be causing the allergy. A few examples of conditions reportedly improved and/or cured as a result of removing dental metal allergens include amyotrophic lateral sclerosis,³⁶⁴ chronic fatigue syndrome,³⁶⁵ dermatitis,³⁶⁶ fibromyalgia,³⁶⁷ multiple sclerosis,³⁶⁸ oral lichen planus,^{369 370 371} oral lichenoid lesion,^{372 373 374} orofacial granulomatosis,³⁷⁵ and other symptoms.³⁷⁶ In their 2011 report, Hosoki and Nishigawa suggested: “In principle, all restorations with allergy-positive metal elements need to be removed.”³⁷⁷

3) Safe Removal of Existing Amalgam Fillings

Although individual response varies, in addition to the recovery situations listed above, research has documented the reduction of other health issues after the removal of amalgam fillings.^{378 379 380 381 382 383 384 385 386 387 388} However, it is important to note that removal of any dental material requires a number of precautions.

Essentially, an unsafe amalgam removal process releases mercury vapor and particles that can be harmful to the patient, the dentist, the dental staff, and the environment.^{389 390 391 392 393 394 395 396} Obviously, the danger to the patient is increased since mercury is being released directly into the mouth and lungs.

To assist in mitigating the potential negative outcomes of mercury exposure to dental professionals, students, staff members, patients, and others, the IAOMT has developed new safety recommendations for removal of existing dental mercury amalgam fillings.³⁹⁷ The IAOMT’s innovative recommendations build upon traditional safe amalgam

removal techniques such as the use of masks, water irrigation, and high volume suction by supplementing these conventional strategies with a number of additional protective measures, the need for which have only recently been identified in scientific research. IAOMT's Safe Mercury Amalgam Removal Technique (SMART) is located online at <https://iaomt.org/safe-removal-amalgam-fillings/>.³⁹⁸ Patients might want to familiarize themselves with the recommendations to ensure that these protective strategies will be applied during the amalgam removal process.

4) Educating Dentists

While some dentists have already stopped using amalgam, others require training in mercury-free dentistry [dentistry that does not place any new mercury amalgam fillings]. Since some countries have banned or drastically reduced the use of dental mercury, their dental schools shed light upon how to make a successful transition away from amalgam.

Yet, it must also be recognized that all dentists (even mercury-free dentists) must remove dental mercury amalgam fillings that are already in the mouths of their patients for a variety of reasons ranging from device failure to consumer request. This means that many dentists and dental students require training in mercury-safe dentistry [dentistry that utilizes protective measures when removing existing mercury amalgam fillings]. Essentially, properly applied protection techniques can minimize mercury exposure to dental workers, dental students, patients, fetuses, and other susceptible and sensitive populations.

For this reason, the IAOMT has developed a rigorous Safe Mercury Amalgam Removal Technique (SMART). More information on SMART is located in the section of this fact sheet entitled and "Safe Removal of Existing Amalgam Fillings" and online at <https://iaomt.org/safe-removal-amalgam-fillings/>.³⁹⁹

The IAOMT has also developed free, online dental education resources detailing implementation strategies for mercury-free and mercury-safe practices, including information for dentists, physicians, health care professionals, patients, and the general public. These resources include the following:

- Dental mercury education videos: <https://iaomt.org/free-online-learning/>
- Position statement against dental mercury amalgam fillings: <https://iaomt.org/iaomt-position-paper-dental-mercury-amalgam/>
- Patient resources: <https://iaomt.org/for-patients/> ; Professional resources: <https://iaomt.org/for-professionals/>
- More resources available at www.iaomt.org

5) Economic Perspective

In a report entitled "The Economics of Dental Amalgam Regulation," the authors noted that amalgam use is already declining and that restrictions on mercury are inevitable.⁴⁰⁰ The authors concluded, "We can then make the case that the overall health care expenditures necessary to deal with diseases and conditions, known or unknown, arising from the continued installation of amalgam could far exceed the relatively manageable cost increases to the consumer for the alternatives...This is not to mention the cost to the U.S. economy of lost work time owing to concomitant illness and disability."⁴⁰¹

However, from a consumer standpoint, some insurance companies only cover the cost of dental mercury amalgam fillings, which means that oftentimes patients have to pay additional fees for alternative materials and techniques.⁴⁰² Changes could be seen in this scenario, though, because the United Nations Environmental Programme (UNEP)'s 2013 "Minamata Convention on Mercury," signed by over 100 nations including the U.S., specifically discourages insurance policies and programs favoring dental mercury amalgam use over mercury-free dental restoration.⁴⁰³

Additionally, since some countries have successfully eliminated dental mercury amalgam, ending the use of mercury in dentistry has already proven to be both feasible and economical.

*"Dental treatment without mercury is becoming the norm."*⁴⁰⁴

--Carsten Lassen and Jakob Maag, Nordic Council of Ministers, INCI, June 2010

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