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REVIEW ARTICLE

An Overview of Evidence that Mercury from Dental Fillings may be an Etiological Factor in Many Health Disorders

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ABSTRACT

Aim: The purpose of this paper is to summarize the research regarding the toxic health effects caused by mercury dental amalgams.

Methods: The study involved summarizing scientific articles in journals regarding health effects of dental amalgam mercury.

Results: The science strongly suggests dental amalgam mercury may be an etiological factor in numerous health disorders. Mental health seems to be affected the most including such conditions as depression, anger, and irritability. Studies have also associated it with schizophrenia and bipolar disorders. The cardiovascular system also is affected including high blood pressure, heart rate, hemoglobin, hematocrit, and red blood cells. Subjects with amalgams have a decreased T lymphocyte percentage compared to a control, and the Immunoglobins IgG, IgA, and IgE correlated with the number of amalgams. Myopia is reduced in amalgam bearing subjects but amalgam mercury is constricting the visual field. When comparing total health disorders of subjects with amalgams compared to those without, they suffered 45% more health disorders. Urine and hair mercury levels were significantly higher in subjects with amalgams compared to those without. The scientific evidence strongly suggests that amalgam mercury is associated with Alzheimer's disease, multiple sclerosis, and amyotrophic lateral sclerosis. Research has shown when amalgams are removed many health conditions improve.

Conclusion: The evidence is overwhelming that mercury from dental amalgam is an etiological factor in many health disorders.

Introduction

Clinical evidence has been coming forth suggesting a relationship between mercury from dental amalgams (silver/mercury tooth fillings) and health disorders [1-3]. It has been shown that inhaled mercury from dental amalgam enters the blood stream and can be deposited in the brain and other parts of the body [4]. Amalgams radioactively tagged with mercury were placed in sheep's teeth, and the amalgam mercury was found in most organs and tissues within 29 days [4]. It is known that mercury can cause a variety of health problems. A non-controlled study of 86 subjects who had their amalgams removed found that nearly all aspects of health improved after amalgam removal [5]. With this evidence, a study was undertaken at Colorado State University between a group of age- and sex-matched subjects with amalgams and a group without amalgams. The results reported in this paper suggest that amalgam mercury may be an unrealized burden causing a multitude of health problems.

Mercury Toxicity

Mercury is one of the most toxic metals, because it can disrupt most biological systems as a result of its affinity for sulfhydryl groups. These groups are functional parts of most enzymes and hormones [6]. Small amounts of mercury exposure over a long period can produce a variety of health disorders.

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Most physiological systems can be affected, such as cardiovascular, endocrine, visual, reproductive, immune, dental, digestive, and neurological, including motor, sensory, and mental functions.

Individual responses to mercury's toxic effects vary considerably. Few other poisons are associated with so many physiological functions and cause so many health problems as mercury. Symptoms of mercury poisoning from chronic inhalation develop gradually and may be difficult to associate with mercury. Symptoms may be attributed to other causes. Tissue levels of mercury are not good indicators of mercury toxicity, and there has been no good correlation between severity of toxicity and mercury levels of blood and urine.

Amalgam Mercury and its Path to the Body

Nearly 80% of the world's dental caries were filled with dental amalgam in the 1970s [7]. This alloy is composed of approximately 50% mercury, 35% silver, 13% tin, and 2% copper [4]. It is very unstable and continuously releases elemental mercury.

Mercury is released from dental amalgam in the form of elemental mercury vapor. An average of 75% [8] to 80% [9] of this elemental mercury vapor can be inhaled and absorbed through the alveoli of the lungs, where it passes into the bloodstream rapidly and completely in the non-ionized state. Once it passes the blood-brain barrier it becomes ionized and entrapped within the brain for up to several decades.

More mercury is released after chewing, and newer fillings release more mercury than older fillings [10]. Two-year-old fillings released four times more mercury after chewing compared to pre-chewing levels, and there was a 17-fold increase from 1-week-old amalgams after chewing. Svare, et al. [11] found that the amount of mercury varied with the number of amalgams, and levels of 87.5ug/m³ have been measured.

Vimy and Lorscheider [12] measured intraoral mercury and calculated that subjects with 12 or more occlusal amalgams released an average daily dose of 29ug of mercury. Subjects with 1- 4 amalgams received an average daily dose of 9ug. These levels exceed some countries' accepted standards for environmental exposure.

Pleva [2] found that the chewing surface of a 5-year-old amalgam had lost almost half of its mercury, while a 20-year-old amalgam had no mercury left on the chewing surface.

The release of mercury from the amalgam is enhanced by mechanical, thermal, electrolyte, and bacterial factors [13]. Chewing and tooth brushing enhance the release of mercury. Evaporation of mercury rapidly intensifies during uptake of warm food and drink. Mercury is normally volatile at mouth temperature, and small particles of liquid mercury do evaporate from the surface of the amalgam at mouth temperature. Mercury compounds are easily dissolved by weak acids and sodium chloride solutions [13]. People

who consume salty foods create a perfect electrolyte for dissolving amalgams and releasing mercury. Weak acids from citrus foods will do the same. The *Lactobacillus* bacteria can lower the pH by producing lactic acid and promote the corrosion of amalgam, as does *Streptococcus mutans*.

Stock [14] found that daily mercury concentrations of 10-20ug/m³ in the room, not associated with dental amalgam, produced physical and mental symptoms characteristic of mercury toxicity in the majority of those exposed. Trachtenberg, et al. [15] reported that mercury induced asthenic vegetative symptoms in people exposed to less than 10ug/m³ of mercury. Symptoms included cardiovascular disorders, such as chest pain and heart palpitations, as well as high or low blood pressure.

In the United States, the American National Standard Institute established the maximum allowable mercury concentration as 100ug/m³ in air. This concentration is based on a daily exposure of 8h/day during a 5-day work week. In 1972 it had been raised from 50ug/m³. In the Soviet Union and Switzerland, it is 10ug/m³. The U.S. Environmental Protection Agency (EPA) established the National Emission Standard for mercury as a hazardous air pollutant at levels of 1ug/m³ over a 24h period. In the Soviet Union, the level of 0.3 ug/m³ of mercury was considered hazardous over 24h of exposure.

Eggleston and Nylander [16] found higher concentrations of mercury in the olfactory region and pituitary gland in humans with amalgams compared to those without. They also found a direct correlation between the number of amalgams and the mercury concentrations in the brain.

Nylander, et al. [17] found a direct correlation between the number of tooth surfaces containing amalgam and the concentration of mercury in the occipital lobe cortex. The study concluded that the cause of the association between the number of amalgams and accumulation of mercury in tissue is the release of mercury from amalgam fillings.

Hahn, et al. [4] found that mercury placed in sheep's teeth can enter the body through three uptake sites, which include lungs, gastrointestinal (GI) tract, and jaw tissue. Within 29 days, amalgam mercury was found in the pituitary, thyroid, adrenal, pancreas and ovary glands. Mercury from the amalgams was also found in the frontal cortex, occipital cortex, thalamus, and cerebrospinal fluid; it was also found in the kidney, liver, spleen, heart, lung, trachea, and GI tract. The authors concluded that dental amalgams can be a major source of chronic mercury exposure, as it has been estimated that in North America, nearly 100,000kg of mercury is used in dentistry each year.

Mercury and Health

Clinical reports by Raue [1], a German ophthalmologist, found such symptoms as migraine headaches, nausea, headaches, dizziness, sleep disorders, cardiovascular problems, suicidal tendencies, poor memory, confusion, psychological disturbances, depression, intestinal disorders,

rheumatoid symptoms, dermatitis, eczema, and bronchial asthma all disappeared after amalgams were removed from 100 patients he studied over 2 years.

Pleva [2], a corrosion scientist in Sweden, described his experience of mercury toxicity from dental amalgam. For over 20 years Pleva experienced a multitude of health problems that the physicians could not cure. When Pleva discovered the corrosion of his amalgams, he began to suspect mercury poisoning. Within three months after his amalgams were removed, his mental symptoms were eliminated, including anxiety, irritability, indecision, tiredness, feeling stressed, and loss of interest in life. Other symptoms that disappeared were irregular heartbeat, joint pains, lower back pain, pleurisy, inflammation, vertigo, headaches, GI irritation, eczema, and weak muscles. Ocular symptoms that were eliminated were retinal bleeding, dim vision after exercise, slow and poor accommodation, inability to fix gaze, uncontrollable eye movement, dry eye syndrome, and film over eyes.

A study [5] of 86 subjects who had their amalgams removed found most aspects of health improved after amalgam removal. Eighty percent of subjects felt better after amalgam removal, with 48% of the subjects stating they were able to tolerate stress better. All areas of health improved after amalgam removal. Of 1,815 health symptoms reported in 12 health categories before amalgam removal, 16% were eliminated, 54% improved, 27% did not change, and 3% got worse within an average of 10 months. The study raised the question of whether people with amalgams were less healthy compared to an age and sex-matched group without amalgams.

METHODOLOGY

Three factors led us to study the relationships among dental amalgam, mercury poisoning, and general health. First, mercury poisoning causes health disorders; second, mercury is released as vapor from amalgams; and third, the mercury can enter the blood stream and be distributed to all parts of the body.

If mercury from dental amalgam causes health problems, one would expect that individuals with dental amalgam would exhibit more health problems compared to a control group without amalgams. Most symptoms inquired about in this study have been associated with mercury poisoning.

Subjects

Seventy subjects were selected from respondents to ads in the college newspaper; 23 subjects volunteered from student physiology labs at Colorado State University; and 8 came from a local fraternity.

The amalgam and nonamalgam groups were closely matched for sex and age. Of the 101 subjects, 50 (30 females and 20 males) had amalgams and 51 (30 females and 21 males) had no dental amalgams. The average age of the nonamalgam group was 22.35 years compared to 23.28 years

for the amalgam group.

Mercury levels in hair and urine

A hair sample was taken from the nape of the neck to be analyzed for mercury. Doctors Data Lab in West Chicago, IL analyzed the mercury content by atomic absorption analysis. The hair sample underwent a special cleansing by the lab that removed exogenous contaminants.

The subjects were given a plastic specimen bottle and asked to provide a urine sample on the morning of their next appointment. It was to be collected from the first urination upon arising. The pathology lab at Colorado State University analyzed it for mercury content with a Varian model 1275 atomic absorption spectrophotometer.

Health questionnaire

Volunteers completed two health questionnaires designed to evaluate their subjective perception of their health status. One survey was completed at home and the other while waiting for lab testing.

The health questionnaires asked the subjects about their life style and health history regarding the categories of skin, cardiovascular, nervous disorders, digestion, blood, endocrine, mental, annoying symptoms, allergies, diseases, eye, and dental.

Physical assessments

A dental hygienist and dental assistant recorded the dental status of each subject. The females averaged 9.8 amalgams and the males averaged 10.1 amalgams.

Blood pressure and blood analysis was also done.

Data analysis

Statistical analysis was performed by the Statistics Laboratory at Colorado State University. Numerical data was compared by analysis of variance and the questionnaire responses were analyzed by *Chi square*. The significance level chosen was at $p = 0.10$ because the study was looking for trends. Some findings whose significance level were slightly greater than 0.10 are discussed in the paper as well, because the paper's purpose is to look for trends and demonstrate how mercury may be an etiology factor of the particular health disorder.

Results

Mercury Levels

Table 1: A Comparison of Health of Subjects with Amalgams to Subjects Without Amalgams [3,50].

A: Mercury in Tissue			
Tissue Mercury	Nonamalgam <i>n</i> = 50	Amalgam <i>n</i> = 51	Significance (<i>P</i>)
Hair Mercury (ppm)	1.13	1.43	0.008
Urine Mercury (ppb)	1.23	3.70	0.0002
Lifestyle Questionnaire (Nonamalgam Subjects, <i>n</i> = 45, Amalgam Subjects <i>n</i> = 47)			
B: Mental and Emotional [3,50]			

Mental	Nonamalgam	Amalgam	Significance (P)
1. Stress Tolerance (1 good, 2 avg., 3 poor)	1.76	1.70	0.296
2. Amount of Stress (1 low, 2 avg., 3 high)	2.30	2.41	0.157
3. Emotion Level (1 low, 2 avg., 3 high)	2.13	2.26	0.122
4. Health Description (1 poor, 2 avg., 3 good)	2.54	2.57	0.466
5. Health (scale 1-10, 10 best)	8.36	8.15	0.220
6. Happiness (scale 1-10, 10 best)	8.48	8.02	0.047
7. Peace of Mind (scale 1-10, 10 best)	8.02	7.54	0.033
8. Reading Comprehension			
Good	41	35	0.04
Average	4	12	
Poor	0	0	
9. Grade Point Average (on 4.0 scale)	3.15	3.07	0.196
C: Diet [47,50]			
Diet Category	Nonamalgam	Amalgam	Significance (P)
1. Vitamins	25	28	0.313
2. Minerals	8	14	0.112
3. Fish (2 or more times a week)	4	5	0.487
4. Vegetarian	3	7	0.185
5. Sweet Cravings	13	19	0.14
6. More than 2 cups of coffee daily	9	14	0.175
7. Skip Breakfast	19	20	0.495
8. Eat a lot of sweets	6	10	0.205
9. More than one daily drink of alcohol	3	5	0.375
10. Trouble handling alcohol	1	1	
E: Dental [48,50]			
Dental Category	Nonamalgam	Amalgam	Significance (P)
1.Braces	14	16	0.472
2. Number of Filling			
Male Average		10.1	
Female Average		9.8	
F: Life Style Health [47,50]			
Health Category	Nonamalgam	Amalgam	Significance (P)
1. Yearly Visits to M.D.	1.53	1.79	0.184
2. Birth Control Pill	4	11	0.019
3. Smoking	1	6	0.08
Health Questionnaire I (Nonamalgam Subjects 45, Amalgam Subjects 47)			
G: Mental [47,50]			
Mental Category	Nonamalgam	Amalgam	Significance (P)
1. Lack of Interest	3	5	0.375
2. Shyness	14	10	0.20
3. Nightmares	4	7	0.285
4. Forgetfulness	8	10	0.435
5. Lack Self Confidence	5	10	0.15
6. Nervous	8	12	0.26
7. Fear	3	6	0.265
8. Lack of Attention	4	7	0.285
9. Inability to Concentrate	8	12	0.26

10. Loss of Memory	3	3	
Total	63	85	35% More Symptoms in Amalgam Group
H: Dental [48,50]			
Dental Category	Nonamalgam	Amalgam	Significance (P)
1.Foul Breath	0	4	0.07
2.Bleeding Gums	3	8	0.11
3. Grind Teeth	4	7	0.14
Total	7	19	171% More Symptoms in Amalgam Group
I: Health [47,50]			
Health Category	Nonamalgam	Amalgam	Significance (P)
1. Tremors	4	17	0.07
2. Asthma	1	5	0.11
3. Edema	2	2	
4. Loss of Appetite	2	0	0.23
5. Dim Vision	3	3	
6. Allergies	18	22	0.42
7. Headaches	22	31	0.16
8. Headaches a Month	2.77	3.92	0.13
9. Colds and Respiratory Infections (greater than 2 a year)	9	17	0.05
Total	64	101	58% More Symptoms in Amalgam Group
J: Total			
Symptoms	Nonamalgam	Amalgam	Significance (P)
Grand Total Questionnaire 1	124	205	0.0001
			56% More Symptoms in Amalgam Group
Health Questionnaire II (Nonamalgam Subjects 48, Amalgam Subjects 47)			
K: Skin Problems [47,50]			
Skin Category	Nonamalgam	Amalgam	Significance (P)
1. Unexplained Rashes	5	8	0.267
2. Excessive Itching	5	3	0.367
3. Red Flushes of Color	1	4	0.172
4. Rough Skin	3	4	0.488
5.Acne (pimples)	31	23	0.091
6. Other Skin Conditions	4	14	
Total	49	56	0.174
48 Nonamalgam Subjects 47 Amalgam Subjects	1.02 Symptom per Subject	1.19 Symptoms per Subject	14% More Symptoms in Amalgam Group
L: Cardiovascular [47,50]			
Cardiovascular Symptoms	Nonamalgam	Amalgam	Significance (P)
1. Heart or Chest Pain	1	5	0.098
2. Tachycardia (racing heartbeat)	0	3	0.127
3. Heart Murmur	5	5	
4. High Blood Pressure	2	1	0.346
5. Low Blood Pressure	4	2	0.346

6. Other Heart Problems	1	0	0.245
Total	13	16	0.204
48 Nonamalgam Subjects 47 Amalgam Subjects	0.27 Symptoms per Subject	0.34 Symptoms per Subject	23% More Symptoms in Amalgam Group
M: Nervous [47,50]			
Nervous Symptoms	Nonamalgam	Amalgam	Significance (P)
1. Multiple Sclerosis	0	0	
2. Bell's Palsy	0	0	
3. Shingles (Herpes Zoster)	0	3	0.116
4. Numbness in Any Part of Body	4	7	0.248
5. Tingling in Any Part of Body	5	5	
6. Epilepsy or Convulsions	0	2	0.232
7. Dr. Said "It's Your Nerves"	4	3	0.50
8. Shakes of hands, feet, head, etc	2	3	0.49
9. Twitching of eyelids or other muscles	15	9	0.131
10. Other Nervous Disorders	1	2	0.353
Total	31	34	0.353
48 Nonamalgam Subjects 47 Amalgam Subjects	0.65 Symptoms per Subject	0.72 Symptoms per Subject	11% More Symptoms in Amalgam Group
N: Digestion [47,50]			
Digestion Symptoms	Nonamalgam	Amalgam	Significance (P)
1. Diverticulosis	0	1	0.495
2. Ulcers	2	5	0.207
3. Chrohn's Disease	0	0	
4. Grave's Disease	0	0	
5. Indigestion	6	11	0.131
6. Bloating After Eating	6	9	0.271
7. Heart Burn	4	10	0.068
8. Poor Appetite	4	4	
9. Diarrhea	9	13	0.215
Total	31	53	0.041
48 Nonamalgams Subjects 47 Amalgam Subjects	0.65 Symptoms per Subject	1.13 Symptoms per Subject	71% More Symptoms in Amalgam Group
O: Blood Disorders [49,50]			
Blood Symptoms	Nonamalgam	Amalgam	Significance (P)
1. Mononucleosis	5	3	0.368
2. Anemia	3	6	0.231
Total	8	9	0.391
48 Nonamalgam Subjects 47 Amalgam Subjects	0.17 Symptom per Subject	0.19 Symptoms per Subject	12% More Symptom in Amalgam Group
P: Endocrine System [47,50]			
Endocrine Symptoms	Nonamalgam	Amalgam	Significance (P)
1. Thyroid	0	1	0.495
2. Pancreas	0	0	
3. Hypothyroidism	1	0	0.495
4. Ovaries	1	1	
5. Testes	1	1	
6. Menstruation - Painful, Too Often, Too Seldom, Etc.	10	16	0.09

7. Hysterectomy	0	0	
8. Tipped Uterus	2	4	0.327
9. Cervical Erosion	0	2	
10. Prostate Problems	0	0	
11. Overweight	7	10	0.279
12. Underweight	1	1	
Total	23	36	0.019
48 Nonamalgam Subjects 47 Amalgam Subjects	0.48 Symptoms per Subject	0.77 Symptoms per Subject	57% More Symptoms in Amalgam Group
Q: Emotional and Mental [3,50]			
Emotional/Mental Symptoms	Nonamalgam	Amalgam	Significance (P)
1. Sudden Anger	1	10	0.0046
2. Depression	7	18	0.008
3. Wish You Were Dead	2	4	0.327
4. Irritability	9	19	0.018
5. Suicidal Tendencies	1	4	0.173
6. Divorced	0	1	0.495
7. Frequent Anxiety	9	13	0.225
Total	29	69	0.007
48 Nonamalgam subjects 47 Amalgam Subjects	0.60 Symptoms per Subject	1.47 Symptoms per Subject	138% More Symptoms in Amalgam Group
R: Annoying Symptoms [3,50]			
Annoying Symptoms	Nonamalgam	Amalgam	Significance (P)
1. Frequent Headaches	5	7	0.364
2. Migraine Headaches	3	3	
3. Trouble Making Decisions	6	10	0.195
4. Dizziness	3	4	0.488
5. Motion Sickness	9	7	0.409
6. Noises in Ears	7	8	0.482
7. Hearing Problems	7	2	0.085
8. Tire Easily	2	11	0.007
9. Tired in Morning	10	25	0.001
11. Insomnia	5	5	0.487
12. Cold Hands/Feet	14	11	0.343
13. Low Body Temperature	6	10	0.192
14. Frequently Feel Cold	8	7	0.495
15. Frequent Night Urination	8	11	0.286
16. Frequent Day Urination	9	10	0.479
17. Chronic Eye Inflammation	0	2	0.233
18. Excessive Sweat	2	2	
19. Swollen Lymph Nodes	2	4	0.237
20. Leg Cramps	4	4	
21. Slow Healing	2	3	0.49
Total	112	149	0.068
48. Nonamalgam Subjects	2.33 Symptoms per Subject		
47. Amalgam Subjects		3.17 Symptoms per Subject	33% More Symptoms in Amalgam Group
S: Allergies [47,50]			
Allergies	Nonamalgam	Amalgam	Significance (P)
1. Metals	0	2	0.233

2. Food	3	2	0.49
3. Fabrics	1	1	
4. Soaps/detergents	2	4	0.327
5. Hay Fever	9	19	0.072
6. Other Allergies	14	14	
Total	29	39	0.115
48 Nonamalgam Subjects 47 Amalgam Subjects	0.60 Symptoms per Subject	0.83 Symptoms per Subject	34% More Symptoms in Amalgam Group
T: Diseases [47,50]			
Diseases	Nonamalgam	Amalgam	Significance (P)
1. Arthritis: Rheumatoid, Osteoid	0	2	0.233
2. Bursitis	1	2	0.492
3. Tennis Elbow	1	0	0.495
4. Painful Joints	2	6	0.127
5. Asthma	2	4	0.327
6. Surgery	13	16	0.304
7. Frequent Colds	2	6	0.127
8. Osteomyelitis	0	0	
9. Psoriasis	1	1	
10. Sickle Cell Anemia	0	0	
11. Chronic Anemia	0	0	
12. Kidney Stones	0	0	
Total	22	37	0.021
48 Nonamalgam Subjects	0.46 Symptoms per Subject		
47 Amalgam Subjects		0.79 Symptoms per Subject	68% More Symptoms in Amalgam Group
U: The Eye [31,50]			
The Eye	Nonamalgam	Amalgam	Significance (P)
1. Wears Glasses for Distance	34	26	0.083
2. Trouble with Night Vision	3	13	0.006
3. Trouble with Night Driving	8	13	0.148
4. Trouble Adjusting to Dark	4	6	0.355
5. Eyes Frequently Bloodshot	7	9	0.375
6. Sensitive to Light	12	14	0.385
7. Eye Strain	3	5	0.344
8. Eyes Tire when Reading	9	8	0.495
9. Total	80	94	0.17
48 Nonamalgam Subjects 47 Amalgam Subjects	1.67 Symptoms per Subject	2.00 Symptoms per Subject	18% More symptoms in Amalgam Group
V: Dental History [48,50]			
Dental	Nonamalgam	Amalgam	Significance (P)
1. Metallic Taste	0	8	0.0045
2. Burning Sensation in Mouth	0	1	0.495
3. Increased Flow of Saliva	1	1	
4. Peridontal Disease.	0	2	0.233
5. Gum Disease	1	1	
Total	2	13	0.007

48 Nonamalgam Subjects 47 Amalgam Subjects	0.04 Symptoms per Subject	0.28 Symptoms per Subject	555% More Symptoms in Amalgam Group
W: Health Questionnaire Summary Totals [50]			
Grand Total Symptoms	Nonamalgam	Amalgam	Significance (P)
Questionnaire I	124	205	0.0001
Questionnaire II	429	607	0.005
Total	553	812	0.0001
Symptoms/ Subject Questionnaire I	2.84 Symptoms per Subject	4.21 Symptoms per Subject	
Symptoms/Subject Questionnaire II	8.94 Symptoms per Subject	12.91 Symptoms per Subject	
Total	11.78 Symptoms per Subject	17.12 Symptoms per Subject	0.0001
			45% More Symptoms in Amalgam Group
Symptoms Greater in Amalgam Group	78		62.2%
Symptoms Greater in Nonamalgam Group	19		15.2%
Symptoms Equal in Amalgam and Nonamalgam Groups	17		13.6%
No Symptoms in Each Group	11		8.8%
Total	125 Symptoms		

Physiology

This aspect of the study compared 50 subjects with amalgams (30 females, 20 males, average age 22.3 years) to 51 subjects with no amalgams (30 females, 21 males, average age 22.4 years). The males averaged 10.1 amalgams and females 9.8 amalgams. Blood pressure was tested as were blood samples.

Cardiovascular: Studies have shown that mercury has an affinity for the heart and can cause a multitude of electrocardiogram changes. Studies also show that mercury increases blood pressure.

Table 2:

A: Significant Difference of Cardiovascular and Blood Parameters [27,50].

Cardiovascular	Nonamalgam	Amalgam	Significance (P)
Systolic Blood Pressure (50 Amalgams, 51 Nonamalgam Subjects))	100.71 mm/Hg	106.41 mm/Hg	0.0005
Diastolic Blood Pressure (50 Amalgams, 51 Nonamalgams)	58.67 mm/Hg	63.04 mm/Hg	0.0015
Heart Rate	72.71	69.90	0.074
Hemoglobin (gdl-1)	14.88	14.66	0.016
Hematocrit (% Packed Cell Volume)	43.91	43.15	0.013
Mean Corpuscular Hemoglobin Conc.	33.98	34.17	0.027
Total Protein (gdl-1)	7.63	7.54	0.098

T Lymphocytes % 40 Females	55.55	53.00	0.045
B: Significant Correlations of Mercury with Cardiovascular and Blood Parameters [50]			
Blood Parameters	Significant Correlation with Urine Mercury in Amalgam Group (44 Subjects)	Significance (P)	
1. Systolic Blood Pressure	- 0.301	0.0233	
2. Diastolic Blood Pressure	- 0.304	0.0234	
3. Heart Rate	+ 0.299	0.024	
4. Hemoglobin	- 0.421	0.003	
5. Hematocrit	- 0.393	0.005	
6. Red Blood Cell.	- 0.468	0.001	
7. Mean Corpuscular Hemoglobin Volume	- 0.225	0.017 n = 44	
8. Eosinophils	- 0.219	0.100 n = 36	
The amalgam subjects reported significantly more heart/chest pains ($p = 0.02$), Tachycardia ($p = 0.127$), tired in morning ($p = 0.001$), and tiring easily ($p = 0.007$).			

Immunity: The health questionnaire suggested that subjects with amalgams may have a weaker immune system. They reported more colds, hay fever, and respiratory symptoms. Further evidence that the immune system is affected is demonstrated by the stimulation of antibodies, which directly correlates to the number of fillings and urine mercury.

Table 3: Immunoglobulin Correlations [50].		
Immunoglobulin	Correlation to Amalgams	Significance (P) n = 14
IgG	+ 0.614	0.010
IgA	+ 0.713	0.002
IgE	+ 0.503	0.033
	Correlation to Urine Hg	
IgG	+ 0.46	0.049
IgA	+ 0.59	0.014
IgE	+0.70	0.003
The amalgam group had a significantly lower percentage of T lymphocytes (T lymphocyte percentage, 40 females, Nonamalgam - 55.55, Amalgam - 53.00, $p = 0.045$). Evidence has found that newly placed amalgams can lower T lymphocyte levels. T lymphocytes are an important defense against cancer and viruses.		

IgG, IgA, and IgE were all significantly correlated to fillings and urine mercury and amalgams. IgG and IgM provide a defense against bacteria, while IgA is found in mucous secretions fighting both bacteria and viruses.

The amalgam group had a significantly lower percentage of T lymphocytes (T lymphocyte percentage, 40 females, Nonamalgam - 55.55, Amalgam - 53.00, $p = 0.045$). Evidence has found that newly placed amalgams can lower T lymphocyte levels. T lymphocytes are an important defense against cancer and viruses.

The eye: The mean refraction of the nonamalgam group

was -2.42 diopters of myopia compared to -1.52 diopters in the amalgam group. This 59% difference was significant at the 0.028 level. Visual acuities averaged 20/205 in the nonamalgam group and 20/122 in the amalgam group ($p = 0.017$). The eye is considered to be part of the brain.

The amalgam subjects had a white visual field of 40.1 degrees compared to 49.1 degrees in the nonamalgam group. The constricted white visual field was significant at the $p = 0.013$ level. Mercury has an affinity for the rods. Amalgam subjects had significantly more difficulty with night vision which is associated with the rods.

Table 4:		
A: Visual Field Correlation of Amalgams and Nonamalgam Subjects Combined to Urine Mercury [31,50]		
Visual Field - Combined Amalgam & Nonamalgam Subjects n = 83	Correlation	Significance (P)
White Field	- 0.232	$p = 0.007$
Green Field	- 0.173	$p = 0.059$
Red Field	- 0.210	$p = 0.029$
B: Visual Field Correlation of Amalgam Subjects to Urine Mercury [50]		
Visual Field - Amalgam Group	Correlation	Significance (P)
White Field	- 0.270	$p = 0.038$
Red Field	- 0.468	$p = 0.001$

Discussion

The relationships between dental amalgam, mercury poisoning, and health problems are provocative and may have significant implications for effective health treatment. Although the number of subjects is small (50 subjects with amalgams, and 51 subjects without), the results are statistically significant and warrant additional research.

Mercury in hair and urine

The data shows that mercury levels are significantly higher in urine and hair in the amalgam group. These findings support those of Abraham, et al. [18], who found higher blood mercury levels in subjects with amalgams. Svare and Peterson [19] measured a decrease in blood mercury levels after amalgam removal. Nilsson and Nilsson [20] also found that urine levels of mercury were correlated to the number of dental amalgams.

Mental health

Mercury has an affinity for the brain, and psychological disorders are characteristic of mercury poisoning. Such symptoms include irritability, anger, tension, anxiety, and depression [21]. All these symptoms were exhibited significantly more in the amalgam group. In severe cases, hallucinations, suicidal tendencies, melancholia, and manic-depressive symptoms can occur in mercury toxicity. Psychosis may also occur. During the 19th century and early 20th century, felt hat makers were regularly exposed to mercuric nitrate. They became known as "mad hatters" because of the emotional problems they developed [22].

In this study, emotional and mental symptoms were exhibited significantly more by the amalgam group, suggesting amalgam mercury may be the cause.

A mental health study [3] found subjects with amalgams had significantly more mental health symptoms compared to those without amalgams. They were age and sex matched. They had significantly more anger ($p = 0.0046$), more depression ($p = 0.008$), and more irritability ($p = 0.018$). Standardized mental health questionnaires also found significant differences in depression and anger.

A non-controlled study of 86 subjects [5] who had their amalgams removed reported 409 psychological symptoms before amalgam removal. Within 10 months after amalgam removal, 69% of their mental health symptoms improved, 15% were eliminated, 15% did not change, and 3% got worse.

Research on bipolar disorders (manic depression) compared 11 subjects with amalgams to a control group of 9 subjects with amalgams who were told a sealant was going to keep the mercury from escaping to serve as the placebo. There is no such sealant. Amalgams were removed in the first group. Standardized mental questionnaires found the mental symptoms of depression, anxiety, hostility, psychotism, obsessive compulsive, and paranoia significantly improved after amalgam removal when compared to the control. The study suggested that bipolar disorders may be related to amalgam mercury [23].

A second study involved 8 schizophrenic patients. They were given a standardized psychological test, the Minnesota Multiphasic Personality Inventory -2, which consisted of 61 scales. There was significant improvement after amalgam removal in 41 of the 61 scales at the $p = 0.05$ level including schizophrenia, hysteria, paranoia, anger and low self-esteem, suggesting amalgam mercury may also be involved in schizophrenia [24]. Studies have shown most symptoms of schizophrenia can be explained by mercury [24]. Amalgam mercury does affect mental health.

Dental

Without taking amalgam restorations into consideration, it is interesting to note that many oral symptoms appear with chronic exposure to mercury. Some of the associated oral symptoms include metallic taste, bleeding gums, and increased salivation [25]. The amalgam subjects experienced more symptoms of metallic taste, bleeding gums, foul breath, and grinding teeth compared to subjects without amalgams.

Cardiovascular

Tachycardia is a common symptom of mercury poisoning, as evidenced by the many people who developed tachycardia in the Iraq poisoning by a mercury fungicide [26]. All three subjects in this study who reported tachycardia had

amalgams. Chest or heart pains are also common in mercury poisoning, and significantly more amalgam subjects reported this symptom.

Although it was not at a significant level, twice as many amalgam subjects reported having anemia. The amalgam subjects also reported significantly more symptoms of tiring easily and being tired in the morning, which are symptoms of anemia. Amalgam subjects were found to have significantly fewer red blood cells than nonamalgam subjects.

This study also found that subjects with amalgams had significantly lower levels of hematocrit and hemoglobin compared to the nonamalgam control. Hematocrit and hemoglobin carry the oxygen to the cells. The study also found that mercury chloride increased the oxidation rate of oxyhemoglobin, and we hypothesized that the free oxyradicals produced by mercury are destroying the hemoglobin molecule [27]. There was also a significant negative correlation ($p = 0.001$) with urine mercury and red blood cells. The more mercury in the urine, the lower count of red blood cells.

A health questionnaire was given to 86 subjects who had their amalgams removed. and 83% of their cardiovascular symptoms were either improved or eliminated [5].

Approximately 90% of all people with hypertension have "essential hypertension," meaning hypertension of unknown origin. The amalgam group had significantly higher systolic and diastolic blood pressure compared to the nonamalgam group. It is known that mercury increases blood pressure. Could amalgam mercury be causing hypertension? Interestingly, there was a significant negative correlation between urine mercury and blood pressure. Could it be that the body is not excreting mercury but retaining it, resulting in higher blood pressure as some mercury-free dentists believe? Subjects with amalgams had a significantly lower heart rate, and mercury is known to cause both a slower and faster heart rate.

Immunity

The amalgam subjects reported significantly more colds and respiratory infections. They also reported significantly more instances of hay fever, suggesting that the immune system is affected. Research by Koller, et al. [28] demonstrated that mercury can suppress the immune system. Eggleston [29] found a relationship between amalgam mercury and T lymphocytes. This study also found a significant negative correlation between urine mercury and T lymphocytes. Two people with amalgams reported having rheumatoid arthritis, an auto immune disease, compared to none in the nonamalgam group. Six amalgam subjects reported painful joints, compared to two without amalgams. Mercury is known to cause painful joints.

T lymphocytes were significantly lower in the amalgam group, and T lymphocytes protect against viruses. The antibodies IgG (Immunoglobulin G), IgA, and IgE all

correlated with the number of amalgams and urine mercury suggesting that mercury is stimulating the production of antibodies.

The eye

The evidence suggests that amalgam mercury slows down the progression of myopia. An early study [30] at Colorado State University researched the relationship between nutrition and myopia involving 25 myopic children between the ages of 10 and 17. They were compared to a control group of 25 nonmyopes who were age and sex matched. The nonmyopes had hair mercury levels of 0.14 ppm compared to 0.10 ppm in the myopic group ($p = 0.005$).

A later study [31] compared 124 subjects with amalgams who were compared to 123 subjects without myopia. The nonamalgam group had 34% more subjects wearing glasses for distance ($p = 0.007$).

Mercury vapor has an affinity for both the retina and occipital lobe. Fox and Stillman [32] found that mercury decreased the amplitude response of the rod in a bullfrog, which was irreversible. If mercury interacts with the rods, Khayat and Denckar [33] demonstrated that radioactive metallic mercury vapor in rats and marmoset monkeys accumulated in the receptor layer of the retina. The amalgam group in this study had significantly more problems with night vision. Rods are involved in night vision. They also had a significantly smaller visual field.

The nonamalgam group reported significantly more subjects wearing glasses for distance compared to the amalgam volunteers. This was verified by the refractive status of the nonamalgam, group compared to the amalgam group. Their myopia averaged 59% more than the amalgam group (nonamalgam -2.42 diopters, amalgam -1.52 diopters, $p = 0.0275$), suggesting mercury may slow down the progression of myopia. Visual acuities were significantly lower as well (nonamalgam - 20/205, amalgam - 20/158, $p = 0.0565$). One cause of myopia is disassociation of sclera collagen by fiber cross linking, resulting in an elongation of the eyeball. A study by Roman - Franco, et al. [34] found that after mercuric chloride was administered to rabbits, there was an increased amount of collagen fibrils in the interstium around the tubular basement membrane of the kidney. Perhaps mercury causes an increase of collagen fiber formation in the sclera. Studies have that shown mercury can increase collagen fibrils. This is a plausible explanation for its retardation of myopia.

Animal studies have shown mercury has an affinity for the eye, especially the retina and choroid. The eye is considered to be part of the brain. During the 1950s, Dr. C. Desusclade, a French physician, was using mercury and vitamin E to retard the progression of myopia [35].

Lifestyle and mercury

The life-style questionnaire found the life style of the amalgam group to be poorer than the nonamalgam group.

Although not at a significant level, they craved and ate more sweets, smoked more cigarettes, drank more coffee, and consumed more alcohol. Could this life style contribute to the poorer health of the amalgam subjects or is it the result of mercury toxicity from dental amalgam? Maybe both. We hypothesize that if people are nervous, depressed, angry, and tired, as amalgam-bearing subjects are, they might drink more coffee as a stimulant to fight fatigue, smoke more cigarettes if nervous, and drink more alcohol because they are depressed. Mercury toxicity can lead to emotional problems, which can lead to substance abuse, which can lead to health disorders.

The amalgam subjects took more supplemental vitamins and minerals, and more of them were vegetarians compared to the nonamalgam group but not at a significant level. As people develop health problems, many will turn to alternative health care, such as better nutrition, to try and improve their health.

Other disorders

Multiple Sclerosis (MS): Studies [36] give evidence that amalgam mercury may be an etiological factor in Multiple Sclerosis (MS). Mercury has been shown it can cause demyelination of nerve fibers, which is the pathogenesis of MS. Epidemiological studies have shown the death rates from MS is linearly related to the number of decayed, missing, and filled teeth [37]. In the state of Colorado, many MS patients had their amalgams removed after hearing about the possible relationship to mercury from dental amalgam.

The research [36] compared 50 MS subjects with amalgams removed to 47 MS subjects with amalgams. The MS subjects without amalgams had significantly higher levels of red blood cells, hematocrit, and hemoglobin. Their total T lymphocyte count was higher. 38% of the MS subjects felt their MS had improved, and a few thought it was even eliminated. During the past 12 months, the MS amalgam removal group had 33% fewer exacerbations of neuromuscular symptoms.

Another study [38] of 7 female MS subjects who had their amalgams removed found their nerve conduction velocity significantly increased after amalgam removal when compared to before removal. Reduced nerve velocity is a hallmark symptom of MS. Their hearing improved by an average of 8db ($p = 0.02$) following amalgam removal [39].

Mental health problems often accompany MS. Subjects who had their amalgams removed reported significantly fewer mental health symptoms compared to MS subjects with amalgams. A standardized mental health questionnaire found significantly fewer symptoms of depression, anxiety, obsessive compulsive, hostility, psychotism, sadness, suicidal ideas, and self-dislike in the amalgam removal group when compared to the MS subjects with amalgams [40].

Other neurological disorders have improved after

amalgam removal. Amalgams were removed from an amyotrophic lateral sclerosis patient (Lou Gehrig's Disease) and the patient recovered [41].

Alzheimer's Disease (AD): A recent study by the authors [42] suggested mercury may be an etiological factor in Alzheimer's disease. The study examined 70 physiological and pathological changes occurring in Alzheimer's disease and cross referenced them with mercury on the internet through PubMed. All 70 changes could be explained by mercury toxicity, strongly suggesting mercury may be the cause of Alzheimer's disease ($p = 0.0001$).

Mutter, et al. [42] had a paper published entitled Alzheimer's disease: Mercury as a Pathogenic Factor and Apolipoproteins as a Moderator, giving evidence that mercury is an etiological factor and that certain apolipoproteins can help detoxify mercury [43], explaining one of the roles of apolipoproteins. In another paper, Mutter [44] provided additional evidence of mercury's role in Alzheimer's disease.

The rate of Alzheimer's disease has been declining. In Sweden and Denmark the use of amalgams has been banned. Many dentists in the United States have stopped using them or have curtailed their use, perhaps explaining the decline of the AD rate [45].

All these studies suggest that mercury is entering the brain at a relative young age and may be causing a multitude of health disorders such as mental illness, multiple sclerosis, and Alzheimer's disease. Symptoms of Alzheimer's disease begin 20 to 50 years after changes begin developing in the brain. Perhaps there should be a world wide ban on dental amalgam, because the greatest source of mercury originates from dental amalgams according to the World Health Organization.

CONCLUSION

Evidence has been presented that individuals with amalgams are less healthy than subjects without amalgams. They reported 45% more health disorders ($p = 0.0001$) in a health questionnaire of 125 questions. Many of the symptoms inquired about were typical of mercury poisoning. With the prevalence of dental amalgam worldwide, this could easily be one of the greatest health problems in the world today.

If mercury from dental amalgam was affecting health, removal of the amalgam should improve health. The hypothesis was confirmed in a non-controlled study of 86 subjects who had their amalgams removed [5]. Seventy percent of 1815 health disorders were either improved or eliminated within 10 months following amalgam removal. Other clinical evidence in the literature supports the fact that health improves after amalgam removal [1,2].

Health care practitioners should consider mercury toxicity from dental amalgam as a possible cause in the treatment of chronic respiratory symptoms, emotional/

mental disorders, digestive problems, immune disorders, cardiovascular anomalies, menstrual disorders, dental disease, and a host of other health disorders such as multiple sclerosis [46].

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