A Hypothesis and Additional Evidence that Mercury May be an Etiological Factor in Multiple Sclerosis

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Abstract

Mercury is one of the most toxic elements that can cause a multitude of health problems. This study was created to determine if mercury could be causing multiple sclerosis (MS) by cross referencing 88 factors associated with MS to mercury. The results found that all but five factors could be attributed to mercury, and with the remaining five factors there was not enough evidence one way or another to possibly be associated with mercury. The hallmark change of MS is nerve demyelination, and mercury is known to cause nerve demyelination. Similar physiological and pathological changes occur in MS and mercury toxicity including those involved in the basal ganglia, Bell’s palsy, brain atrophy and shrinkage, brain scarring, dysmetria, myelin basic protein, myelin oligodendrocytes, glycoprotein, oligoclonal bands, oligodendrocytes, ciliary neutrophil factor, white matter, axon and myelin damage, electroencephalography, and brainstem auditory evoked potentials. Similar changes also occur in the immune system including autoimmunity, cytokine changes, gamma globulins, Epstein Barr virus, T cells, herpes virus, and urinary infections. Likewise similar changes are also found in hormones and biochemistry including myelin basic protein, myelin oligodendrocytes, glycoprotein, estriol, free radicals, glial cells, glucosteroids, female hormones, and snifferon.

A study was conducted on a man who injected himself with metallic mercury for five months. After his death, the brain was studied. Inorganic mercury was taken up by five types of human brain astrocytes, by cortical oligodendrocytes (the precursor of myelin), cortical neurons, and by locus ceruleus neurons. The study concluded that mercury in these cells could play a role in the pathogenesis of MS. Mercury induces oxidative stress, interferes with nerve function causing the symptoms of MS [4].

This study explored the mercury/MS hypothesis even further. All the physiological and pathological changes associated with MS were identified in a comprehensive book on multiple sclerosis entitled Encyclopedia of Multiple Sclerosis researched and written by Carol Turking [4]. Each of these physiological and pathological changes was identified and cross referenced with mercury data bases and PubMed to identify scientific articles that could explain whether, and if so, how mercury could be causing these changes. Positive and negative reports were considered equally, and all data presented in this paper helped explore the hypothesis. A total of 88 changes that occur in MS were identified. Seventy-five changes could be explained by mercury toxicity, eight could possibly be explained by mercury toxicity, and five changes could not be explained in the literature if mercury was involved. There were no physiological changes that ruled out mercury’s involvement. The following is a brief summary of the physiological and pathological changes that occur in MS, which were cross referenced with mercury to determine if there could be a relationship.

Results

A. Hallmark Symptom

1. Nerve Demyelination: Demyelination is a loss of myelin, the fatty sheath surrounding the nerve fiber in white matter of the central nervous system. This interferes with nerve function causing the symptoms of MS [4].

Mercury: A study was conducted on a man who injected himself with metallic mercury for five months. After his death, the brain was studied. Inorganic mercury was taken up by five types of human brain astrocytes, by cortical oligodendrocytes (the precursor of myelin), cortical neurons, and by locus ceruleus neurons. The study concluded that mercury in these cells could play a role in the pathogenesis of MS. Mercury induces oxidative stress, stimulates autoimmunity, and damages DNA, all associated with MS [5]. A study by Deleu, et al, was conducted on a 36-year-old man who chronically used ammoniated mercury ointment. A nerve biopsy showed mixed axonal degeneration and nerve demyelination [6].

B. Nerve Physiology and Pathology

1. Basal Ganglia: The basal ganglia is affected in MS, resulting in involuntary movement, trembling, and weakness [4].

Mercury: Mercury has a tendency to accumulate in the basal ganglia leading to neurological disorders such as involuntary movement, trembling, and weakness [7].

2. Bell’s Palsy: Bell’s Palsy can occur in MS, which is a form of facial paralysis. It is characterized by an acute, partial, or complete paralysis of the face. Most people make a spontaneous recovery within a month [4].

Mercury: Nothing in the literature could specifically be found that associate mercury with Bell’s palsy. However, cerebral palsy has been associated with mercury toxicity [8]. There has also been a relationship between the herpes virus and MS, Bell’s palsy, and mercury [9,10].
3. Brain Atrophy and Shrinkage: As myelin axons and neurons are destroyed, the brain begins to shrink in MS. An MRI can also detect shrinkage in the spinal cord [4].

**Mercury:** Autopsies of 14 subjects exposed to organic mercury intoxication found a slight shrinkage of neurons in the vestibular and fastigial nuclei of all patients [11]. The brain of an eight year old who was exposed to methyl mercury poisoning died at the age of 30. His brain showed cortical atrophy [12].

4. Chaddocks Sign: This is a reflex test that can indicate MS. If a subject's ankle is touched on the outside, there is an upward fanning of the big toe [4].

**Mercury:** Nothing in the literature was found regarding mercury and Chaddocks sign. However, the herpes virus has been associated with MS, Chaddock's sign, and mercury [9].

5. Brain Scarring: Brain scarring occurs with roughly equal frequency in the right and left halves of the brain of white matter in MS patients [4].

**Mercury:** Rat studies found that mercuric chloride caused tubular changes and small scars of the kidney [13]. Mercury can cause brain atrophy, which is a form of scarring.

6. Detrusor-external Sphincter Dyssynergia (DESD). DESD is a type of bladder dysfunction where there is a failure to store urine and a failure to empty urine. It is caused by inflammation or transverse myelitis [4].

**Mercury:** Mercury can cause inflammation and myelitis [14].

7. Dysmetria: Dysmetria is a problem with coordination caused by lesions in the cerebellum [4].

**Mercury:** Rat studies have shown that methyl mercury exposure for up to four weeks can produce severe cerebellum pathological changes [15].

8. Myelin Basic Protein (MBP): MBP is a major component of myelin and can be found in abnormally high levels in the cerebral spinal fluid if the myelin is damaged [4].

**Mercury:** Rat studies found exposure to methyl mercury produced significantly elevated IgG antibodies to MBP (P = 0.01). Zinc appears to stabilize the myelin sheath. Mercury has been found to be very effective in interfering with the binding of zinc. MBP is the major target for zinc binding [16].

9. Myelin Oligodendrocytes Glycoprotein (MOG): MOG is a component of myelin that has a potential role as an auto antigen in MS within the CNS [4].

**Mercury:** Rat studies found that mercury injected into MOG resulted in the collapse of the mitochondrial potential. The study concluded that mercury accelerates the progression of MS through mitochondrial damage related to oxidative stress and finally apoptosis [17].

10. Oligoclonal Bands (OB): OB is a diagnostic sign that indicates an abnormal level of certain antibodies in the cerebral spinal fluid. It is seen in 90% of MS subjects [4].

**Mercury:** Mercury is known to cause autoimmune glomerulonephritis by suppressing the host resistance to pathogens. Exposure of mice to HgCl2 induced an oligoclonal response with increases of \( \upsilon_{beta 5+} \), \( \upsilon_{beta 7+} \), \( \upsilon_{beta 13+} \), CD4+, and splenic cells [18].

11. Oligodendrocytes: These are special cells of the CNS that produce myelin.

**Mercury:** Inorganic mercury is taken up by five types of human brain astrocytes as well as oligodendrocytes. Mercury can induce oxidative stress and stimulate autoimmunity and damage DNA, suggesting a role in the pathogenesis of MS [5].

12. Ciliary Neutrophil Factor (CNTF): CNTF promotes the survival of the oligodendrocyte. Some believe this is the target of the agent causing MS [4].

**Mercury:** Mercury chloride inhibits CNTF [19].

13. White Matter: White matter is another term for white nerve fibers. The white appearance comes from myelin, which is a fatty substance that surrounds axons to enhance electrical signals [4].

**Mercury:** Mercury distribution was analyzed in the mouse brain after mercury vapor exposure. Mercury was found in almost the entire brain with white matter being a target [20].

14. Axon and Myelin Damage: The axons and myelin get damaged in MS [4].

**Mercury:** There is a known association between mercury toxicity and axon neuropathy. There have been several studies reporting acute inflammatory neuropathy and demyelinating neuropathy in mercury toxicity [21].

15. Electroencephalography (EEG): The EEG is abnormal in MS [4].

**Mercury:** A computerized analysis on chlor-alkalai workers subjected to long term exposure to mercury, showed significantly slower and more attenuated EEGs [22].

16. Brainstem Auditory Evoked Potentials (BAEP): About 67 % of people with definite MS have abnormal BAEP test results. MS subjects have higher latencies in nerve conduction velocities [4].

**Mercury:** The latency of the electrical transmission from the acoustic nerve to the brain was significantly increased after exposure to mercury [23].

C. Immunity and Microbes

1. Autoimmune: Most neurologists believe that MS is an autoimmune disease. The target of the immune attack is a component of myelin when the process occurs. T cells become sensitized to myelin and enter the CNS. The T cells injure the myelin and secrete chemicals that damage the axons, and recruit more immune cells to the site of inflammation. Experts suspect some environmental factor activates the T cells [4].

**Mercury:** Mercury is a well established toxicant and is linked to autoimmune. Studies have shown individuals with autoimmune disease have higher levels of Mercury is known to cause autoimmune [24].

2. Cytokine Change: Cytokines help regulate the immune system. They are secreted by various white blood cells to help regulate immunity, inflammation, and tissue repair. MS causes cytokine changes [4].

**Mercury:** Mercury elicits a pro-oxidative state linked to pro-inflammatory cytokine production [25].

3. Gamma Globulin: Gamma globulins are a family of antibodies that is increased in the spinal fluid of many MS patients. Gamma globulins help fight infection [4].

**Mercury:** A study on green sea turtles found mercury levels positively correlated with gamma globulins, suggesting inflammation and immune modulation [26].

4. Epstein Barr Virus (EBV): EBV is a common virus that causes mononucleosis. Some researchers suggest it is linked to MS. One study found that 83% of children with MS had been exposed to EBV. People with MS have higher than normal levels of antibodies to EBV. Those with the highest level of antibodies to EBV were 33 times more likely to develop MS [4].

**Mercury:** EBV is in the herpes family. Mercury exposure increases herpes virus replication [10].

5. Immune System: When a person develops MS, the immune system goes awry and mistakenly attacks the patient’s own myelin covered nerves. Antibodies are made by the white blood cells. There are two types of lymphocytes, B and T cells, that produce antibodies that neutralize germs. Experts believe that the immune system recognizes myelin as non self. As a result, B cells, T cells, and macrophages accumulate around lesions in myelin [4].

**Mercury:** Cytokines contribute to inflammation, and mercury significantly induces cytokine expression which regulates the immune system [27].

6. T cells: T cells are white blood cells developed in the bone marrow. They in turn increase the production of antibodies by B cells. It is believed that destruction of myelin is caused by an abnormal autoimmune process by activation of T cells against some component of the CNS myelin [4].

**Mercury:** The subclass of T-8 lymphocytes is suppressed in MS subjects, especially when there is an exacerbation of the MS symptoms. A study at Colorado State University and another by Eggleston, et al, found reduced T-lymphocytes in subjects with mercury amalgams. The T-8 suppressors help control the immune system. One theory on the etiology of MS is that with a suppression of the T-8 suppressor cells, the immune system becomes overactive and attacks the nervous tissue resulting in sclerotic lesions [2,28].

7. Infections: Some researchers believe that an infection may be the cause of MS. The top three contenders include herpes virus, chlamydia pneumonia, and the Epstein Barr virus.

**Herpes virus:** This virus is related to MS as a higher rate of herpes infection is found in MS patients. Viruses can cause demyelination of nerves. Epidemiology studies suggest exposure to herpes infection is related to MS [4].
Mercury: Herpes virus replication is increased after mercury exposure [10]. The Epstein Barr virus is of the herpes family. Mercury has also been found to increase chlamydia infection [29].

8. Urinary Tract Infections: These infections are common in MS [4].

Mercury: Urinary tract infections were found in patients with Niigata Minamata disease caused by mercury poisoning, with a higher prevalence in patients aged 60 to 69 [30].

D. Hormones and Biochemistry

1. Myelin Basic Protein MBP: MS subjects have antibodies against MBP [4].

Mercury: Myelin basic protein is a biochemical marker of neurotoxicity by mercury [31].

2. Myelin Oligodendrocyte Glycoprotein (MOG): MOG is a component of myelin and has the potential role as an autoantigen in MS [4].

Mercury: One study on mice found that repeated exposure to mercury accelerates the progression of MS-like changes through mitochondrial damage related to mercury stress. The experimental encephalomyelitis was induced by injecting oligodendrocyte glycoprotein with mercury. The study concluded that exposure to mercury can accelerate the progression of MS [32].

3. Estradiol: Estradiol is a form of estrogen hormone that increases during pregnancy. Pregnant women with MS are known to experience lower exacerbation rates during pregnancy. Also, an experimental autoimmune encephalomyelitis was eased with estradiol [4].

Mercury: There is not much in the literature regarding mercury and estradiol. However, one study found glucose transport was inhibited both by mercury and estradiol [33].

Mercury: Mercury produces free radicals [34].

5. Gial Cells: Gial cells make up the supportive tissue of the brain and CNS. They protect, support, and feed neurons. There are two types of gial cells in the CNS, oligodendrocytes and astrocytes [4].

Mercury: Mercury induces cytotoxic effects on oligodendroglia cells. Experimental encephalomyelitis was induced by injecting oligodendrocyte glycoprotein with mercury. Astrocyte damage by methyl mercury can help explain its neurotoxicity [35].

6. Glucosteroids: Glucosteroids are produced by the adrenal glands in response to stimulation by adrenocorticotopic hormones. These hormones play an immunosuppressive and anti-inflammation role in the treatment of MS [4].

Mercury: Animal studies suggest mercury suppresses the adrenocortical response [36].

7. Hormones: Both estrogen and progesterone may suppress some immune activity. MS symptoms are more common in premenstrual women. A worsening of symptoms often occurs within one week of menstruation. During pregnancy estrogen and progesterone are very high, perhaps explaining why pregnant MS women have fewer exacerbations [4].

Mercury: There is little in the literature regarding estrogen and mercury. One study conducted on human estrogen receptor cells involved treating breast cancer with methyl mercury, which resulted in proliferation of the cancer cells. Higher doses of methyl mercury induced apoptosis [37].

8. Interferon: Interferon is a group of proteins produced by white blood cells to respond to viral infections. There are two types used to treat MS; interferon beta (1A and 1B) and interferon gamma produced by activated T cells [4].

Mercury: Protein synthesis of interferon alpha and beta was reduced when exposed to mercury. Auto antibodies are potential biomarkers of mercury induced immunotoxicity including interferon induced transmembrane protein [38].

9. Vitamin D: A high intake of vitamin D has been linked to a lower risk of MS. A Harvard study found women with the highest intake of vitamin D had a 40% lower risk of developing MS. Lack of exposure to sunlight increases the risk of developing MS. Vitamin D is produced naturally by the body when exposed to UVA sunlight. The higher the vitamin D level, the lower the disease activity. Animal studies show appropriate levels of vitamin D can slow the progression of autoimmune diseases such as MS [4].

Mercury: There is very little in the literature directly relating mercury and vitamin D. It is known that mercury produces inflammation and that vitamin D is anti-inflammatory.

E. Symptoms of Multiple Sclerosis

1. Ageusia: Occasionally MS subjects lack taste [4].

Mercury: Nothing was found in the literature regarding mercury and a lack of taste. In herpes virus caused brainstem encephalitis, a 45 year old man developed ageusia. The herpes virus has been associated with MS and mercury [39].

2. Balance: Some MS subjects have difficulty with balance [4].

Mercury: A symptom of Minamata disease (mercury poisoning by fish) is a slight balance failure [40].

3. Bladder Dysfunction: Bladder dysfunction is found in 80% of MS patients [4].

Mercury: A symptom found in mercury toxicity is urinary bladder dysfunction [41,42].

4. Bowel Dysfunction: Constipation is the most common bowel complaint in multiple sclerosis [4].

Mercury: A 13-year old African American was poisoned for two months by mercury and developed acute inflammatory demyelination polyneuropathy and constipation as one of the symptoms [43].

5. Fatigue: Fatigue is reported by 80% of MS patients, usually occurring daily [4].

Mercury: Fatigue is a common symptom in dental personnel exposed to mercury vapor [44].

6. Numbness: Reduced sensitivity to touch is a common symptom of MS [4].

Mercury: Gold miners exposed to mercury had significant symptoms of numbness [45].

Mercury: Toxic levels of inorganic mercury can cause muscle spasm [46].

8. Tremor: If the cerebellum is involved, MS subjects will experience tremors [4].

Mercury: Tremors are a common symptom of chronic mercury intoxication. Rat studies have shown exposure to mercury vapor by inhalation is toxic to the cerebellum [46]. People with dental amalgams inhale the mercury vapor from the amalgams.

9. Ataxia: MS subjects can exhibit ataxia symptoms such as unsteady gait and shaky movement [4].

Mercury: Ataxia is a typical symptom of metallic mercury intoxication [47].

10. Cold Feet: Cold feet is a symptom reported by MS patients [4].

Mercury: Mercury can cause numbness, which is associated with cold feet [46].

11. Exacerbations: Exacerbation is a sudden worsening of an MS symptom or appearance of a new symptom. The condition must last 24 hours [4].

Mercury: MS subjects who had their mercury amalgams removed reported 33 % fewer exacerbation of MS symptoms compared to a control group of MS subjects with amalgams [2].

12. Flaccid Bladder: MS subjects may have a flaccid bladder [4].

Mercury: Subjects with Niigata Minamata disease caused by chronic methyl mercury poisoning from fish reported overactive bladder symptoms [48].

13. Flexor Spasm: Subjects with MS may have involuntary and sometimes painful contraction of flexor muscles [4].

Mercury: Chronic mercury poisoning can produce muscle spasm [47].

14. Gait Problems: MS subjects often have difficulty in walking, the most common movement limitation in MS [4].

Mercury: Subjects with chronic mercury exposure can experience gait disturbances [49].
15. Gastro Esophageal Reflux: Acid reflux can occur in MS patients if the lesions are in the medulla oblongata region of the brain [4].

**Mercury:** Nothing in the literature could be found regarding mercury and gastro esophageal reflux. Inflammatory changes in the esophagus can be caused by gastro reflux content as a result of the herpes virus. Both MS and mercury are associated with the herpes virus [10].

16. Gout: MS is associated with uric acid and gout [4].

**Mercury:** Rat studies have shown that mercury chloride increases uric acid [50].

17. Headaches: Migraine headaches are twice as common in MS subjects compared to a control group without MS [4].

**Mercury:** Mercury released from amalgam dental fillings is often claimed to be a possible cause of migraine headaches, chronic fatigue and headaches [51]. It is known that mercury can cause headaches.

18. Hearing Loss: Hearing loss occurs in 6% of MS patients, which is thought to be caused by inflammation or scarring of the 8th cranial nerve [4].

**Mercury:** A symptom of chronic methyl mercury poisoning is hearing loss.

Seven female MS subjects had their mercury amalgams removed. Before and after hearing testing was done. Their hearing improved an average of 8db (P = 0.02) after amalgam removal [52].

19. Heat: In many cases high temperatures worsen MS [4].

**Mercury:** Studies have found a significant synergistic interaction effect of mercury and heat, with a reduced tolerance to heat following mercury exposure [53].

20. Inflammation: In MS and other autoimmune diseases, the inflammation response appears to be triggered without any kind of germ or invading substance [4].

**Mercury:** Evidence suggests mercury exposure in humans is linked to markers of inflammation and autoimmunity [54]. Could mercury be the cause of autoimmunity and inflammation found in MS?

21. Intention Tremor: Goal induced movement produces shaking in the moving body, especially in the hands. This is common in MS [4].

**Mercury:** A typical symptom of chronic mercury intoxication is tremor [47].

22. Itching: Itching is a symptom of MS [4].

**Mercury:** One of the symptoms of mercury toxicity is itching [55].

23. Menopause: Some MS women complain of their MS symptoms becoming worse during menopause [4].

**Mercury:** High mercury levels have been associated with early menopause [56].

24. Menstrual Cycle: Approximately 70% of MS symptoms change at a regular time in the menstrual cycle such as fatigue, weakness, imbalance, and depression [4].

**Mercury:** Exposure to elemental mercury may be associated with a higher prevalence of irregular menstrual cycles in women living in Artisanal gold mining region in Columbia where mercury levels are high [57].

25. Pain: About 70% of MS patients report some kind of pain [4].

**Mercury:** A study of seven patients that had been intoxicated by elemental mercury found that all of them had severe extremity pain [58].

26. Urinary Infections: Urinary tract infection is a common symptom of MS [4].

**Mercury:** A study of patients with Niigata Minamata disease, caused by mercury poisoning, found a higher prevalence of lower urinary tract symptoms [59].

27. Sexual Problems: One study found that 63% of MS patients reported a decline in sexual activity [4].

**Mercury:** Mercury is known to cause sexual disorders [60].

28. Spasticity: Spasticity is one of the most common MS symptoms. This is when stiff tight muscles contract and are not coordinated with other muscles [4].

**Mercury:** Some Minamata disease patients were found to have progressive spastic paraplegia [48].

29. Speech Problems: Some MS patients have speech problems thought to be associated with demyelination of certain cells in the brain [4].

**Mercury:** A study was conducted in a community in northwestern Ontario in Canada, which had been contaminated by mercury from a chlor-alkalai plant in the province. Speech impairment was a symptom [61].

30. Vertigo: Vertigo is a common symptom in MS [4].

**Mercury:** A study was done on a subject who had been exposed to soap containing high levels of mercury. One of the symptoms was vertigo [62].

31. Weakness: One of the most disabling symptoms of MS is a feeling of weakness [4].

**Mercury:** A study was conducted on dental personnel who had been exposed to mercury. The symptom of weakness was quite common [63].

32. Auditory Agnosia: This symptom is the inability to hear because the auditory stimulus cannot be interpreted [4].

**Mercury:** Nothing was found in the literature regarding auditory agnosia and mercury. One study on monkeys found the herpes virus could cause auditory agnosia. Both MS and mercury are associated with the herpes virus [64].

F. Mental Symptoms:

1. Cognitive Dysfunction: Between 50% to 60% of MS patients have a slow ability to think, reason, and concentrate [4].

**Mercury:** Chronic neurological disease due to methyl mercury poisoning includes cognitive impairment [65].

2. Memory: Poor memory in MS subjects may be due to physical damage to both myelin and nerve cells within the frontal and temporal lobes of the brain [4].

**Mercury:** A hallmark symptom of mercury toxicity is memory loss [3].

3. Depression: Depression is a common symptom of MS. It may be caused by the disease itself or the physiology of MS which may predispose MS people to depression [4].

**Mercury:** A study [66] conducted on 48 subjects with mercury dental amalgams found they suffered significantly more from depression (P = 0.008) than 47 subjects without amalgams [67]. Another study found MS subjects who had their mercury amalgams removed suffered significantly less depression compared to subjects with amalgams [67].

4. Emotional Problems: MS subjects often suffer from depression, grief, anxiety, distress, moodiness, and some exhibit inappropriate behavior [4].

**Mercury:** Subjects with mercury dental amalgams suffered significantly more from sudden anger, depression, and irritability compared to a control group without mercury amalgams [66].

5. Forgetfulness and Memory Loss: MS subjects often have minor memory lapses. About half of MS patients will develop some degree of memory loss but only 5% to 10% will develop severe problems [4].

**Mercury:** Memory loss is a hallmark symptom of mercury toxicity [3].

6. Mood Swings: Mood swings are common in MS [4].

**Mercury:** A review of the literature in one study reported mercury exposure of dental personnel found many suffered mood disorders [68].

7. Suicidal Tendencies: The suicide rate is higher in subjects with MS due to depression [4].

**Mercury:** Depression is a common symptom in mercury toxicity. Subjects with mercury amalgams had more symptoms of suicidal tendencies than a control group without amalgams [66].

G. Ocular Symptoms

1. Visual Impairment: MS symptoms may include double vision, blurring, and visual loss [4].

**Mercury:** Examination of patients with chronic mercury toxicity reveals marked visual disorders and inhibited neuronal structures of the retina and optic nerve [69].

2. Double Vision (Diplopia): Diplopia is a common symptom of MS [4].

**Mercury:** A 35-year-old Latin American man subacutely developed diplopia one year after subcutaneous injection of elemental mercury, a practice common in Latin-American cultures [70].
3. Visual Evoked Response (VER): This is a test that measures electrical activity in parts of the brain. MS subjects have damaged myelin that slow nerve impulses. The VER measures the speed of the brains electrical activity in response to a visual response [4].

Mercury: Seven MS subjects had a VER performed before their mercury dental amalgams were removed. The VER was again performed six months later. The latencies of the VER decreased significantly [71].

4. Visual Acuity Changes: MS subjects report changes in their visual acuity [4].

**Mercury:** A study on battery factory workers who worked with mercury found visual acuity differed significantly from a healthy control group [72].

5. Optic Disc Changes: MS subjects can have a change in appearance of the optic disc [4].

**Mercury:** Pregnant squirrel monkeys were exposed to mercury vapor for approximately two thirds of their pregnancy. The eyes were enucleated, and mercury was detected mainly in the optic disc. A study at Colorado State University found that subjects with mercury dental fillings had significantly more pigment around the optic disc compared to subjects without amalgams [69].

6. Visual Field: MS subjects often have a constricted visual field [4].

**Mercury:** One of the classical findings in mercury toxicity is a concentric constriction of the peripheral visual field as was demonstrated in the mercury poisoning in Iraq and Japan. Another study found an average constriction of 18% of the peripheral white visual field (P = 0.013) in a group with mercury dental amalgams compared to the control group without amalgams [73].

7. Nystagmus: Nystagmus is uncontrolled eye movements, a common symptom of MS [4].

**Mercury:** A study was conducted on 25 patients who had been intoxicated with organic mercury. There were six cases of spontaneous nystagmus that disappeared, but then in nine other subjects spontaneous nystagmus appeared [74].

8. Ocular Inflammation: Inflammation of the iris is reported in 10% of MS subjects [4].

**Mercury:** It is known that mercury causes inflammation, and that mercury toxicity affects the eye which is part of the brain. Mercury is a preservative used in thimerosal that was used in contact lens solutions. One study found 31 of 38 patients had ocular provocation [75].

9. Optic Atrophy: Optic atrophy is the wasting of the optic disc, which may occur in MS [4].

**Mercury:** Heavy metals are known to cause optic atrophy, and mercury does have an affinity for the optic disc [76].

10. Optic Neuritis: Optic neuritis is the inflammation of the optic nerve that can lead to demyelination of the optic nerve and is one of the most common beginning symptoms of MS. About 50% to 60% of people with optic neuritis go on to develop MS [4].

**Mercury:** Toxic metals are known to cause optic neuritis, and mercury is known to cause inflammation of the optic nerve [76].

11. Afferent Pupillary Effect (APE): APE is an abnormal reflex to light in which the pupil does not react to the level of light reaching it. One pupil looks larger. It can occur in MS [4].

**Mercury:** A study was done on 29 pediatric children who had mercury poisoning. The most common neurological abnormality was partly dilated pupils in 31% of the children [77].

H. Epidemiology:

The epidemiology findings of MS presented here do not have physiological or pathological evidence regarding MS and mercury, but may be due to the fact that MS is more common in the northern latitudes where there is less sunshine. The sun provides the body with vitamin D, which is anti-inflammatory. MS subjects lack vitamin D, and mercury is known to cause inflammation. The hypothesis is that if mercury is involved in MS, there may not be enough vitamin D to counteract mercury’s inflammation.

1. African American: MS is more common among Caucasians than African Americans. However, the cause of the disease may be more aggressive among African Americans [4].

**Mercury:** MS is more prevalent in northern latitudes. Fewer African Americans live in the northern latitudes than southern latitudes. If mercury is involved, and there is more exposure to sunshine providing vitamin D, that may in turn counteract mercury’s inflammation.

2. Young Adult Disease: MS is primarily a disease of young adults. Most people are diagnosed between the ages of 20 and 50. Only 5% are diagnosed before the age of 21 and 9.4% after 50 [4].

**Mercury:** There is nothing in the literature about mercury explaining this discrepancy. Perhaps younger people have newer mercury amalgams, and with newer amalgams, the more mercury vapor is released.

3. Asia: Multiple sclerosis is rare in Asia. Asian Americans have a comparatively higher rate suggesting some environmental factor may be involved [4].

**Mercury:** There is nothing in the literature explaining why Asians have a lower MS rate. This study hypothesizes that the lower incidence of MS in Asia may be due to the wide use of tumeric/cumin in the diet. Tumeric is one of the key ingredients in many Asian dishes for thousands of years. It is a major part of Ayurvedic medicine. It is anti-inflammatory and has been shown to counteract hepatotoxicity caused by mercury.

4. Canada: Canada has one of the highest rates of MS in the world. MS rates are twice as high in the prairie provinces than in Newfoundland [4].

**Mercury:** Perhaps it may be the sunshine/vitamin D hypothesis. MS subjects have lower vitamin D levels than non MS subjects, and vitamin D is anti-inflammatory.

5. Caucasian: MS is far more common in Caucasians than in other racial groups. Nothing in the literature explains this but Caucasians are found in a higher percentage at the northern latitudes than other races [4].

**Mercury:** Perhaps the sunshine and vitamin D hypothesis may explain this and the anti-inflammation property of vitamin D.

6. Higher Incidence in Women. MS rates are higher in women [4].

**Mercury:** Perhaps it may be a hormone factor, as we have mentioned, mercury affects female hormones.

7. Geographical: The high frequency zones for MS, affecting 50-120 people out of 100,000, include Europe, northern United States, Canada, and southeast Australia. The low risk areas include Africa, Asia, Caribbean islands, and Mexico. In Norway, MS is five times more prevalent inland as compared to coastal fishing areas [4].

**Mercury:** Again, it may be the sunshine/vitamin D hypothesis.

8. Hispanics: MS occurs infrequently in South America but more often in Hispanic Americans. It is more common in Caucasian Americans than Hispanic Americans [4].

**Mercury:** More Hispanics live in the south than northern states. Again, it may be the sunshine/vitamin D hypothesis and the anti-inflammation properties of vitamin D.

9. MS Clusters: An MS cluster occurred between 1943 and 1981 in the Faeroe Islands. During WWIII the region was occupied by British troops. The incidence of MS rose each year after the war. Researchers thought the troops brought with them some disease causing agent [4].

**Mercury:** Doctors have expressed concern about the potential hazards of mercury consumption in certain fish. The diet of the inhabitants of the Faeroe Islands is centered on the fishing industry and fish processing. Fish is a source of mercury. The diet consists of a high intake of seafood and whale meat. Both mercury and MS cause tremors, and a study was done in the Faeroe Islands studying the prevalence of essential tremors which was found in 2.9% of the population. Also, the Faeroe Islands are in the northern latitudes [78].

10. Genes: There is no evidence that MS is directly inherited. People with different ethnicity have different tendencies to develop MS. Relatives of MS patients have a higher risk, ranging from 1 in 100 to 1 in 40. The normal rate is 1 in 750 [4].

**Mercury:** People have different abilities to detoxify mercury based on their genetic makeup. If they have an APOE 4 allele, they have difficulty ridding the cell of mercury. If they have an APOE 2 allele, they are less susceptible to mercury toxicity. Mercury can cause DNA damage [79,85].

Discussion

Mercury is a persistent, bio-accumulative, neurotoxic metal that can accumulate in the brain. Since industrialization, mercury in the air and water has increased three to five fold, and between 1977 and 2002, mercury increased in fish four to five fold. Mercury in fish increases by about four percent every year.
The half-life of mercury in the brain is from several years to decades. The World Health Organization rates mercury as one of the ten most dangerous chemicals to public health. A study on autopsyed brains by Weiner, et al, found that mercury concentrations of the brain increased with age. Mercury exposure in humans is mainly derived from fish consumption, dental amalgam, and mercury-based vaccines.

For decades, there has been a controversy regarding whether mercury exposure from these sources has clinical relevance. For fish consumption, there are confusing observations regarding health, because some species of fish are also big sources of selenium and omega-3 fatty acids, which combat mercury toxicity. Additionally, the chemical form of mercury in fish already has reacted to molecules like cysteine and selenium. It may be much less toxic than the form used in toxicology studies or that is produced in the gastrointestinal tract of humans by the methylation of inorganic mercury from dental amalgam. Surprisingly, mercury vapor seems to be more toxic in rats than the unreacted form of methyl mercury. The question arises, which are the main sources of mercury in the human brain? The monitoring of blood, urine, or other biological specimens in living organisms has not correlated with brain mercury content. However, the World Health Organization has stated that the greatest source of mercury in humans originates from dental amalgams.

Evidence has been presented exploring the hypothesis that mercury from dental amalgams may be associated with MS. Supporting this hypothesis, epidemiology studies have linked dental caries with MS. In Australia, the rates of death to MS are linearly related to the number of decayed, missing, and filled teeth (R = 0.9, P<0.002). In the United States, a direct correlation between dental caries and MS is also found (R=0.55, P=0.006). The incidence of MS in 45 countries correlates with the frequency of decayed, missing, and filled teeth among children of school age (R=0.78, P = 0.001) school age. The highest frequency of MS is found in Northern Ireland and the Scottish islands of Orkney and Shetland. These areas of the world are ranked highest in dental fillings.

Evidence has been presented regarding the pathological and physiological similarities between MS and mercury toxicity. Mercury is known to destroy the myelin sheath, reduce nerve conduction velocity, cause auto-immune response, reduce immunity to viruses, and damage the blood-brain barrier all of which have been associated with MS. Research has compared neuromuscular exacerbations between MS subjects with amalgams and those who had their amalgams removed in the previous 12 months. Those with amalgams removed reported 33 percent fewer exacerbations. All fifty physical, ocular, and mental health symptoms identified in this paper with MS can be explained by mercury toxicity.

This study provided additional evidence that mercury is an etiological factor in MS. Eighty-eight physiological changes, pathological changes, and symptoms were identified in MS. Nearly all these changes could be explained by mercury toxicity. A hypothesis of vitamin D and sunshine was presented to explain why MS is more common in the northern latitudes. For some symptoms there was no reference in the literature to mercury but could be explained by viruses. Mercury is known to increase the replication of the herpes virus, and a hypothesis was presented that mercury may influence the cause of the symptom by a virus. The evidence also suggests that if mercury is involved, it is probably originating mainly from dental amalgams.

Conclusion

In summary, the evidence presented in this paper strongly suggests that mercury may be an etiological factor in MS. The greatest source of mercury originates from dental amalgams. Many dentists have discontinued using amalgams or have reduced the use of them because of the possibility that amalgam mercury may cause health disorders. The evidence presented here suggests that when mercury dental amalgams are removed from people with MS, their number of exacerbations, nerve conduction velocity, hearing, immunity, and mental health all improve.

References


