WHY WE ALL DON'T GET SICK IN THE SAME WAY: THE SCIENCE BEHIND DENTAL MERCURY AND OTHER ENVIRONMENTAL TOXICANTS

By Amanda Just and John Kall, DMD

Posted June 15, 2017

If everyone had the same reaction to environmental toxicants like mercury, these hazardous substances would probably be banned immediately. It would be obvious to everyone, as well as their doctors, that exposure to a specific toxic material results in a definitive outcome-- the exact same illness shared by all of those who come into contact with a particular dangerous substance. However, research has clearly demonstrated that individuals respond to environmental toxicants in a way that is unique to their own bodies.

This "personalized response" has been studied in depth in the case of dental mercury. In fact, examining the science behind dental mercury sheds light on the complex variability of environmental illnesses. It also offers hope that this newfound understanding can help heal the ailing state of 21st century public health.

What is dental mercury?

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. Mercury is a known neurotoxin that can cause harm to humans, especially children, pregnant women, and fetuses. A 2005 World Health Organization (WHO) report warned of mercury: "It may cause harmful effects to the nervous, digestive, respiratory, immune systems and to the kidneys, besides causing lung damage. 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. Recent studies suggest that mercury may have no threshold below which some adverse effects do not occur."[1]

There is a global effort spearheaded by the United Nations Environment Programme to reduce mercury usage, including that of dental mercury,[2] and some countries have already banned its use.[3] However, amalgams are still used for about 45% of all direct dental restorations worldwide,[4] including in the United States. In fact, it has been estimated that 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.[5]

Reports and research are consistent that these mercury-containing fillings emit mercury vapors,[6] [7] [8] and while these restorations are commonly referred to as "silver fillings," "dental amalgam," and/or "amalgam fillings," [9] the public is often unaware that amalgam refers to the combination of other metals with mercury.[10]

What are some of the health risks that have been linked to dental mercury?

Properly diagnosing "adverse health effects" related to dental mercury amalgam fillings is impeded by the intricate list of potential responses to the elemental form of the substance, which include over 250 specific symptoms.[11] The table below is a brief listing of some of the symptoms most commonly associated with inhalation of elemental mercury vapors (which is the same type of mercury continually emitted from dental amalgam fillings):

Acrodynia or similar symptoms such as emotional instability, loss of appetite, general weakness, and skin changes[12]	**Anorexia**[13]	**Cardiovascular problems**/ labile pulse [frequent changes in heart rate]/tachycardia [abnormally rapid heartbeat] [14]
Cognitive/neurological impairments/memory loss/decrease in mental function/difficulties with verbal and visual processing[15 16 17 18 19]	**Delusions/delirium/hallucination**[20 21]	**Dermatological conditions**/ dermographism [skin condition characterized by raised red marks]/dermatitis[22 23]
Endocrine disruption/enlargement of thyroid[24 25]	**Erethism** [symptoms such as irritability, abnormal responses to stimulation, and emotional instability] [26 27 28 29]	**Fatigue**[30 31]
Headaches[32]	**Hearing loss**[33]	**Immune system impairments**[34 35]
Insomnia[36]	**Nerve response changes**/peripheral neuropathy/decreased coordination/ decreased motor function/ polyneuropathy/neuromuscular changes such as weakness, muscle atrophy, and twitching[37 38 39 40 41]	**Oral manifestations**/ gingivitis/metallic taste/ oral lichenoid lesions/ stomatitis/salivation[42 43 44 45 46 47]
Psychological issues/mood changes related to anger, depression, excitability, irritability, mood swings, and nervousness[48 49 50 51]	**Renal [kidney] problems**/ proteinuria/nephrotic syndrome[52 53 54 55 56 57]	**Respiratory problems**/ bronchial irritation/bronchitis/cough/ dyspnea [breathing difficulties]/ pneumonitis/ respiratory failure[58 59 60 61 62 63 64]
Shyness [excessive shyness]/social withdrawal[65 66]	**Tremors**/mercurial tremors/ intention tremors[67 68 69 70 71]	**Weight loss**[72]

Not all patients will experience the same symptom or combination of symptoms. Moreover, in addition to the symptoms above, an extensive number of studies have documented risks for other health conditions associated with dental amalgam. In fact, scientists have associated the mercury in amalgam fillings with Alzheimer's disease,[73 74 75] amyotrophic lateral sclerosis (Lou Gehrig's disease),[76] antibiotic resistance,[77 78 79 80] anxiety,[81] autism spectrum disorders,[82 83 84] autoimmune disorders/immunodeficiency,[85 86 87 88 89 90 91 92 93 94] cardiovascular problems,[95 96 97] chronic fatigue syndrome,[98 99 100 101] depression,[102] infertility,[103 104] kidney disease,[105 106 107 108 109 110 111 112] multiple sclerosis,[113 114 115 116] Parkinson's disease,[117 118 119] and other health problems.[120]

Dental mercury response factor #1: The form of the substance

The different forms of elements are an essential factor in evaluating the gamut of symptoms related to environmental toxicants: mercury can exist in different forms and compounds, and these different forms and compounds can produce different results in humans that are exposed to them. The type of mercury used in amalgam fillings is elemental (metallic) mercury, which is the same type of mercury used in certain types of thermometers (many of which have been banned). In contrast, the mercury in fish is methylmercury, and the mercury in the vaccine preservative thimerosal is ethylmercury. All of the symptoms described in the previous section are specific to elemental mercury vapor, which is the type of mercury exposure associated with dental amalgam fillings.

Dental mercury response factor #2: Impact on different organs within the body

Another reason for the wide-range of symptoms is that mercury taken into the body can accumulate in virtually any organ. In relation to dental amalgam fillings, the World Health Organization (WHO) has stated: "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 μg/day."[121] Research has shown that this results in 67 million Americans aged two years and older exceeding the intake of mercury vapor considered "safe" by the U.S. EPA due to the presence of dental mercury amalgam fillings [or over 122 million Americans exceeding the intake of mercury vapor considered "safe" by the California EPA due to their dental mercury amalgam fillings].[122]

An estimated 80% of the mercury vapor from amalgam fillings is absorbed by the lungs and passed to the rest of the body,[123] particularly the brain, kidney, liver, lung, and gastrointestinal tract.[124] The half life of metallic mercury varies depending on the organ where the mercury was deposited and the state of oxidation.[125] For example, the half lives of mercury in the whole-body and kidney regions have been estimated at 58 days,[126] whereas mercury deposited in the brain can have a half life of up to several decades.[127]

Furthermore, mercury vapor taken into the body binds to sulfhydryl groups of protein and to sulfur-containing amino acids throughout the body.[128] Mercury vapor, which is lipid soluble, can cross the blood-brain barrier with ease and is converted into inorganic mercury in the cells by catalase oxidation.[129] This inorganic mercury is eventually bound to glutathione and protein cysteine groups.[130]

Dental mercury response factor #3: Delayed effects

Effects of toxic exposure are even more insidious because it can take many years for symptoms to manifest themselves, and previous exposures, especially if they are relatively low-level and chronic (as is often the case from mercury amalgam fillings), might not be associated with the delayed onset of symptoms. The concept of a delayed reaction after a chemical exposure is supported by the Occupational Safety and Health Administration (OSHA)'s requirement that employers keep a record of incidences with toxic substances on-site for three decades in part because "[m]any chronic diseases are characterized by long latency periods of 20-30 years or longer."[131]

Dental mercury response factor #4: Allergies

A 1993 study reported that 3.9% of healthy subjects tested positive for metal reactions in general.[132] 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,[133] 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.[134] [135]

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."[136]

Ionization of metals appears to play a major role in these types of 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.[137] The electrolytic conditions can also cause corrosion of the dental metals and generate electrical currents in a phenomenon known as oral galvanism.[138] Not surprisingly, oral galvanism has been established as a factor in sensitivities to dental metals.[139] 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.[140 141 142]

A gamut of health conditions has been linked to dental metal allergies. These include autoimmunity,[143 144] chronic fatigue syndrome,[145 146 147] fibromyalgia,[148 149] metallic pigmentation,[150] multiple chemical sensitivities,[151 152] multiple sclerosis,[153] myalgic encephalitis,[154] oral lichenoid lesions,[155 156 157 158 159] orofacial granulomatosis,[160] and even infertility.[161]

Dental mercury response factor #5: 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. 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.[162] Additionally, 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."[163]

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 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).'"[164] 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.'"[165]

Another area of genetic susceptibility in relation to dental mercury risk that has merited attention is the APOE4 (Apo-lipoprotein E4) genetic variation. A 2006 study found a correlation between individuals with APOE4 and chronic mercury toxicity.[166] 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.[167 168 169]

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."[170]

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),[171 172 173] metallothionein (MT) polymorphisms,[174 175] catechol-O-methyltransferase (COMT) variants,[176] and MTHFR mutations and PON1 variants.[177] 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."[178]

Dental mercury response factor #6: Other considerations

Even with the recognition that allergies and genetic susceptibility can both play a role in reactions to dental amalgam, there are a variety of other factors tied into health risks of mercury as well.[179] In addition to the weight and age of the individual, the number of amalgam fillings in the mouth,[180 181 182 183 184 185 186 187 188 189 190 191 192] gender,[193 194 195 196 197] dental plaque,[198] selenium levels,[199] exposure to lead (Pb),[200 201 202 203] consumption of milk[204 205] or alcohol,[206] methylmercury levels from fish consumption,[207] the potential for mercury from dental amalgam fillings to be transformed into methylmercury within the human body,[208 209 210 211 212 213] and other circumstances[214 215] can play a role in each person's unique response to mercury. For example, the tables below identify over 30 different variables that can influence reactions to dental mercury.

TABLES SUMMARIZING PERSONALIZED RESPONSES TO DENTAL MERCURY[216]

Factors related to mercury vapor release from dental amalgam filling

Age of amalgam filling
Cleaning, polishing, and other dental procedures
Contents of other materials mixed with the mercury, such as tin, copper, silver, etc.
Dental plaque
Deterioration of amalgam filling
Habits such as brushing, bruxism, chewing (including gum chewing, especially nicotine gum), consumption of hot liquids, diet (especially acidic foods), smoking, etc.
Infections in the mouth
Number of amalgam fillings
Other metals in mouth, such as gold fillings or titanium implants
Root canals and other dental work
Saliva content
Size of amalgam filling
Surface area of amalgam filling
Techniques and safety measures applied when removing amalgam filling
Techniques used when placing amalgam filling

Personal traits and conditions related to mercury exposure response

Alcohol consumption
Allergy or hypersensitivity to mercury
Bacteria, including mercury-resistant and antibiotic resistant
Burdens in organs and tissues such as kidney, pituitary gland, liver, and brain
Diet
Drug use (prescription, recreational, and addiction)
Exercise
Exposure to other forms of mercury (i.e. fish consumption), lead, pollution, and any toxic substances (presently or previously)
Fetal or breastmilk exposure to mercury, lead, and any toxic substances
Gender
Genetic traits and variants
Infections
Microbes in the gastrointestinal tract
Milk consumption
Nutrient levels, especially copper, zinc, and selenium
Occupational exposures to toxic substances
Overall health
Parasites and heleminths
Stress/trauma
Yeast

Moreover, the concept of multiple chemicals interacting within the human body to produce ill-health should now be an essential understanding required for practicing modern-day medicine. Researchers Jack Schubert, E. Joan Riley, and Sylvanus A. Tyler addressed this highly relevant aspect of toxic substances in a scientific article published in 1978. Considering the prevalence of chemical exposures, they noted: "Hence, it is necessary to know the possible adverse effects of two or more agents in order to evaluate potential occupational and environmental hazards and to set permissible levels."[217]

This is especially important considering that individuals can be exposed to different substances through their home, work, and other activities. Furthermore, exposures experienced as a fetus are also known for their potential to contribute to health risks later in life.

Conclusion on the science behind dental mercury

Clearly, the precise way that a person's body responds to an environmental toxicant is based on a spectrum of circumstances and conditions. The factors described in this article are only a fraction of numerous pieces in the puzzle of adverse health effects related to toxic exposures. The science behind dental mercury demonstrates that in order to fully understand environmental illness, we need to recognize that just as each toxic exposure is unique, so is each person impacted by such a toxic exposure. As we accept this reality, we also offer ourselves the opportunity to create a future where dentistry and medicine acknowledge that each patient responds to materials and treatments differently. We also offer ourselves the opportunity to use safer products that reduce the overall toxic burden in our bodies and forge the path to renewed health.

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