

Neurological Effects of Mercury Exposure

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1 Neurological effects of mercury exposure

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1.1 Introduction

Toxic metals such as mercury, lead, cadmium, etc. have been documented to be neurotoxic, according to U.S. Government agencies cause adverse health effects and learning disabilities to millions in the U.S. each year, especially *children*¹ and the elderly (160, 105, 27d). The health effects of toxic metals are *synergistic*² with other toxic exposures such as *pesticides*³, *endocrine*⁴ disrupting substances like organochlorine compounds and PCBs, etc. There are also synergistic effects with the various types of parasites, bacteria, viruses to which people have common exposures and commonly become infected when the immune system is weakened by toxic exposures (485, 469b, 470, 581). Studies have found considerable genetic variability in *susceptibility*⁵ to toxic metals as well. While there is considerable commonality to the health effects commonly caused by these toxic metals, and effects are cumulative and *synergistic*⁶ in many cases, this paper will concentrate on the health effects of elemental mercury from amalgam fillings.

Mercury amalgam dental fillings have been found to be the *largest source of both inorganic and methyl mercury*⁷ in most who have several amalgam fillings. Those with several amalgam fillings have been found by hundreds of thousands of medical lab tests to have mercury exposure levels approximately 10 times the average level of those without amalgam, and saliva and excretion levels decline 90% after amalgam replacement.

Clinical experience has identified some of the factors that cause mercury to accumulate in various areas of the body (581). These include past physical trauma to an area, inflammation, food allergies, Geopathic Stress, scars and dental trauma, structural abnormalities, biochemical deficiencies such as zinc, environmental toxicity, and unresolved psychological problems.

¹**Informative:** "Effects of Toxic Metals on Learning Ability and Behavior".
²**Internet:** "<http://www.flcv.com/synergis.html>".
³**Internet:** "<http://www.flcv.com/pesticid.html>".
⁴**Internet:** "<http://www.flcv.com/endocrin.html>".
⁵**Informative:** "Susceptibility Factors in Mercury Toxicity: Immune Reactivity, Detoxification System Function, Enzymatic Blockages, Synergistic Exposures".
⁶**Internet:** "<http://www.flcv.com/synergis.html>".
⁷**Informative:** "Dental Amalgam Mercury Solutions".

1.2 Neurological Effects of Mercury and Toxic Metals

Studies have found that mercury is neurotoxic (kills or damages brain cells and nerve cells) (19, 27, 34, 36, 43, 69, 70, 147, 148, 175, 207, 211, 258, 273, 291, 295, 327, 329, 301, 303, 305, 395/39, 262, 274, 303); generates high levels of reactive oxygen species (ROS) and oxidative stress, depletes glutathione and thiols causing increased neurotoxicity from interactions of ROS, glutamate, and dopamine (13, 56, 98, 102, 145, 169, 170, 184, 213, 219, 250, 257, 259, 286, 288, 290, 291, 302, 324, 326, 329, 416, 424, 442, 496, 564, 565); kills or inhibits production of brain tubulin cells (66, 67, 161, 166, 207, 258, 300); inhibits production of neurotransmitters by inhibiting: calcium-dependent neurotransmitter release (372, 432), dihydropteridine reductase (27, 122, 257, 333), nitric oxide synthase (259), blocking neurotransmitter amino acids (412), causes abnormal migration of neurons in the cerebral cortex (149), and effecting phenylalanine, serotonin, tyrosine and tryptophan transport to neurons (34, 122, 126, 257, 285, 288, 333, 372, 374, 412/333) Part of the toxic effects of mercury, lead, cadmium, etc. are through their replacing essential minerals such as zinc at their sites in enzymes, disabling the necessary enzymatic processes.

While there have been large increases of most neurological and immune conditions among adults over the last 2 decades (574), the incidence of neurotoxic or immune reactive conditions in infants such as *autism*, *schizophrenia*⁸, *ADD*, *dyslexia*, *learning disabilities*⁹, etc. have been increasing especially rapidly in recent years (2, 409, 441, 476). A report by the National Research Council found that 50% of all pregnancies in the U.S. were resulting in prenatal or postnatal mortality, significant birth defects, developmental neurological or immune conditions, or otherwise chronically unhealthy babies (441). Exposure to toxic chemicals or environmental factors appear to be a factor in as much as 28 percent of the 4 million children born each year (441, 160), with 1 in 6 having one of the neurological conditions previously listed. EPA estimates that over 3 million of these are related to lead or mercury toxicity (2, 125, 276, 409), with approximately 25% of U.S. infants receiving dangerous levels of mercury exposure (276). A study found that prenatal Hg exposure is correlated with lower scores in neurodevelopmental screening, but more so in the linguistic pathway (32c). A study at the U.S. CDC found “statistically significant associations” between certain neurologic developmental disorders such as attention deficit disorder (ADD) and autism with exposure to mercury from thimerosal-containing vaccines before the age of 6 months (476), and a follow on study using federal vaccine data bases confirmed that autism, speaking disorders, and heart arrest have increased exponentially with increasing exposures to mercury thimerosal-containing vaccines (476b). Thimerosal has also been found to cause hormonal effects (555, 413). Prenatal exposure to mercury has also been found to predispose animals and infants to seizures and *epilepsy*¹⁰ (5, 52). There is evidence supporting a link between the aluminum hydroxide used in vaccines causing brain inflammation and symptoms associated with Parkinson’s, amyotrophic lateral sclerosis (Lou Gehrig’s disease), and Alzheimer’s (585). Brain inflammation has also been found to be a factor in autism.

A large epidemiological study, *NHANES III*¹¹, by the National Institute for Health has found a significant correlation between several chronic health conditions and having more than average number of dental amalgam surfaces. The conditions in which the number of dental amalgam surfaces were most highly correlated with disease incidence were MS, epilepsy, migraines, mental disorders, diseases of the nervous system, disorders of the thyroid gland, cancer, and infectious diseases (543). Other conditions where incidence was significantly correlated with having more than the average number of amalgam surfaces are: diseases of the male and female genital tracts, Disorders of the peripheral nervous system, Diseases of the respiratory system, and Diseases of the genitourinary

⁸**Informative:** “Neurological and Immune Reactive Conditions Affecting Kids: The mercury connection to neurological pervasive developmental disorders (**autism, schizophrenia, dyslexia, ADD, childhood depression, learning disabilities, OCD, etc.**) and developmental immune conditions (**eczema, asthma, and allergies**)”.

⁹**Informative:** “Effects of Toxic Metals on Learning Ability and Behavior”.

¹⁰**Informative:** “Epilepsy/Seizures”.

¹¹**Internet:** “<http://www.flcv.com/nhanes3.html>”.

system (543).

There has been a huge increase in the incidence of degenerative neurological conditions in virtually all Western countries over the last 2 decades (574, 581). The increase in Alzheimer's has been over 300% while the increase in Parkinson's and other motor neuron disease has been over 50%. The primary cause appears to be increased exposures to toxic pollutants (574).

Oxidative stress and reactive oxygen species (ROS) have been implicated as major factors in neurological disorders including stroke, PD, MS, Alzheimer's, ALS, MND, FM, CFS, etc. (13, 35c, 56, 84, 98, 145, 169, 207b, 258, 424, 442-444, 453, 462, 496, 581). Mercury induced lipid peroxidation has been found to be a major factor in mercury's neurotoxicity, along with leading to decreased levels of glutathione peroxidation and superoxide dismutase (SOD) (13, 254, 489, 494-496, 577). Metalloprotein (MT) is involved in metals transport and detoxification (442, 464). Mercury inhibits sulfur ligands in MT and in the case of intestinal cell membranes inactivates MT that normally bind cuprous ions (477), thus allowing buildup of copper to toxic levels in many and malfunction of the Zn/Cu SOD function. Exposure to mercury results in changes in metalloprotein compounds that have genetic effects, having both structural and catalytic effects on gene expression (114, 241, 296, 297, 442, 464, 477, 495). Some of the processes affected by such MT control of genes include cellular respiration, metabolism, enzymatic processes, metal-specific homeostasis, and adrenal stress response systems. Significant physiological changes occur when metal ion concentrations exceed threshold levels. Such MT formation also appears to have a relation to autoimmune reactions in significant numbers of people (114, 60, 313, 342, 369, 442, 464). Of a population of over 3000 tested by the immune lymphocyte reactivity test (MELISA, 60, 275), 22% tested positive for inorganic mercury and 8% for methyl mercury.

Programmed cell death (apoptosis) is documented to be a major factor in degenerative neurological conditions like ALS, Alzheimer's, MS, Parkinson's, etc. Some of the factors documented to be involved in apoptosis of neurons and immune cells include inducement of the inflammatory cytokine Tumor Necrosis Factor-alpha (TNF α) (126), reactive oxygen species and oxidative stress (13, 43b, 56a, 296b), reduced glutathione levels (56, 126a, 111a), inhibition of protein kinase C (43), nitric oxide and peroxynitrite toxicity (43a), excitotoxicity (490, 496, 521, 524), excess free cysteine levels (56d, 111a), excess glutamate toxicity (13b, 416e), excess dopamine toxicity (56d, 13a), beta-amyloid generation (462), increased calcium influx toxicity (416e, 296b, 333, 432, 462c, 507) and DNA fragmentation (296, 297) and mitochondrial membrane dysfunction (56d, 416e, 51a).

Mitochondrial DNA mutations or damage are important contributors to aging and degenerative diseases (297b, 298), and mercury is common cause of mitochondrial DNA damage and degeneration (296, 297a, 56d, 416e, 51a). Pyrroloquinoline Quinone (PPQ), an essential micronutrient many are deficient in, has been found to improve such damage (299).

TNF α (tumor necrosis factor-alpha) is a cytokine that controls a wide range of immune cell response in mammals, including cell death (apoptosis). This process is involved in inflammatory and degenerative neurological conditions like ALS, MS, Parkinson's, rheumatoid arthritis, etc. Cell signaling mechanisms like sphingolipids are part of the control mechanism for the TNF α apoptosis mechanism (126a). Glutathione is an amino acid that is a normal cellular mechanism for controlling apoptosis. When glutathione is depleted in the brain, reactive oxidative species increased, and CNS and cell signaling mechanisms are disrupted by toxic exposures such as mercury, neuronal cell apoptosis results and neurological damage. Mercury has been shown to induce TNF α and deplete glutathione, causing inflammatory effects and cellular apoptosis in neuronal and immune cells (126b, 126c).

Another neurological effect of mercury that occurs at very low levels is inhibition of nerve growth factors, for which deficiencies result in nerve degeneration. Mercury vapor is lipid soluble and has an affinity for red blood cells and CNS cells (21a). Only a few micrograms of mercury severely disturb cellular function and inhibits nerve growth (175, 147, 226, 255, 305, 149). Prenatal or neonatal

exposures have been found to have life long effects on nerve function and susceptibility to toxic effects. Prenatal mercury vapor exposure that results in levels of only 4 parts per billion in newborn rat brains was found to cause decreases in nerve growth factor and other effects (305). This is a level that is common in the population with several amalgam fillings or other exposures (500). Insulin-like-growth factor I (IGF-I) are positively correlated with growth hormone levels and have been found to be the best easily measured marker for levels of growth hormone, but males have been found more responsive to this factor than women (497). IGF-I controls the survival of spinal motor neurons affected in ALS during development as well as later in life (497, 498). IGF-I and insulin levels have been found to be reduced in ALS patients with evidence this is a factor in ALS (497, 498). Several clinical trials have found IGF-I treatment is effective at reducing the damage and slowing the progression of ALS and Alzheimer's with no medically important adverse effects (498). It has also been found that in chronically ill patients the levels of pituitary and thyroid hormones that control many bodily processes are low, and that supplementing both thyrotropin-releasing hormone and growth control hormone is more effective at increasing all of these hormone levels in the patient.

Mercury can cause *depression*¹² and mood disorders through increased neurological problems related to lowered levels of neurotransmitters dopamine, serotonin, norepinephrine, and acetylcholinesterase (35, 38, 104, 107, 125, 140, 141, 175, 251, 254, 275, 288, 290, 296, 297, 305, 365, 367, 372, 381, 432, 451, 465, 412, 581, 582). In such cases mercury has been found to accumulate in and affect the function of the brain limbic system (581). The reduced neurotransmitter levels in those with amalgam appear to be a factor encouraging smoking since nicotine increases these neurotransmitter levels and a much higher percentage of those with amalgam smoke than in those without amalgam (141).

Some of the effect on depression is related to mercury's effect of reducing the level of posterior pituitary hormone (oxytocin). Low levels of pituitary function are associated with depression and suicidal thoughts, and appear to be a major factor in suicide of teenagers and other vulnerable groups. The pituitary glands of a group of dentists had 800 times more mercury than controls (99). This may explain why dentists have much higher levels of emotional problems, depression, suicide, etc (Section VIII.). Amalgam fillings, nickel and gold crowns are major factors in reducing pituitary function (35, 50, 369, etc.). Supplementary oxytocin extract has been found to alleviate many of these mood problems (35), along with replacement of metals in the mouth (Section VI.). The normalization of pituitary function also often normalizes menstrual cycle problems, endometriosis, and increases fertility (35, 9).

Animal studies of developmental effects of mercury on the brain have found significant effects at extremely low exposure levels, levels commonly seen in those with amalgam fillings or in dental staff working with amalgam. One study (305) found prenatal mercury vapor exposure decreased NGF concentration in newborn rat's forebrain at 4 parts per billion (ppb) tissue concentration. Another study (175) found general toxicity effects at 1 micromole (uM) levels in immature cell cultures, increased immunoreactivity for glial fibrillary protein at 1 nanomole (0.2 ppb) concentration, and microglial response at even lower levels. Other animal studies on rodents and monkeys have found brain cellular migration disturbances, behavioral changes, along with reduced learning and adaption capacity after low levels of mercury vapor exposure (149, 175, 210, 264, 287, 305). The exposure levels in these studies are seen in the fetus and newborn babies of mother's with amalgam fillings or who had work involving amalgam during pregnancy (61). Mercury vapor has been found to primarily affect the central nervous system, while methyl mercury primarily affects the peripheral nervous system (175c).

Long term occupational exposure to low levels of mercury can induce slight cognitive deficits, lability, fatigue, decreased stress tolerance, etc. Higher levels have been found to cause more serious neurological problems (119, 128, 160, 285, 457, etc.). Other studies (285bg, 395) found that workers

¹²**Informative:** "Depression and other Neurotransmitter Related Conditions - The Mercury Connection".

exposed at high levels at least 20 years previous (urine peak levels above 600 $\mu\text{g}/\text{L}$ demonstrated significantly decreased strength, decreased coordination, increased tremor, paresthesia, decreased sensation, polyneuropathy, etc. Significant correlations between increasing urine mercury concentrations and prolonged motor and sensory distal latencies were established (285g). Elemental mercury can affect both motor and sensory peripheral nerve conduction and the degree of involvement is related to time-integrated urine mercury concentrations. Thirty percent of dentists with more than average exposure were found to have neuropathies and visuographic dysfunction compared to none in the control group (395d). Other studies have also found a connection between mercury with peripheral neuropathy and paresthesia (190, 449, 502, 71bdef, 395, 581, 582). Chronic mercury exposure has been found to be a significant factor in many neurological conditions including *Alzheimer's*, *Dementia*¹³, *Parkinson's*¹⁴, *MS*¹⁵, etc. Neurological problems are among the most common and serious problems caused by mercury and include memory loss, moodiness, *depression*¹⁶, anger and sudden bursts of *anger/rage/violence*¹⁷ (290, 465, 480-483, 487, 534), self-effacement, suicidal thoughts, lack of strength/force to resolve doubts or resist obsessions or compulsions, etc. Many studies of patients with major neurological diseases have found evidence amalgam fillings may play a major role in development of conditions such as depression (94, 107, 109, 212, 222, 271, 294, 212, 229, 233, 285e, 317, 320, 322, 372, 374, 453, 581, 582), schizophrenia (34, 35, 295, 465, 560), bipolar disorder (294), memory problems (212, 222, 581, 582), and other more serious neurological diseases such as *MS*¹⁸, *ALS*¹⁹, *Parkinson's*²⁰, and *Alzheimer's*²¹. A large U.S. CDC study found that those with more amalgam fillings have significantly more chronic health problems, especially neurological problems and cancer (543).

Some factors that have been documented in depression are low serotonin levels, abnormal glucose tolerance (hypoglycemia), and low folate levels (480-83), which mercury has also been found to be a cause of. Occupational exposure to mercury has been documented to cause depression and anxiety (534). One mechanism by which mercury has been found to be a factor in aggressiveness and violence is its documented inhibition of the brain neurotransmitter acetylcholinesterase (175, 251c, 305, 451, 465, 254). Low serotonin levels and/or hypoglycemia have also been found in the majority of those with impulsive and violent behavior (481, 482).

Numerous studies have found long term chronic low doses of mercury cause neurological, memory, behavior, sleep, hearing loss (566), and mood problems (3, 34, 60, 69, 70, 71, 74, 107-109, 119, 140, 141, 160, 199, 212, 222, 246, 255, 257, 282, 290, 453, 581, 582). Neurological effects have been documented at very low levels of exposure (urine Hg; 4 $\mu\text{g}/\text{L}$), levels commonly received by those with amalgam fillings (290). One of the studies at a German University (199) assessed 20,000 people. There is also evidence that fetal or infant exposure causes delayed neurotoxicity evidenced in serious effect at middle age (255, 306). Organic tin compounds formed from amalgam are even more neurotoxic than mercury (222, 262). Studies of groups of patients with amalgam fillings found significantly more neurological, memory, mood, and behavioral problems than the control groups. (3, 34, 107, 108, 109, 140, 141, 160, 199, 212, 222, 290, 453, 581, 582).

Other studies (285c) found that mercury at levels below the current occupational safety limit causes adverse effects on memory at very low exposure levels. More studies found that long term exposure causes increased micro nuclei in lymphocytes and significantly increased IgE levels at exposures below current safety levels (128), as well as maternal exposure being linked to mental retardation

¹³**Informative:** "Alzheimer's Disease and Other Autoimmune Degenerative Conditions: the Mercury Connection".

¹⁴**Informative:** "Toxic Exposures and Parkinsons: the Mercury Connection".

¹⁵**Informative:** "Mercury from Amalgam Fillings is a Common Cause of MS, ALS, PD, SLE, RA, MCS, AD, etc.".

¹⁶**Informative:** "Depression and other Neurotransmitter Related Conditions - The Mercury Connection".

¹⁷**Internet:** "<http://www.flcv.com/violence.html>".

¹⁸**Informative:** "Mercury from Amalgam Fillings is a Common Cause of MS, ALS, PD, SLE, RA, MCS, AD, etc.".

¹⁹**Informative:** "Amyotrophic Lateral Sclerosis (ALS): Lou Gerhig's Disease - The Mercury Connection".

²⁰**Informative:** "Toxic Exposures and Parkinsons: the Mercury Connection".

²¹**Informative:** "Alzheimer's Disease and Other Autoimmune Degenerative Conditions: the Mercury Connection".

(110). Very high levels of mercury are found in brain memory areas such as the cerebral cortex and hippocampus of patients with diseases with memory related symptoms (158, 34, 207, etc.) Mercury has been found to cause memory loss by inactivating enzymes necessary for brain cell energy production and proper assembly of the protein tubulin into microtubules (258). DMSO has been found to have some capability to repair such damage (581).

1.3 Treatment of Toxic Related Neurological Conditions

The mechanisms by which mercury causes neurological conditions have been documented, but it has also been found that people with such conditions commonly recover or have significant improvement after amalgam replacement-from conditions including: memory disorders (8, 35, 94, 212, 222, 322, 440, 453, 552, 557, 581, 582), schizophrenia and bipolar disorder (294, 295, 465, 560, 581, 34, 35), depression (62, 94, 107, 163, 185, 212, 222, 229, 233bcfh, 271, 294, 285e, 317, 322, 376, 386de, 453, 465, 485, 523, 525c, 532, 538, 551, 556, 557, 581, 582, 35, 40), insomnia (35, 62, 94, 212, 222, 233ag, 271, 317, 322, 376, 525c, 581, 582), anger (212, 233, 102, 557, 35, 62), anxiety & mental confusion (62, 94, 212, 222, 229, 233abcfgh, 271, 317, 322, 440, 453, 525c, 532, 551, 557, 581, 35, 57), neuropathy/paresthesia (8, 35, 62, 94, 163, 212, 222, 322, 556, 557, 581, 582), MS (62, 94, 95, 102, 163, 170, 212, 222, 229, 271, 291, 302, 322, 369, 469, 485, 34, 35c, 229, 523, 532, 581), ALS (97, 423, 405, 469, 470, 485, 535, 35), Parkinson's/ muscle tremor (222, 248, 228a, 229, 233f, 271, 322, 469, 535, 557, 581, 582, 212, 62, 94, 98, 35), Alzheimer's (62, 204, 251c, 386e, 535, 581, 35), headaches/migraines (5, 8, 34, 35, 47f, 62, 95, 185, 212ab, 222, 229, 233abdefgh, 271, 317, 322, 349, 354, 115, 376, 440, 453, 523, 525, 532, 537, 538, 552, 556, 581, 582, 583), epilepsy (5, 35, 309, 229, 386e, 557, 581), ataxia/balance problems (250c, 581, 582);

Lipoic acid has been found to have protective effects against cerebral ischemic-reperfusion, excitotoxic amino acid (glutamate) brain injury, mitochondrial dysfunction, diabetic neuropathy (572, 550). Other antioxidants such as carnosine (495a), Coenzyme Q10, Vitamins C & E, ginkgo biloba, pycnogenol and selenium have also been found protective against degenerative neurological conditions and ginkgo biloba and 5-HTP for ADHD (176, 494, 495e, 444, 237, 550, 20). Several doctors have found thiamin (B3), Vit B6, inositol, and folic acid supplementation to alleviate peripheral neuropathies, pain, tinnitus, and other neurological conditions (502). Several studies have documented that lipoic acid (an antioxidant and chelator) resulted in improvement in the majority of diabetes cases it was used for, by improving glucose metabolism, increasing insulin sensitivity, and reducing nerve damage (including in diabetic neuropathy)(501e, 550). Properly formulated nutritional treatments have been found to be effective in treating ADHD and depression (522). Hormonal imbalances such as from taking birth control pills can be a factor in causing B vitamin deficiencies such as B6 and Riboflavin which can be a factor in migraine headaches. Supplementation has been found to be helpful in such circumstances (20).

One chelation expert (581) suggests when chelating with DMPS supplementation with a good multivitamin/multimineral plus Vit E (400 IU), selenium (200-400 μ g), and Vit C (=2 grams or Vit C IV) (581). He also finds chlorella beneficial for most. He has found that other factors that reduce detoxification include:

Low sodium, calcium, potassium, or selenium levels

Low protein in diet or low stomach acid

Hormonal problems

Low serum cholesterol (carrier)

Low glutathione or other detox enzymes

Kidney problems or damage from mother's amalgams

Constipation or Leaky Gut

Electromagnetic influences (scars, Geopathic Stress, EMF, RF waves)

For information and treatment of factors involved in neurological conditions other than toxic metals, see the treatment section of the individual condition review paper of interest, linked above.

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