ALERT:
MERCURY RELEASES TO THE ENVIRONMENT CAUSED BY DENTAL AMALGAM FILLINGS

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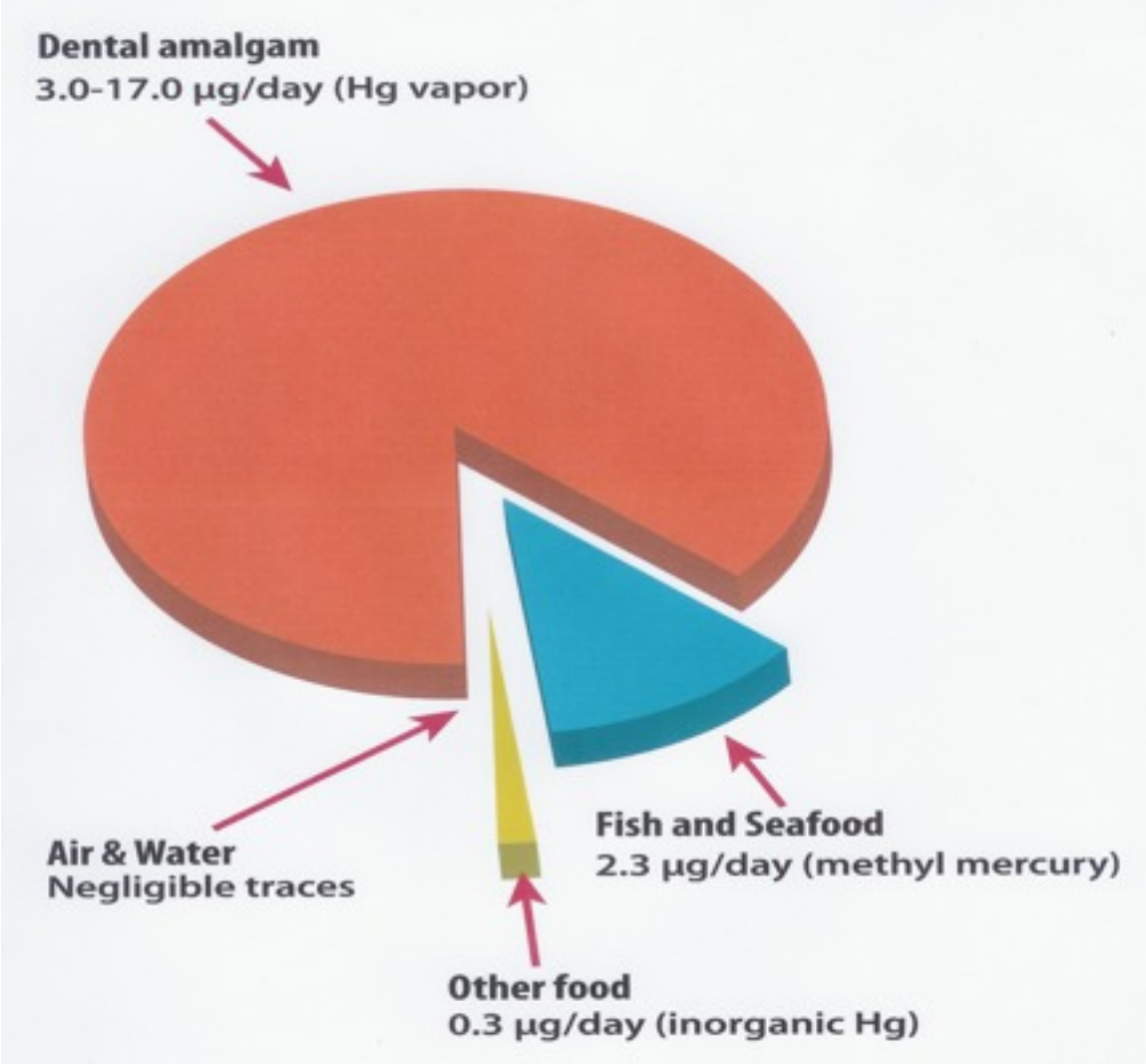
Introduction to Dental Amalgam and the Impact of Mercury on the Environment

Dental amalgam has been the primary "back tooth" dental filling material in North America and in developed countries around the globe for the past 140 years. The material, often called "silver," actually consists roughly of 50% mercury and 50% base metals. The base metals are usually comprised of silver, tin, zinc, and other trace metals. At one time, copper was used as a base metal in amalgam fillings; however, copper was shown to increase the vaporization of mercury and has thus been largely discontinued.[1]

The process that binds mercury to base metals is known as amalgamation. It is understood that the amalgamation process does not fully prevent the release of mercury vapor from the surface of dental fillings, and that the mercury vapor emitted from amalgam fillings is known to be the single largest source of mercury exposure to humans:[2]

Human Exposure to Mercury by Source (WHO, 1991)



The amount of mercury vapor released from amalgam filling material is dependent on a variety of factors. Surroundings such as temperature, pH, and physical stimulation affect the rate of mercury vaporization. Also, the force at which the mercury is compacted into the tooth, referred to as "condensation force," can impact the amount of mercury vapor produced, as can the age of the restorations and the specific metal composition of the filling.

Furthermore, when mercury vaporizes off of the surface of an amalgam filling, it increases the porosity of the tooth, thereby increasing the surface area, which in turn increases the mercury vaporization rate.

Considering that mercury vaporization from fillings basically causes the disassociation of mercury from the amalgamated metals, dental amalgam is a significant primary source of inorganic mercury releases to soil, air, and water. Any vaporized mercury eventually becomes part of the global water and air cycle and the food web, which means that all living organisms share the toxic burden. Additionally, depending on the size of the amalgam particulate released to the environment, the material can continue slowly giving off more toxic mercury for decades.

Both within the environment and living beings, methylation of inorganic mercury is possible, and methylation by microorganisms creates a highly toxic form of the metal.[3] For example, bacteria in soil and water convert mercury into methyl mercury, a form of the element sometimes consumed by fish and shellfish,[4] and numerous governments and global environmental groups have been quick to caution pregnant women and children about consuming fish and shellfish that might contain methyl mercury.[5] [6] [7] [8]

Consequently, governmental groups and other authorities have been active in attempting to raise public awareness about emissions of mercury into the environment from industries, products, and practices that involve mercury such as coal-fired power,[9] [10] [11] thermometers,[12] [13] [14] [15] compact fluorescent light bulbs,[16] [17] [18] [19] gold mining,[20] batteries,[21] [22] electrical switches,[23] cosmetics,[24] chloralkali,[25] crematoriums,[26] [27] and waste from dental offices.[28] [29] [30] [31]

Despite the risks that amalgam fillings pose to the environment, a 2006 Zogby poll found that 76% of Americans did not realize that mercury is the main ingredient in amalgam.[32] The same poll reported that 47% of the respondents felt mercury was a serious environmental threat.[33] These statistics suggest that the general public is unaware of the significant threat dental amalgam poses to our environment.

Yet, consumers are learning about the issue, and the United Nations Environmental Programme (UNEP) is negotiating a 2013 legally-binding treaty to reduce the use of mercury worldwide. In the United States, new standards to lower mercury emissions from coal-fired power plants were passed on December 21, 2011, and UNEP, the United States Environmental Protection Agency (EPA), and other authorities are currently considering adapting mercury regulations for dental practices as well.

Brief History of Amalgam Use in Dentistry

Controversy has surrounded the use of mercury in dentistry since the 1800's, when the neurotoxin was first introduced as a filling material. The American Society of Dental Surgeons, the predecessor to the American Dental Association, made its members pledge not to use mercury because of its known toxicity, and in more recent years, government officials, scientists, dentists, consumers, and many others have raised serious concerns about the threats dental amalgam poses to humans and the environment at large.[34]

Today, authorities including the United States Food and Drug Administration (FDA) and the European Commission (EC) are actively assessing health risks associated with dental amalgam.[35] [36] [37] The governments of Norway, Sweden, and Denmark have banned the use of mercury fillings or limited their use to a very specific circumstances in dentistry,[38] Germany has limited their use for pregnant women,[39] and France, Finland and Austria have recommended that alternative dental materials be used for pregnant women. [40]

In Canada, the last risk assessment on the use of dental amalgam was carried out in 1994-1995 and published in 1996. The following recommendations on the use of amalgam fillings were made at that time:[41]

> Health Canada advises dentists to take the following measures:
>
> *Non-mercury filling materials should be considered for restoring the primary teeth of children where the mechanical properties of the material are suitable.
> *Whenever possible, amalgam fillings should not be placed in or removed from the teeth of pregnant women.
> *Amalgam should not be placed in patients with impaired kidney function.
> *In placing and removing amalgam fillings, dentists should use techniques and equipment to minimize the exposure of the patient and the dentist to mercury vapor, and to prevent amalgam waste from being flushed into municipal sewage systems.
> *Dentists should advise individuals who may have allergic hypersensitivity to mercury to avoid the use of amalgam. In patients who have developed hypersensitivity to amalgam, existing amalgam restorations should be replaced with another material where this is recommended by a physician.
> *New amalgam fillings should not be placed in contact with existing metal devices in the mouth such as braces.
> *Dentists should provide their patients with sufficient information to make an informed choice regarding the material used to fill their teeth, including information on the risks and benefits of the material and suitable alternatives.
> *Dentists should acknowledge the patient's right to decline treatment with any dental material.

Despite the good intentions of Health Canada, the application of these recommendations to achieve the safe delivery of dentistry for Canadians and their environment is largely incomplete. For example, a 2007 survey of dental practices demonstrated that only 70% of the practices had installed amalgam separators,[42] and more than 985,000 amalgam fillings were placed into Canadian children's baby teeth since 1996.[43]

Such evidence indicates inadequate integration of Health Canada's 1996 recommendations, and this has disastrously led to a significant mercury exposure to the environment and to high-risk populations such as children.

It should be noted that the common practice of using of mercury-based dental restorations around the world[44] is [mistakenly] justified in a variety of ways:

1) The global increase in tooth decay related to sugar consumption in developing countries[45] means more fillings are needed. [Governments who have banned mercury fillings prove there are viable alternatives to amalgam.[46]]

2) Ease of handling and strong physical properties make amalgam an obvious choice. [Governments who have banned mercury fillings prove there are viable alternatives to amalgam.[47]]

3) Mercury is used in other industries such as small-scale gold mining. [The 2013 UNEP mercury treaty is considering limiting the use of mercury in gold mining and other industries.[48]]

4) Mercury is the most inexpensive filling material. [A recent European Environmental Bureau report showed that the cost of handling mercury-related environmental and human hazards is not usually calculated into the economy of placing dental amalgam.[49] Considering the management of dental amalgam waste and contaminated sundries, as well as the increasing protective measures required to minimize occupational exposure and the cost of health care for any unintentional exposures, amalgam may actually be the most expensive dental restoration.]

5) The American and Canadian Dental Associations and World Dental Federation (FDI) endorse amalgam. [Recently the Federation Dentaire Internationale (FDI), the International Association for Dental Research (IADR), and the International Federation of Dental Educators and Associations (IFDEA) issued a joint statement agreeing that amalgam separators should be used in dental offices to prevent harm caused by mercury fillings to the environment. The groups also agreed that people should take better care of their teeth so they don't need mercury fillings and that new alternative dental materials need to be developed and commercialized.[50]]

6) Mercury amalgam is said to be the easiest filling to place. [A 2008 report established that 52 % of North American dentists have rejected the use of amalgam.[51]]

Since the use of dental mercury in developed countries is decreasing, one would surmise that the Canadian usage of mercury for dental restorations would be decreasing as well. A 2009 WHO report entitled "Future Use of Dental Restorations" states that "Canadian use of amalgam use is decreasing,"[52] and yet, an examination of the following table suggests otherwise:

Importation of Mercury into Canada for Dental Use in Kgs:[53] [54]

1999	2003	2007	2008
3000	5352	4665	4700

During the same time frame represented in the table above, the ratio of dentists using mercury has decreased, and more and more patients are requesting non-mercury restorative material.[55] Overall, there have not been substantial increases in decay rates during this time period; however, there are subsets of the population who have suffered increases in decay, such as low income populations and aboriginal people.[56] It is difficult to ascertain whether the need for fillings among financially struggling and minority populations explains the increase in mercury importation into Canada for dental use.

The Artisanal Gold Council database[57] estimates that up to 2000 kg of mercury is released into the atmosphere in Canada each year from artisanal gold mining, and other reports suggest that mercury for gold mining can be acquired from mercury imported for dentistry.[58] Thus, the increased importation of dental mercury in Canada could also be due to a diversion of mercury supposedly being imported for dentistry but actually being used in small-scale gold mining. This factor could possibly explain why "dental mercury" use has not decreased in Canada like it has in the U.S.[59]

An Examination of Three Different Global Dental Profiles

It is universally appreciated that the dental needs of the world are constantly changing. Currently, there are three distinct populations on the planet, who, because of their unique dental situations, each have a profound effect on the global use of amalgam. That being said, understanding these three profiles is essential in assessing future needs for dental restoration, as well as quantifying the impact the use of dental mercury has on the world's environment.

1) Global Profile #1: Populations in Developed Countries

20% of the over 7 billion people on this planet are considered to live in developed countries,[60] and it has been reported that this group has the highest need for tooth restorations. [61]

Because residents of developed countries visit the dentist more often, many mercury fillings are already in the mouths of citizens who live in areas with adequate and available medical care. It should be recognized that these are the same people who could need additional medical care due to health issues caused by mercury.

Additionally, according to the United States Environmental Protection Agency (EPA), there is currently over 1,000 tons of mercury in the mouths of Americans, which is more than half of all the mercury being used in the U.S. today.[62] Thus, patients who have amalgam fillings carry a "societal load" of mercury in their mouths.

A significant trend is that the demand for mercury fillings in this developed countries group is decreasing slightly, and the amount of mercury being removed from this group is slightly higher than that which is being placed.[63]

2) Global Profile #2: Populations in Underdeveloped Countries

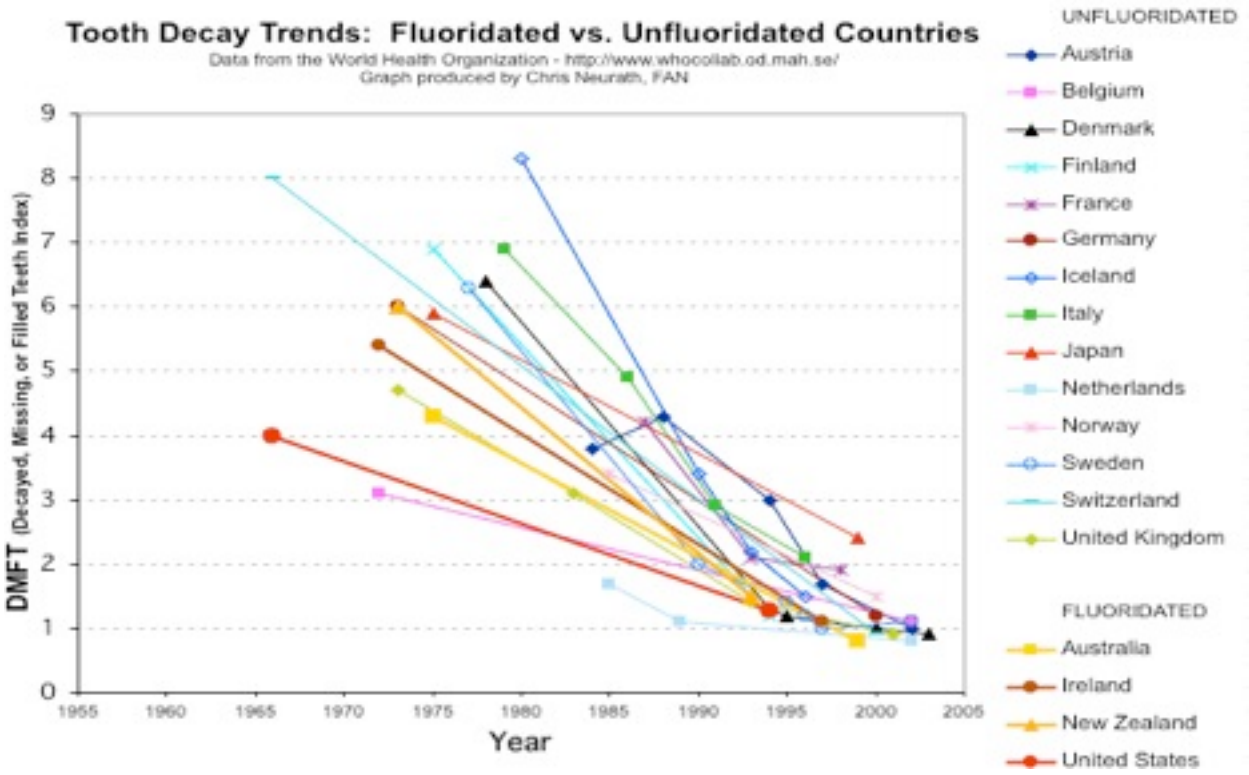
Another 20% of the over 7 billion people on this planet are considered to live in underdeveloped countries. There is difficulty in tracking the need for restorations and dental decay in the underdeveloped population of the world because of a lack of data. Yet, possibly due to a lesser access to fermentable sugars, the reportable decay rate for this group is very low. However, an accurate, statistically-demonstrated need for restorations in "underdeveloped" countries does not exist until the country moves into a "developing" status.[64]

3) Global Profile #3: Populations in Developing Countries

The population of the developing nations, which comprises the remaining 60% of the over 7 billion global population,[65] presently has a decayed, missing, and filled (DMF) tooth status in 12-year olds that is moving from a relatively low rate to a significantly higher level.[66]

As populations in developing countries gain more wealth, they also have greater access to sugar, and as this consumption increases, the probability is that this population's DMF will likely continue to rise.

Regardless of the cause, if the developing population required just one additional amalgam filling per person, the amount of mercury required to meet this demand would be over 2000 tons of mercury [.5 gm/filling x 60% (the developing population) x 7.2 billion (the world population)= 2,160,000,000 gm or 2160 tons.] This would be added to the current 350 tons that is presently used globally on an annual basis. There is therefore, a profound greater risk of increased planetary exposure to mercury by the use of dental amalgam in countries that are developing.



Furthermore, the pattern of decay in developed countries has followed a very distinct pattern over the last 40 years, which is very relevant for developing countries to take into account.

Previous reports show that as countries were developing, decay rates in the general population rose to a peak of 4-8 DMF (in the 1960's) and then showed a dramatic decrease (today's levels).

It has been hypothesized that increased access to preventative services and more awareness of the detrimental effects of sugar are responsible for the visible decrease of tooth decay in the chart above. However, it should be noted that this trend occurred with and without the systemic application of fluoridated water,[67] so it would appear that other factors caused this change.

In Denmark and Sweden, the decrease in DMF shown in the chart above was concurrent with a decrease in the use of mercury for dentistry. In these two countries, the peak use of amalgam occurred in the mid 1970's,[68] but continued to decline simultaneously with the growing practice of using alternatives to mercury.

This is significant because newly developing countries may experience a similar pattern in which decay, and therefore restoration requirements, increase substantially before leveling out to developed country levels. In fact, there is evidence of this happening in the world right now. Currently, Latin America has DMF scores over ten in 35-44 year olds.[69] If this trend continues, the use of amalgam would then cause a proportional increase in the risk of mercury exposure to our environment.

The potential increase in dental mercury use is especially concerning in developing countries because these countries usually do not have the resources, infrastructure, or capital to activate proper best practice management (BPM), or to adequately protect the environment, patient, and dental professionals from the mercury in dental amalgam.

Another significant implication in the pattern of developed nations using more dental mercury for fillings is that previously, this trend occurred when environmental issues of amalgam were not known or being considered. Today, we know better, but aside from the easily retrieved mercury waste collected for recycling, the majority of mercury used in dentistry is released to the environment (for more on this, see the Closing Statements at the end of this document).

Dispersive Model of Anthropogenic Release of Mercury from Dental Amalgam

Because the U.S. has some of the most available and up-to-date research on dental health, and because most developed countries have shown similar patterns in dental restoration use,[70] we can conservatively extrapolate the known U.S. data and apply it to other developed nations by multiplying the data by four. (This figure is based on developed populations accounting for 20% of the population and the fact that the U.S. population accounts for one-fifth to one-quarter of the developed countries' population).

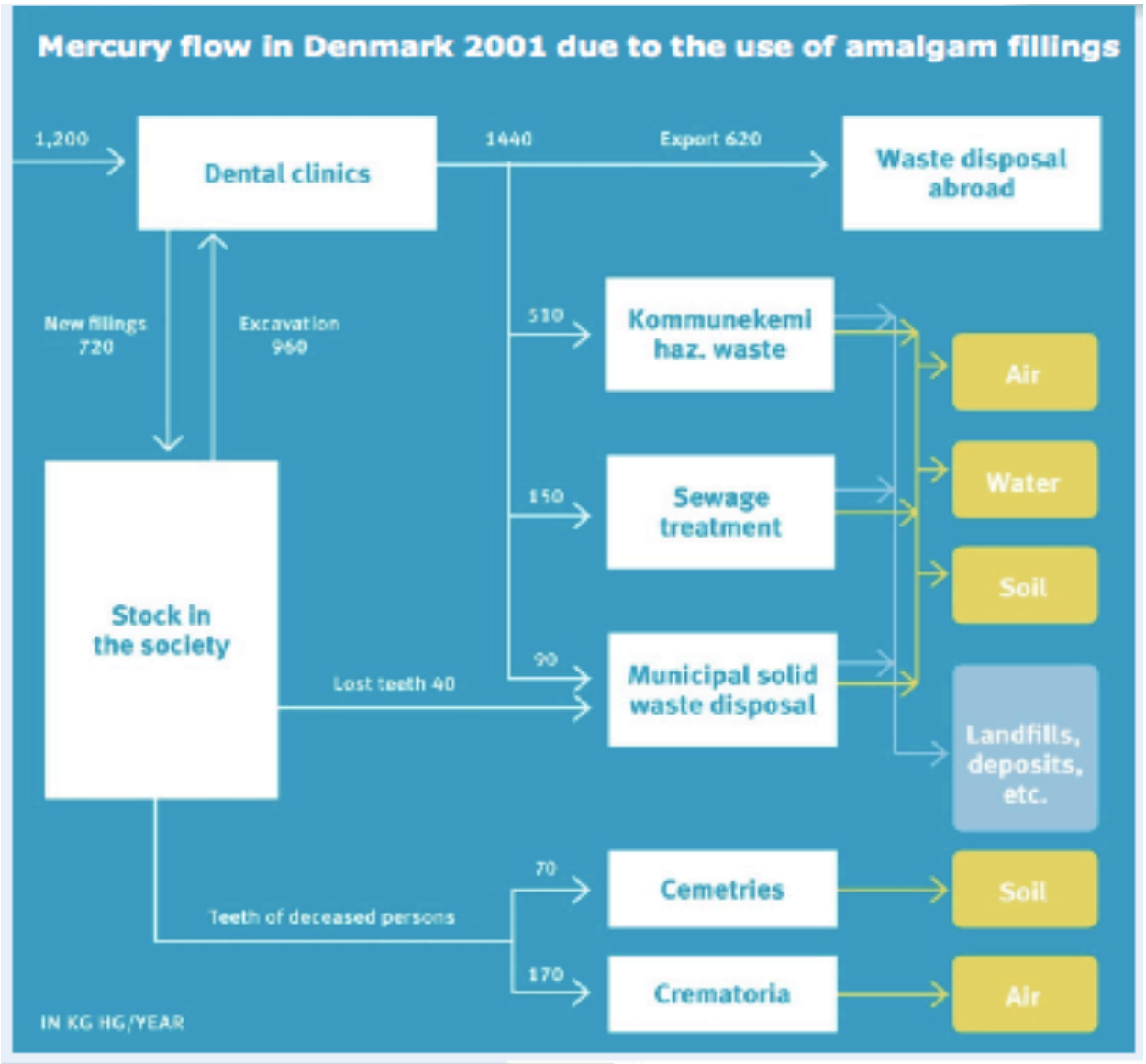
Evaluation of the accessible data shows that dental amalgam creates one of the most dispersive sources of mercury exposure to the environment. Dental use of mercury has globally increased from an estimated 270 tons to 350 tons per year over an eight-year period, making it one of the major anthropogenic sources of mercury into the environment.[71]

One way to assess the environmental impact of dental amalgam fillings is to employ a basic accounting principle for determining the fate of the mercury-containing tooth restorations. Applying estimates of global and domestic mercury usage, using a routine process of accounting, and analyzing available literature, allows one to determine the annual global impact of amalgam on the various subsets of the environment (air, water, soil, and living creatures).

This system helps to identify inadequacies in the use of dental mercury, which assists gauging BPM in need of improvement in developed countries. This is particularly valuable for countries that are underdeveloped or developing, where decay rates and dental restorations could just beginning to increase.[72]

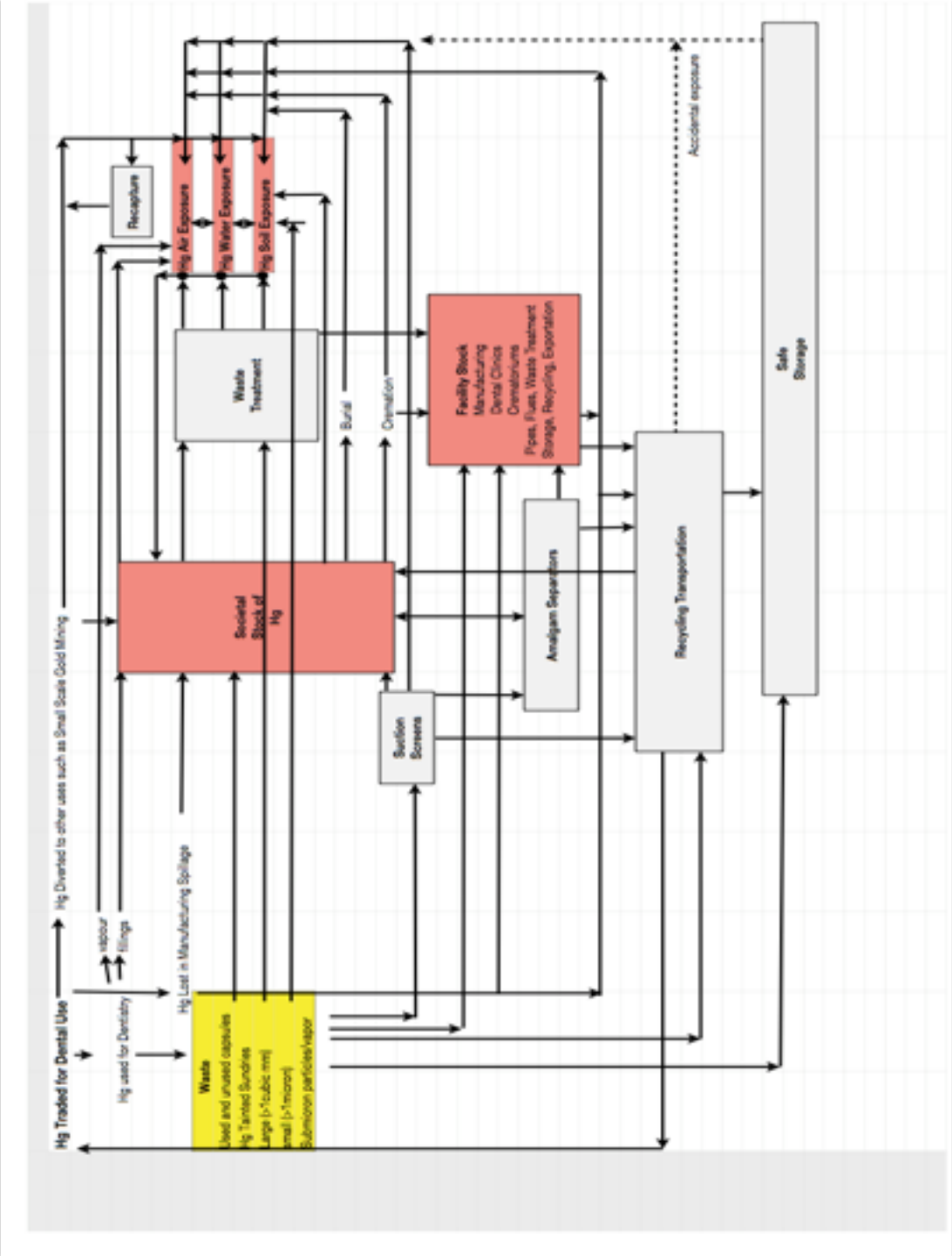
Thoughtful consideration must be made as to infrastructure and BMP, which are required to justify the continued use of amalgam in an environmentally-responsible and conscientious manner. Developing countries, if they choose to use dental amalgam, will require consultation and capital to build BMP, while avoiding the same mistakes environmental mercury exposure has caused to developed countries over the past 140 years.

As such, below is a flowchart developed by the Government of Denmark on the dispersion of mercury from dental amalgam.[73] This chart is especially enlightening when remembering the fact that mercury is vaporized from dental amalgam:



The chart above represents a “year’s snapshot” from 2001, and it would be reasonable to extrapolate these numbers to most developed countries using amalgam fillings, as this model was constructed before Denmark rejected the use of amalgam. However, the ratios of dispersion cannot necessarily be extrapolated to all countries since one must take into account the three distinct global population categories of populations outlined above.

In order to fully account for all of possible global dispersions of mercury from dental amalgam, the Danish model can be expanded, as in the chart below, which clarifies other integral areas of consideration:



The Issue of Dental Mercury that Does Not Reach Dental Facilities

Manufacturing Accidents and Small-scale Mining

The annual global use of mercury for dentistry is approximately 350 tons/year.[74] Considering there is some pre-installation spillage at the manufacturing level and some of this material is diverted for other uses such as small-scale mining, the actual amount used for dentistry is difficult to confirm.

Because there are no accurate tracking methods on a global scale for the ultimate use of mercury or for amalgam manufacturing spillage of mercury, this becomes the first inadequacy in the management of the material. This statistical issue further identifies the need for a global initiative to design a better BPM tracking model.

Although the percentage of spillage is quite likely much less than 1%, it is still significant, as it is a notable source of occupational mercury vapor exposure for those who work in the amalgam manufacturing sector.

It is also understood that virtually all of the dental mercury diverted for small-scale mining (SSGM) ends up in the atmosphere as a result of burning gold amalgam or in the rivers that are associated with the mining. During 2005, in Brazil most of the mercury used in SSGM was labeled for use in dentistry,[75] and the most recent estimates have global anthropogenic release of mercury into the air by SSGM at 1000 tons annually.[76]

Environmental Dispersion of Mercury after It Reaches Dental Facilities

Mercury from dental restorations enters the environment after it reaches the dental office in two ways: dental mercury is released to the environment from amalgam waste (i.e. amalgam that is not in patients' teeth), and/or dental mercury is released to the environment from amalgam that is placed patients' teeth.

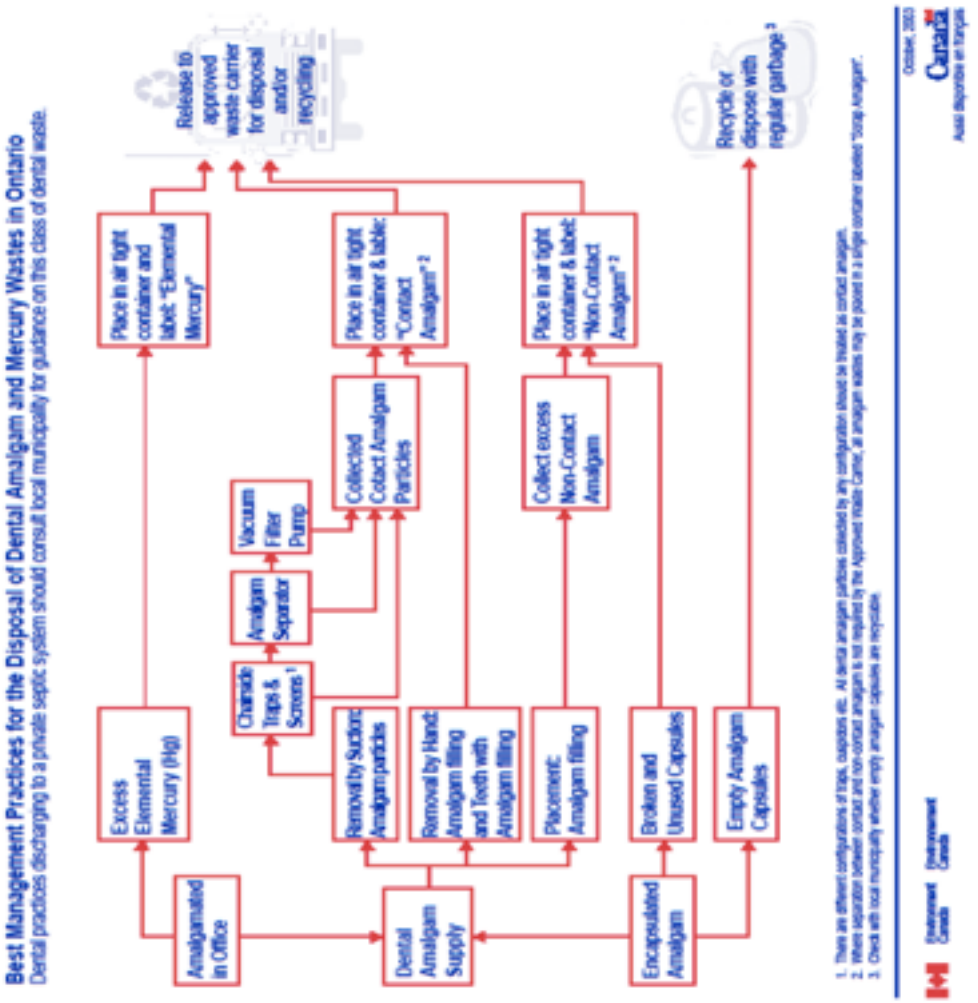
Placing mercury fillings, cleaning them, and/or removing them results in dangerous levels of exposure, as the table below shows:

Comparison of Mercury Limits Established by
the United States Occupational Safety and Health Administration (OSHA)
with Measurements Taken at a Dental Office Using a Jerome Mercury Vapor Analyzer:

OSHA maximum allowable level in the workplace during a single exposure	**100 micrograms**
Mixing with a triturator	400-600 micrograms
Opening autoclave with mercury-contaminated instruments	10-50 micrograms
Opening trap on the back of a dental chair filled with amalgam scrap	300-600 micrograms
Removing amalgam with water	100-200 micrograms
Removing amalgam with drill if water is accidentally turned off	1200-2500 micrograms

1) Dental mercury released into the environment from amalgam waste (i.e. amalgam that is not placed in patients' teeth).

Knowledge of the basic dental process of placing an amalgam filling is necessary to explain the various components of mercury-containing waste created by this routine procedure. Much of this is outlined in the following chart created by Environment Canada; however, there are breaches in the accountability of the mercury's fate because of a lack of monitoring that likewise need to be addressed.



a) Mercury waste from capsules

The first form of mercury waste created by dental amalgam placement is from the capsules (both used and unused) that contain or have contained the mercury and base metal elements. Each capsule contains 400 to 1200 mg of mercury, and there are plastic containers used to mix in the mercury and base metal components of amalgam.

Although some countries only allow encapsulated dental amalgam, there are still countries that allow the use and importation of bulk mercury for dental purposes. It is difficult to calculate the actual number of mercury-filled capsules that must be stored

indefinitely, yet there have been no initiatives until the last decade to control where these capsules end up.

Currently, there is also no international body overseeing the safe disposal of this toxic waste, and as a result, many of the mercury capsules end up in landfills. These unused capsules pose a greater risk to the environment than used capsules because the mercury content in an unused capsule is of greater quantity than the mercury remnants in a used capsule. Therefore, unused capsules have the potential to leak out more mercury over a longer period of time.

The Environment Canada flow chart above suggests that the empty capsules may be thrown in the garbage, as local bylaws allow. This practice means that the incineration of the amalgam waste can result in the production of mercury vapor from the remnants of mercury on the capsules, which would add up to a significant amount when considering the number of amalgam fillings placed in Canada each year.

The only environmentally-safe fate the used or unused capsules have is in indefinite, long-term storage, but interestingly enough, this type of facility has not been developed nationally or globally. In Canada, where only encapsulated dental amalgam is allowed for importation, the approximately 5000 kg of mercury brought in for dental use would yield close to 10 million capsules that require safe disposal annually.

b) Mercury waste from sundries

The second form of mercury waste from placing an amalgam filling is tainted sundries. Rubber dams, gowns, bibs, barriers, masks, gloves, cotton rolls, suction tips, suction screens, and wipes all have the potential to carry amalgam particles. There are no programs in place to collect and store this waste, and as a result, most of it is either sent to the landfill and/or incinerated as waste or bio-hazardous waste, which obviously emits notable amounts of toxic mercury vapor to the environment.

Additionally, a thorough cleaning of amalgam debris is required for reusable instruments, such as mirrors, pluggers, carriers, rubber dam clamps and frames, carvers, and burs. Generally, this waste is rinsed down the drain. For any instrument that is not properly rinsed, subsequent sterilization can produce occupationally hazardous mercury vapor.[77] This second category of mercury waste may account for up to 1 % of the total mercury used for dentistry or 3.5 tons annually on a global basis.

Unfortunately, because the mercury is associated with sundries, the opportunity for recycling this mercury is unlikely. Again, the only other option for BPM for this waste is indefinite storage facilities. Without this type of facility, the waste will continue to be dispensed into the land fill or down the sewers where it is leached into the environment.

c) Mercury waste from large-sized amalgam particles

The third form of waste from placing mercury fillings are large “chunks” of amalgam measuring more than 1 mm3. These are either unused particles or the amalgam scrapings that are produced when the filling is carved into its final shape. The chunks

are supposed to be collected by hand and forceps, screens on suction lines, and amalgam traps.

Then, the amalgam particles are supposed to put in a sealed containers and eventually, taken for long-term storage/recycling. There are no tracking instruments or long-term storage facilities in place in Canada or anywhere else in the world to ensure this safe practice occurs.

Furthermore, the recommended cleaning of the contents in “amalgam traps” provides another opportunity of vaporization and occupational exposure. This waste is not commonly caught in the “amalgam separators,” but rather the 1mm screens that fit inline on the suction hoses.

Theoretically, the “large chunk” waste of the process would account for most of the unused portion of the mercury in the installation of dental amalgam, or 54% of the amalgam not placed into patients’ teeth. This adds up 175 tons of mercury annually.

Yet, there is no reliable way to measure the amount that is recovered from this quantity, and the dental profession and related organizations that collect this waste also cannot account for this very large amount of material. Commonly these “chunks” are either “spit” down the drain and into the sewage system, swallowed by the patient (estimates of 17.5 tons of 10%[78]), thrown in the garbage where they enter the landfill, or disposed of as a biohazard which is incinerated, thus creating mercury vapor released to the air.

The author, a dentist himself, tried to establish some tracking method for how much of this type of waste is collected on an annual basis in Canada; however there was no manageable way to calculate this to date.

d) Mercury waste from medium-sized amalgam particles
The fourth form of waste from amalgam placement is the particles larger than 1 cubic micron but smaller than 1 cubic mm. This size of particle is not as common in the initial placement of amalgam fillings as it is when amalgam fillings are being replaced These smaller scraps are not captured by the inline suction screens and normally make their way into the sewer, although recent recommendations on the use of amalgam separators are geared to prevent this size of particle from entering the environment.

e) Mercury waste from small-sized amalgam particles and vapor
The fifth form of waste from the insertion of amalgam fillings is sub-micron particles and mercury vapor. Mercury vapor from the actions of trituration, condensation (packing), and polishing commonly exceed maximum allowable occupational levels.[79] [80] [81]

As a result, safety measures must be taken to avoid this contact. Sub-micron particles are more commonly released when amalgam fillings are removed, as discussed in the next section.

2) Dental mercury released into the environment from amalgam that is placed in patients' teeth:

46% of the mercury used for dental amalgam is placed in the mouth, which adds to the existing societal stock.[82] According to WHO's estimates on global use of mercury in dentistry, this amount could reach as much as 184 tons a year (400 tons x .46).

The mercury presently stored in the mouths of U.S. population has been estimated at 1000 tons,[83] although this estimate is from 2004 and may be declining since more Americans are choosing non-mercury fillings and since the use of mercury in dentistry has been declining over the last decade.

Applying the 2004 U.S. rate to the population of Canada would provide for an estimated additional 100 tons of mercury stored in the mouths of dental patients. Applying this rate to the population of the developed countries, especially because the populations of the developed countries account for majority of the current societal load, would result in a conservative estimate that the global stock of mercury in the mouths of humans is presently at approximately 4000 tons.

Here it should be noted that there is a lack of clarity as to whether the amalgam fillings present in teeth (societal load) are considered to be part of the *environment*:

If the definition of the *environment* is only the land, water, and soil, then one can consider the mercury placed in the mouth of a human as being "out of the *environment*."

If, on the other hand, the definition of *environment* is taken from the 1988 edition of the Canadian Webster's Dictionary, then the *environment* is the "surrounding, especially the material and spiritual influences which affect the growth, development and existence of a living being."[84] This definition means that the womb of a mother is one of the most important environments there is, and therefore females that are, or potentially will be, mothers should be considered an essential part of the *environment*.

This definition also means that if all men, women, and children are recognized as "living beings," then every person is part of the *environment*, which would mean that any and all dental mercury placed in any human tooth is "in the *environment*."

Regardless of what definition of *environment* is used, all of the mercury placed in the tooth that is not removed by careful protocol and BPM is doomed to end up in the outside environment from excretion via feces, exhalation, urine, sweat, burial, or cremation.

While the trend in the developing countries is generally exhibiting a gradual decrease in the use of mercury in dentistry, trends show that developing countries are in a position to create a much higher need for tooth restoration. If these teeth are restored with amalgam, there will be a concurrent increase in the use of mercury for dentistry. [85]

The societal store of mercury in amalgams has several secondary opportunities to be released into the environment, and these are discussed in the section below.

Secondary Environmental Mercury Exposure from the Societal Load

Exhalation of mercury from placed dental amalgam as a source of air exposure

The continuous vaporization of mercury from fillings in the mouths of humans creates much more of a dramatic impact on the environment than one might first consider.

First, the average filling has .5 gm of mercury,[86] and the global societal store of mercury is estimated at 4000 tons (comprised of up to 8 billion fillings in peoples' mouths worldwide).

Next, as indicated in the introduction, the amount of mercury vapor that comes off amalgam fillings in the mouth is dependent on many factors.

Thus, quantifying the mercury emissions from fillings in patients' mouths has been attempted by many researchers. A conservative estimate of mercury vapor given off an average filling is from 0.6 - 2.5 ug/filling/day.[87] Using 1.5ug/filling/day as an average to calculate the amount of mercury vapor entering our air from existing fillings, the annual global amount released would be approximately 12 billion ug/day x 360 days/year or 4320 billion ug (4.32 tons).

Of this vapor, approximately 80% is absorbed into the body by inhalation. Therefore, the total mercury vapor exhaled from the societal load is 20% of the unabsorbed mercury on inhalation.[88] Based on these estimates, 2.6 tons of mercury vapor is exhaled into the atmosphere annually from amalgam fillings, and about 1.7 tons are absorbed into the human body via the lung.

Recent studies by Mark Richardson used EPA standards to calculate that 67 million Americans exceed the reference exposure level for mercury established by the EPA.[89] Dr. Richardson is currently conducting another risk analysis of the use of amalgam with current data from Canada. His analysis should be complete before the end of 2012 and will be valuable to this assessment.

Mercury exposure from amalgam removal in societal load

There are many reasons why amalgams are removed. In addition to hypersensitivity, metallic taste, restoration failure, and patient desire for superior esthetics, removal also occurs due to concerns about various medical conditions possibly associated with mercury exposure.[90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136] Additionally, the average amalgam filling has a lifetime of 10 to 15 years, after which replacement is required.

Removal of old or unwanted fillings creates its own set of considerations with respect to the dispersion of mercury into the environment. This is largely because the routine technique of amalgam replacement requires removing the old filling with a high-speed dental drill. The action of the bur (bit) on the amalgam creates micron and sub-micron particles, as well as mercury vapor due to the heat of the drilling. It is well-known that heated mercury vaporizes at a higher rate and poses a greater threat to the people and the environment.

Thus, the overall procedure of taking out amalgam fillings produces mercury debris that is very difficult to account for because bits and shards are commonly projected several feet from the operating site. These can end up in the patient's and operator's mouth, eyes, clothing, hair, or on the floor. It is estimated that 10% of this amalgam is swallowed by the patient,[137] but the majority of the waste ends up in the sewage system through the eventual washing of hair, clothing, and floors, or via excretion.

Although the amount of mercury that is vaporized in this process is small percentage-wise, it can lead to levels ranging from .1 to 25 mg/m3 in the breathing space of both operators and patients.[138] These levels exceed ceiling rates that are considered safe and lead to a significant increase in body burden of mercury in unprotected people working in the dental profession as well as their patients.

Alberta Occupational Standards allow no more than a .025 mg/m3 continuous exposure in an eight-hour working day and consider .125 mg/m3 mercury vapor to be the ceiling rate that is never to be exceeded for any duration. In addition, Alberta Occupational Standards consider mercury vapor to be a toxic substance readily absorbed through the skin, so protection for bare skin exposure at these levels is as important as avoidance of inhalation.

Furthermore, during the process of removal, high volume suction is recommended to prevent occupational exposure, but many of these suction units are vented to the outside. The amount of mercury vapor that comes out of suction venting in American Dental Clinics may be as high as 1 ton annually.[139] Any vapor that is not evacuated by the suction has the opportunity to increase societal load by being up taken by dental workers and patients.

There have been attempts to monitor dental clinic air for mercury vapor; however, because the exposures are localized and concentrated, the standard occupational room monitors for mercury vapor do not fully reflect the actual amount of mercury vapor or the occupational risk that exists in a dental clinic setting.[140]

Dental professionals have demonstrated higher levels of mercury in their urine when compared to the general population.[141] The culprit of this phenomenon is unknown, but it could be from mercury vapor releases, intake of micron and sub-micron particles, or both. At any extent, the production of particles of amalgam during removal creates an environment that can create a very significant occupational exposure to mercury, as well as patient exposure.

Studies have shown that the amount of amalgam particulate in the breathing space of patient and worker can equate to an inhalation rate of 19 mg per filling removed.[142] Amalgam particulate is known to embed in the alveoli of the lungs where it is conducive to mercury disassociation. The mercury absorbed by this method is more likely to be elucidated in fecal samples rather than the urine.

The reason for this large volume of inhalation exposure is that regular operative masks commonly used for dentistry are designed for the resistance of micro biota. Masks do not afford any protection from mercury vapor and also allow particles as large as 3 microns to pass through them. It has been estimated that 68% of the particles that are created by drilling on an amalgam filling are .7 um or less,[143] which means these small fragments containing mercury are inhaled by dental personnel.

Table 1 – Comparison between data collected from the 2003 and 2007 National Survey of Dentists.

	2003	2007	2003 vs 2007
Total amount of Hg used in dental amalgam	5352 kg	4665 kg	- 13%
Quantity of Hg being placed in teeth	2314 kg	2051 kg	- 11%
Quantity of Hg present in removed dental amalgam restorations	2472 kg	2703 kg	+ 9%
Quantity of Hg trapped in solids separators[1]	989 kg	1081 kg	+ 9%
% of dentists using ISO certified separators[2]	27%	70%	+ 43%
Quantity of Hg being released to the environment from removed dental amalgam restorations	1046 kg	452 kg	- 57%
% of dentist who had engaged a licensed waste carrier to manage amalgam appropriately3	N/A	71.2 %	-

[1] Conventional solids separators at the chair-side and vacuum pump.

[2] A high efficiency amalgam separator that meets ISO 11143:1999 standards (International Standard Organization 1999).

[3] Appropriate management may include landfilling in an approved, confined, engineered landfill with leachate collection systems, such as a hazardous waste landfill, recycling to either produce reusable materials such as mercury, silver and copper, or for stabilization/immobilization in a form that may be retired permanently.

Another hypothetical issue of the masks commonly used in dentistry today is that the amalgam particles that are caught in the mask are immediately exposed to warming by

the exhalation of the operator. This rise in temperature increases the disassociation of mercury in the amalgam particles, and thus exposes the operator to more mercury vapor.

The particulate produced by dental drilling that is not absorbed by inhalation of the dental staff and/or patient and that does not end up in the operator masks, ends up trapped in the suction, and hopefully in an amalgam separator, or it is dispersed throughout the dental operating room.

This means that mercury particles are taken into the bare skin of any individual within the sub-micron plume, protective layers covering the patient, the dental equipment, the hair and clothing of the workers and their patients, and/or the floor of the clinic.

Because of all of these hazards, extra precaution must be taken to protect the patient and the dental staff. This includes the utilization of the nitrile rubber dam (latex is not impervious to mercury), mercury rated masks impervious to sub micron particles, alternative air sources for the patient, drapes on all bare skin, horizontal mercury suction units, high volume suction, copious amounts of water, and nitrile gloves.

The techniques involved in removing amalgam from teeth causes the same mercury-contaminated sundry burden as what was outlined earlier in the section entitled “Dental mercury released to the environment from amalgam waste (i.e. amalgam that is not in a patient’s tooth).”

The difference between the placement and the removal of amalgam fillings is that the removal causes a much larger ratio of smaller particles that are not captured in conventional suction screens. In North America, it appears that there are slightly more mercury amalgam fillings coming out of the mouth than going in, as the shift to non-mercury fillings in these jurisdictions occurs.

A table from the “2003/2007 National Survey of Dentists” below confirms that there is an increase in amalgam replacement with non-mercury materials:

The decreasing placement of amalgam in developed countries[144] causes a gradual decrease in the developed populations’ contribution to the amalgam societal load; however, this change creates a larger burden on the environment due to the removal of these mercury-based fillings. Extrapolating the numbers in Canada and applying them to other developed countries suggests that there could be as much as 200 tons of mercury drilled out of teeth each year.

Removal techniques have a profound effect on the environmental impact of this mercury. Dentists can reduce the burden on the environment, themselves, their staff, and their patients by using the drill bit to cross-hatch the old amalgam and “chunk” out the amalgam to retrieve these chunks by suction or by forceps. These larger chunks can then be placed into proper storage and disposed of in an environmentally-

conscientious manner. The “chunking” also minimizes drilling and therefore reduces the production of micro and sub-micron particles and vapor. Using a generous water spray while drilling keeps the old amalgam filling cool and reduces the vaporization of mercury from the friction of the drilling. There are also special suction tips designed to increase the capture of mercury-laden aerosol produced by the dental drilling.

The use of amalgam separators in preventing dental mercury releases

Amalgam separators are likewise essential in reducing mercury releases to the environment, as they can reduce up to 99% of the small-sized particles that normally make their way to the sewer.

As such, after 14 years of an ineffective “voluntary” program to install amalgam separators, Canada has instituted a mandatory program for amalgam separators. However, these separators create an added expense to using amalgam, and the separators are only effective if they are maintained properly.

Amalgam separator maintenance creates another situation where human exposure to mercury can occur, and there are risks of spillage during maintenance of the separators and transportation of the waste collected in them. There are very few effective amalgam separator programs where both installation and maintenance are monitored, such as in the province of Ontario. Presently, there are very few jurisdictions in the U.S. where amalgam separators are mandatory, but efforts are underway to enforce their use. Several other developed countries including many European countries have embraced the use of separators.

Thus, although the maintenance of amalgam separators needs consideration and attention, at least their effectiveness in collecting some types of amalgam particulate has been well-established. Specifically, amalgam separators remove a significant amount of “fine” amalgam particles that would otherwise escape into the sewage system, which is known to be burdened by mercury discharge from dental offices. Yet, if the waste from the separators is not handled properly, the particles that were collected could end up being released to the environment anyway.

Studies acknowledging the amount of dental waste emitted into sewage demonstrate the necessity for enforcement of amalgam separators and maintenance regulations, especially because much of the mercury amalgam in sewage sludge ends up being incinerated or spread on the soil as fertilizer, which again adds to the environmental burden.[145]

The impact of waste from amalgam into sewage treatment facilities is prolifically shown by evidence of the quantity of mercury releases to the water supply caused by dental offices. For example, the New York Academy of Sciences estimated that 40-60 % of the mercury in the NY/NJ harbor was a result of dental office waste,[146] and the

Metropolitan Council Environmental Services for Minneapolis-St. Paul estimated the following breakdown of sources of mercury that their sewage system handled:[147]

1) Industrial 5-10%
2) Residential 15-20%
3) Dental Sources 76-80%

While it is clear that the use of amalgam separators is essential for protecting the environment, the separators simply do not prevent all of the mercury releases into the environment by dental amalgam.

A study involving analysis of mercury containment in Ontario wastewater in 2002 calculated that roughly half of the amalgam removed from the societal load makes its way down the suction to the amalgam separator.[148] So, what happens to the other half?

Based on statistics collected in Canada in 2007, about 1350 kgs of the removed mercury from amalgam fillings would become particulate that would be largely captured by amalgam separators (if there were 100% compliance).

The remaining 1350 kgs of waste from amalgam removal, along with the other 2614 kg waste created by new fillings being placed (4665 kg - 2051 kg), must be accounted for. Of this 3964 kgs, 1081 kgs of mercury in amalgam particulate is collected in the 1 mm screens, while 2883 kgs of mercury from amalgam remains unaccounted for.

This missing mercury likely consists of large chunks of amalgam that are collected, jarred, swallowed, or thrown in the waste. The unaccounted mercury may also be comprised of minuscule particles that are either inhaled, embedded in clothing, hair, and dental sundries, or trapped in the operatory, where cleaning procedures are likely to carry this waste into the sewer. Lastly, this unaccounted waste could be in the form of mercury vapor that is inhaled via the lungs or absorbed through the skin by dental staff and/or patients, or mercury that is heated and emitted as vapor to the atmosphere.

The point is that 2883 kgs of Canada's mercury is left unaccounted for, even if amalgam separators are 100% utilized. This is a significant amount which poses a serious hazard to the Canadian environment and the people in it.

Secondary exposure of mercury from the amalgam societal load via extracted teeth

Many times when dentists remove teeth, the extracted tooth contains amalgam filling material. The fate of this mercury is not well-tracked, and there is inconsistency from jurisdiction to jurisdiction regarding the handling of an extracted tooth with an amalgam filling.

For an example, the most recent recommendations from Alberta Health Services advise that extracted teeth be placed in bio-hazardous containers. There is difficulty in classifying this bio-hazardous waste because extracted teeth contain a wide variety of micro biota, which has resulted in a recommendation to incinerate the waste. Yet,

incineration is contraindicated for a material that contains mercury because it causes heat and thus more rapid mercury vapor releases to the environment.

There is still debate on how to best handle these situations; however, there appears to be only two solutions: 1) The tooth with mercury is placed in a landfill, risking mercury and micro-biotic leaching, or 2) The amalgam is removed and placed in the "large chunk" sealed container that ultimately is taken to a recycling/storage facility, and the rest of the material is handled with consideration for micro-biotic leaching. The first scenario results in endangerment to the environment and landfill operators, and the second scenario endangers the person removing the amalgam. Both scenarios add an additional cost to the delivery of the amalgam filling service.

There is no data from any country that specifically tracks extracted teeth, let alone extracted teeth with amalgam fillings. It has been estimated that there could be up to 10 million extractions a year in the U.S. that are not for orthodontic purposes or wisdom teeth (unlikely to contain amalgam).

Considering that numerous teeth are removed because of pathology, and many times as many teeth are removed because of a "deep filling" that has abscessed, there are likely a substantial number of extracted teeth containing amalgam. Conservatively, if merely one-quarter of these teeth have amalgams, and each filling averages .5 gm, then a reasonable amount of mercury in extracted teeth would be in the hundreds of kilograms in America. Globally, this burden could be four times the American amount.

At any extent, there are no established protocols to protect the environment from mercury-containing extracted teeth, even though the releases are clearly substantial.

Secondary mercury exposure from the societal load via human excretion

Although mercury can be excreted both via the feces or the urine, the majority is fecally eliminated. Research has shown that the average person with amalgam excretes approximately .1 mg of mercury per day in his/her feces.[149] In the United States, this amounts to over eight tons of mercury per year eventually being flushed out to sewers, streams, and lakes.[150] Applying this rate to the developed population, the amount of mercury entering our sewers from this route possibly reaches 32 tons.[151] [152] [153]

Mercury from amalgam in the saliva

Mercury releases from the saliva of people with amalgam fillings would seem to be a small amount, but the analysis of these concentrations raises some essential considerations:

First, the amount of mercury in saliva is directly related to number of fillings.[154]

Furthermore, the output of mercury vapor continuously emitted from amalgam fillings[155] is dependent upon other activities associated with the human mouth, such as chewing (such as food and gum), teeth-grinding, and the consumption of hot liquids.[156] [157]

Next, the production and the swallowing of saliva account for up to .5 to 1.5 litres per person, per day.[158] The concentration of mercury in saliva in people with amalgam fillings commonly reaches more than 4.14 ugm/l,[159] which is more than four times Health Canada's allowable limit of 1 ug/l mercury concentration in water.[160]

Finally, the recommended consumption of water per person is 2-3 litres a day,[161] but if the saliva of a person with mercury fillings was assessed for consumption, it would be declared unfit for drinking because of unacceptably high levels of mercury!

Secondary mercury exposure from the societal load via cremation

The amount of mercury that enters the environment from crematoriums is directly related to the amount of mercury contained in amalgam fillings,[162] and the demographics of the population likewise correspond with this pollution. In the developed populations, as more elderly are keeping their teeth, there is a higher prevalence of mercury in the cremated body.[163] Similarly, as the developed populations begin to reject amalgam and chose non-mercury containing filling material, the risk of mercury vapor being produced by cremation will be reduced.

Estimates of mercury releases during cremation have been offered by several researchers. Mills in the UK estimated an average of 3 grams/cremation,[164] and this estimate has been judged reasonable by Swiss[165] and Swedish and Finnish[166] researchers.

Another major factor is that many citizens in the developing populations are choosing cremation over burial. The Cremation Association of North America estimates that over 40% of deaths will be handled via cremation in 2010 in the U.S., and a U.S. estimate of mercury emissions from crematoriums prepared for EPA Region V by Barr Engineering and updated by EPA staff concurred. In the January 2006 version of this document, the estimate was that in 2005, there were 2,961 kilograms of dental mercury in the corpses cremated, and 75% (2,221 kg) of that mercury was released as air emissions, while 25% (740 kg) was released to the land.[167] The primary source of the land emissions is mercury attached to settled particulates from the crematoria.[168]

Overall, global amounts of mercury entering the environment via cremation can be conservatively estimated at 12 tons annually. Obviously, this amount of anthropogenic exposure requires attention, and it is not surprising that localities around the world have even begun fighting crematoriums in their neighborhoods due to fears of mercury releases.[169]

Mercury release by cremation merits consideration of mandatory "extraction" of mercury-containing teeth prior to cremation and/or scrubbers in the stack to help protect

the environment. This once again attaches an additional financial burden to the placement of amalgam fillings. Although these management practices can help reduce mercury exposure, one has to consider that scrubbers on stacks are not known to be 100% efficient. They are also extremely expensive. The practice of removing the mercury-containing teeth from the deceased not only increases the financial burden, but it also creates an increased need for storage, recycling, and/or handling , as well as an additional risk of exposure to the people that remove the teeth and/or amalgam.

Secondary mercury exposure from the societal load via burial

There are no studies on whether mercury from the fillings of the deceased who are buried leach out into the surrounding soil over time. Yet, a variety of burial methods would seem to cause environmental exposure.

Whether an individual is buried in a sealed casket, a cement vault, a tomb, or a shroud, inevitably bugs, worms, water, bacteria, and soil find their way into the area. A so-called "natural burial" (commonly promoted as a "green" resting place) actually seems to have higher potential for mercury exposure into the soil and water table since the body is not at all encased in this circumstance.

Any type of burial that promotes the oxidation of the body and the casket (if used) presents a greater risk of causing mercury contamination. If these types of "green burials" gain popularity, then there is an urgent necessity for an established protocol to remove the mercury from the mouths of these bodies before they are placed in the earth.

One thing is clear: any mercury amalgam buried with a person impacts the soil, water, and animals in the vicinity.

Motherhood as another secondary exposure of the societal load

If environment is, as defined by the 1988 Canadian Webster's dictionary as "the surrounding, especially the material and spiritual influences which affect the growth, development and existence of a living being", then the mother or potential mother most certainly plays a major role in the "environment."

Indeed, scientific studies have already proven the devastating impact of mercury on pregnant women and children, which is why pregnant women and children are advised not to eat certain types of seafood that might contain methyl mercury.[170] [171] [172]

The dangers of fetal and infant exposure to mercury via maternal dental amalgam have likewise been scientifically established, and specific concerns have been raised about neurological issues, developmental delays, and cleft palate development.[173] [174] [175] [176] [177] [178] [179] [180] [181] [182] [183]

Furthermore, the most up-to-date science continues to expose the havoc that the mercury in dental amalgam fillings wreaks upon pregnant women and children. A study published in the April 2011 edition of Environmental Monitoring and Assessment notes, "As we showed, the number of amalgam filled teeth in breast-feeding mothers strongly influences the mercury level in their milk. Take it into consideration that maternal milk is the only source of nutrition during the first few months after birth."[184]

Another recent study published in Science of the Total Environment cautions, "Changes in dental practices involving amalgam, especially for children, are highly recommended in order to avoid unnecessary exposure to Hg."[185]

Perhaps the best summation of using mercury in products for children was made at the 2010 United States Food and Drug Administration's Dental Product Panel hearings by Dr. Suresh Kotagal, a pediatric neurologist at the Mayo Clinic, when he announced, "There is really no place for mercury in children."[186]

Meanwhile, mercury has suspected as a factor in autism,[187] [188] [189] [190] [191] [192] [193] [194] [195] [196] and as such, maternal dental amalgam fillings have been linked to autism as well."[197] [198] [199] [200] [201]

Background on Alternatives to Amalgam

There is a distinct split amongst dentists on the need for amalgam. This split is also demonstrated in various faculties, academies, organizations, and trade organizations globally, although commentary and suggestions about the use of amalgam seem to be rapidly changing due to the United Nations Environmental Programme's negotiations for a 2013 legally-binding global treaty on mercury.[202]

Even the World Dental Federation (FDI), a trade organization that is funded by several companies who profit from the sale of amalgam and defend its use,[203] recently issued a joint statement with the International Association for Dental Research (IADR) and the International Federation of Dental Educators and Associations (IFDEA), admitting that new alternative dental materials *need* to be developed and commercialized.[204]
Given that a number of well-used alternatives already exist (see below), the history of action on amalgam by groups like FDI seems to exhibit an unfortunate history of denial and delay tactics.

For example, FDI stated in their 2010 General Assembly Resolution on Amalgam: "Amalgam is a safe and highly effective restorative material. To maintain and protect global public health, a phase down of amalgam will be only appropriate when an alternative and suitable restorative material is available."

In the FDI's 2007 revised version of their "Mercury Hygiene Guidance," they offered the following advice:[205]

> Know the key issues on potential exposure to mercury:

· avoid direct skin contact with mercury or freshly mixed dental amalgam
· avoid exposure to the following potential sources of mercury vapor--
accidental mercury spills
malfunctioning amalgamators
leaky amalgam capsules
malfunctioning bulk mercury dispensers
during trituration (mixing)
during placement and condensation of amalgam
during polishing or removal of amalgam;
vaporization of mercury from contaminated instruments
open storage of amalgam scrap or used capsule

Thus, while the FDI document recognizes the risk of occupational exposure to mercury, which is readily absorbed through the skin or by inhalation, and also offers strategies on how to avoid exposure in some cases, there is no guidance about *how to avoid mercury vapor exposure during*

1)trituration
2)placement
3)condensation
4)polishing
5)removal of amalgam

Some of these five procedures, which are necessary practices when using amalgam, commonly produce vapor that exceeds occupational ceiling limits.[206][207] The only way to surely protect the dental staff from these sources is the use of a mercury vapor rated mask rated for sub-micron particulate, as well as the use of a full gown with a material that is impermeable to mercury vapor. These sundries are presently not respected as necessary by the FDI for the protection of the dental workers.

Furthermore, in the same 2007 document, the FDI does not offer any strategies on how to protect the patient from mercury vapor when these procedures are occurring. Minimum protection must include a nitrile rubber dam and suction under the dam, extensive draping, as well as an alternative breathing source. Data from a recent research project in a Canadian Dental suggests that mercury vapor exposure from placement and condensing (packing) amalgam can exceed .500 mg/m3 [208] which is five times that of EPA's ceiling rate of .100 mg/m3. The EPA ceiling rate is a level that is NEVER to be breached, but currently is being exceeded in an area 2-7 cm from the patient's nose and 38 cm from the dental workers breathing space, Most jurisdictions, such as Alberta Occupational Health recognize that mercury vapour is a hazardous material that is "known to be absorbed through the skin". Because of this, protection of the skin from mercury vapour becomes as important as prevention from inhalation.

Without including these protective measures, the use of amalgam can, does, and will continue to create significant and unnecessary exposures to mercury vapor. The necessity for these measures should be taken into account, along with the issues about releases caused by amalgam particulate explained previously in this document. The

combination of these situations means that THOUSANDS of tons of mercury are released by amalgam globally per year, although they are not even taken into consideration.

While regulations will increase the cost of amalgam use and create large amounts of mercury-contaminated waste, they are essential to make the immediate environment around dental staff and patients safe. Unfortunately, there is obviously no guidance on "unregulated" and "unrecognized" types of mercury-contaminated waste, and as such, there are likewise no available technologies to separate amalgam from sundries, so all of this biohazard becomes part of the landfill burden of mercury.
In an FDI-generated document regarding the "Safety of Dental Amalgam," it is reported: "Although much research effort has been expended in developing amalgam alternatives, no universal substitute is currently available."

As you have seen, this is the same rhetoric used again and again by groups who justify the use of mercury, but the section below outlines all of the viable and commercialized alternatives to amalgam that already exist.

Available and Viable Alternatives to Amalgam as of 2012

Composite fillings

Composite fillings have long been deemed as "more expensive than amalgams" and "not as long lasting." As the development and improvement of this material occurs, a recent study confirms that composite fillings last as long as amalgam and have a higher overall survival rate.[209]

The WHO confirmed this phenomenon by stating "recent data suggests that composites perform equally well" as amalgam.[210] Not only have composites evolved into a formidable replacement for amalgam in most situations, the cost of composites and their placement is very comparable to amalgam[211] without having the negative environmental effects.

Approximately half of the dentists in North America provide dental care without using amalgam,[212] and countries such as Denmark, Sweden and Norway have provided their people with excellent dental care without the use of amalgam for almost a decade The Nordic countries have even provided documentation designed to promote mercury-free dental practices.[213]

It appears that the general trend for the populations of the developed countries to reject amalgam use is primarily supported by the increased and successful use of composites.

Arguments by organizations and dentists that support the use of amalgam commonly refer to the needs of the developing countries and the lower socioeconomic peoples of developed countries. Such arguments include the ease of training dental personnel

and the low cost of amalgam placement as being reasons to value this material. Yet, these arguments do not consider the expenses that the use of amalgam fillings create in order to manage environmental and health implications.

As an example, if the BPM protocols identified in this paper were fully implemented, then the complete cost of amalgam would be far greater than the cost of placement itself. Additionally, there are anthropogenic exposures of dental mercury to all facets of the environment that cannot be prevented. If the large population of developing nations chooses to use amalgam, then there will be a relative increase in the exposure to the environment that cannot be avoided.

It is undeniable that other countries have banned amalgam fillings specifically because "composites were adequate replacements" for amalgam,[214] so it is blatantly obvious that amalgam is not a necessity anymore.

Atraumatic Restorative Technique (ART)

There is a very good restorative alternative for people of low income and developing countries known as atraumatic restorative technique, or ART

The primary excuse for the continued use of amalgam is the supposed ease of training and alleged lack of suitable and affordable alternatives. These publicized justifications have resulted in resistance of many faculties of dentistry to embrace dental treatment without amalgam, but ironically, ART has been both practiced and encouraged by a variety of groups around the world, including charity organizations who offer free dental care in third-world countries.[215]

Canadian Chief Dental Officer Dr. Peter Cooney participated in a Pan American Health Organization initiative in 2005 and designed the "Technology and Health Services Delivery Health Services Organization Regional Oral Health Program." The elements of this program offer strong support to "utilize ART extensively."[216]

Other research proves that ART has been used successfully for decades in 25 countries and is even recommended by the World Health Organization.[217] [218] [219] [220] The ART technique requires only dental hand instruments and an adhesive dental restorative material such as glass ionomer cement.[221] One research study from the University College London Medical School explains:

> The advantages of this treatment compared with conventional restorative techniques using dental hand piece and burs include the following: provision of restorative dental treatment outside the dental surgery setting, a biologically friendly approach, minimal cavity preparations and low costs (Frencken 1999; Mjör 1999; Yip 2001; Yip. 2002), reduced risk for subsequent endodontics and tooth extraction (Anusavice 1999) and lower dental anxiety in children and adults (more patient-friendly) (Mickenautsch 2007; Schriks 2003). These advantages are particularly important in developing countries, where electricity supplies are

> intermittent and people have difficulties accessing dental care. In addition, elderly, medically-compromised (e.g. HIV infected) and dental phobic patients who have problems accessing dental care would benefit from the ART approach (Cole 2000; Honkala 2002; Steele 2007).
>
> Glass-ionomer cements (GICs) are the predominant restorative materials used for ART (Yip 2001). GIC restorative materials have advantages such as the ability to bond chemically to enamel and dentine, biocompatibility with pulpal tissue and less potential to induce recurrent caries, inhibition of enamel demineralization, good cavity seal, ease of use and low costs. (Frencken 1996; van 't Hof 2006).[222]

Similarly, a study published in 2010 concluded: "In the permanent dentition, the longevity of ART restorations is equal to or greater than that of equivalent amalgam restorations for up to 6.3 years and is site-dependent. No difference was observed in primary teeth. More trials are needed in order to confirm these results."[223]

Additional comments about alternatives to amalgam and FDI's role

Improved awareness of viable alternatives, as well as dental amalgam's environmental and health impact, would go far in helping transform these institutions. Besides training future dental professionals in the use of non-mercury containing restorative materials, it is imperative, based on the discussions in this paper, that a thorough understanding of protecting the environment, the patient, and the dental staff during the removal of amalgam fillings in teeth is provided for future and current dental health providers.[224]

Although there is not a universal alternative for amalgam, as the FDI suggests must occur before phasing down amalgam, the use of two inexpensive, available and relatively environmentally-friendly materials can justify the discontinued use of amalgam today with adjustment in mindset, curriculum, and training and without jeopardizing the dental health of the population.

That being said, it is concerning that the FDI has such a strong influence in shaping policy in Canada as they are referenced in many documents from Health Canada. The FDI maintains several positions on the use of amalgam that do not reflect the current position of Health Canada.
Although it is important to allow all related stake holders to have input in this project, it must be underlined that the FDI is a trade organization that receives financial support from companies who profit from the sale of amalgam.[225] This must be considered when weighing their position.

The following is a review of some examples that demonstrate the FDI policy does not align with Health Canada's:

- In their document entitled “Amalgam Waste Management” 2009, FDI does not acknowledge the mandatory use of an amalgam separator as part of BPM to protect the environment.[226]

- In the FDI-generated document “The Safety of Dental Amalgam,” FDI fails to acknowledge the concern for patients with kidney disease, pregnant women, or children that Health Canada does.[227]

- Analysis of the FDI document entitled “Mercury Hygiene Guidance”[228] confirms that the FDI acknowledges dangers that come with the use of dental mercury amalgam; however, there are no specific recommendations on how to achieve occupational safety. Many of the items FDI lists are necessary for completing an amalgam restoration such as trituration, condensation, and polishing, but it is not clear how one can avoid mercury exposure during these critical steps of the process. The obvious method would be to not use the material anymore.

Closing Statements

A review of major concerns presented in this report:

It is clear that the dispersion of mercury into the environment by the use of dental mercury amalgam is very complex. As it stands now, there is a vast amount of the 350 tons of mercury the world uses annually for dental restorations that cannot be accounted for.

This paper has identified the following destinations of mercury from amalgam that has not or cannot be estimated, tracked or controlled:

- Diversion into other applications such as artisanal gold mining
- Spillage in manufacturing, transportation, and dental use which all lead to mercury intoxication of the air, soil and water
- Vapor from spillage, amalgam placement, polishing, dental suction exhaust, sterilization of amalgam tainted instruments, exhalation, handling of waste, and cremation
- Transfer of mercury from mother to offspring
- Amalgam particulate waste >1mm that is not collected by hand and placed in sealed containers for recycling/longterm storage
- Amalgam particulate waste <1mm that is not collected by an amalgam separator, including embedded waste in various dental sundries and capsules, particulate that makes its way into the hair, body, and clothes of the dental professionals and their patients, and waste that ends up in the dental office environment, all of which can enter the sewage system
- Secondary mercury dispersion into the environment from the societal load via feces, urine, burial, extracted teeth with mercury fillings

As well, this document has identified that as safer protocols are integrated into the dental practice, there will be a growth of mercury-tainted sundries that are poor candidates for recycling and therefore will require indefinite storage facilities that, to date, have not been widely established.

As with any hazardous material, the objective of agencies responsible for human and environmental safety must design and institute best practice management protocols. It is clear that this does not fully exist with respect to dental amalgam, and if there is any contemplation in continuing to allow a dental restorative made up of 50% mercury, the shortcomings in the tracking and control must be addressed.

Final Comments

A peak of mercury use in 70's has been recognized,[229] and since dental amalgam use began in the mid 1800's, there has been very little attention given to the environmental impact of this material until the last 15-20 years.

Because dental amalgams require replacement every 15 years or so, it can be argued that the majority of mercury used in dentistry from its initial use up until 1995 is functionally "in the environment." The only mercury that was recaptured during this time would be the large chunks of amalgam waste that dentists might have collected. The rest of the mercury is inevitably in the soil, air, water, and patients. There is not enough data to calculate this burden, but an educated guess would put the number in the thousands of tons.

This mercury released from dental amalgam exists in all facets of the environment, and it exists in many forms. It may exist as an amalgam particle continually vaporizing mercury, it may exist as inorganic mercury, or it may have been converted into methyl mercury by a number of organisms that have this potential.

Considering this, it may be a moot point to separate the methyl mercury from the consumption of fish and the inorganic mercury that is produced by mercury vapor. There is a real possibility that because of the magnitude of mercury pollution created by dental amalgams, the mercury in fish might have originated from dental amalgam filling material.

It is concerning that although the developed countries are beginning to understand and act upon the environmental mercury hazard created by amalgams, there is a population three times the size of the developed population that is just beginning to enter a phase requiring extensive dental restoration.

Thus, when considering the population of the developing countries, an important question is: Can infrastructure and the protocols be put in place to prevent more of the mercury exposure to the environment that the developed countries have created over the last 150 years?

It is clear that an attempt to curtail the same mistakes would take a substantial amount of education and money.

It is also clear that a phase down of dental amalgam[230] would assist in a smoother, safer, and more economical transition to a healthier world without so many mercury releases to the environment. The filling alternatives are already in place, and there are organizations such as The International Academy of Oral Medicine and Toxicology and countries such as Norway, Sweden, and Denmark that are willing to assist in this changeover, which in many ways is inevitable anyway.[231]

It's now or later, and putting off the phase down of amalgam for any length of time will only incur damage to the environment and human health, promote a growing distrust of governmental protection agencies, and create the need for an even more expensive clean-up act in the future.

The Nordic Countries have been global leaders on banning mercury amalgam filings, and perhaps the entire subject matter is best summarized by the words of Maths Berlin in 2003:

"For medical reasons, amalgam should be eliminated in dental care as soon as possible. As a result, one of our largest sources of mercury in the environment can be eliminated."[232]

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

Let Canada take its place in history among the countries of the world who first took action to protect their environment and citizens from the mercury in dental amalgam.

Appendix A: Handling Amalgam

This appendix outlines the best available practices in the safe handling of amalgam fillings in dentistry. Guidance for this document comes from a variety of sources including the following:

Health Canada recommendations from 1996 available on the internet at http://www.hc-sc.gc.ca/dhp-mps/alt_formats/hpfb-dgpsa/pdf/md-im/dent_amalgam-eng.pdf

- Non-mercury filling materials should be considered for restoring the primary teeth of children where the mechanical properties of the material are suitable.
- Whenever possible, amalgam fillings should not be placed in or removed from the teeth of pregnant women.
- Amalgam should not be placed in patients with impaired kidney function.
- In placing and removing amalgam fillings, dentists should use techniques and equipment to minimize the exposure of the patient and the dentist to mercury vapor and to prevent amalgam waste from being flushed into municipal sewage systems.
- Dentists should advise individuals who may have allergic hypersensitivity to mercury to avoid the use of amalgam. In patients who have developed hypersensitivity to amalgam, existing amalgam restorations should be replaced with another material where this is recommended by a physician.
- New amalgam fillings should not be placed in contact with existing metal devices in the mouth such as braces.
- Dentists should provide their patients with sufficient information to make an informed choice regarding the material used to fill their teeth, including information on the risks and benefits of the material and suitable alternatives.
- Dentists should acknowledge the patient's right to decline treatment with any dental material.

World Dental Federation's (FDI) statement on "Mercury Hygiene" available on the internet at http://www.fdiworldental.org/c/document_library/get_file?uuid=618df037-2097-4ed1-8ebf-eaa664d46abe&groupId=10157

Introduction: The FDI Mercury Hygiene Statement includes recommendations on handling both pre-capsulated and bulk mercury. The use of pre-capsulated mercury/alloy is the preferred technique. Recommendations that are only applicable to bulk mercury are not necessary when there is no bulk mercury used in the operatory.

Know the key issues on potential exposure to mercury:
· avoid direct skin contact with mercury or freshly mixed dental amalgam
· avoid exposure to the following potential sources of mercury vapor--
accidental mercury spills
malfunctioning amalgamators
leaky amalgam capsules
malfunctioning bulk mercury dispensers
during trituration
during placement and condensation of amalgam
during polishing or removal of amalgam;
vaporization of mercury from contaminated instruments

open storage of amalgam scrap or used capsule

World Health Organization "Future Use of Dental Materials" available on the internet at http://www.who.int/oral_health/publications/dental_material_2011.pdf

From 1.4.1...WHO/ORH was requested to review again the WHO/FDI Consensus Statement and if necessary draft a relevant document on dental amalgam use, taking into account the benefits, but also risks for individual, occupational, and environmental health of restorative materials.

From 2...To highlight the environmental concerns of mercury pollution from the dental sector, and the effect and implications of occupational exposure from mercury for dental personnel.

From 5....Occupational exposures have been reported to arise from work in several industries and from work in dental clinics with poor mercury handling practices.

...The report considered that dental personnel may experience occupational exposure in dental clinics with poor mercury handling practices and that dental fillings made with amalgam can be a source of human exposure to elemental mercury vapors for many populations. Amalgam surfaces release mercury vapor into the mouth and lung. Depending upon the number of amalgam fillings and other factors, the estimated average daily absorption of mercury vapor from dental fillings varies between 3 and 1 µg mercury.

Attention to reducing dental amalgam use in order to contribute to overall mercury use is not limited to the immediate concerns related to direct human exposure. A significant amount of mercury is estimated to be released to the environment from the use of dental amalgam either as an indirect result of the diversion of traded amalgam for other purposes or as a result of improper waste management practices or through cremation.

Table 3 sets out some of the major releases and pathways of mercury that result from use of dental amalgam. When released from dental amalgam use into the environment through these pathways, mercury is transported globally and deposited. Mercury releases may then enter the human food chain especially via fish consumption.

From 9.2...Various groups have opposed the use of amalgam in dentistry based on claims of an adverse effect on patient's health and as a factor in occupational health. Earlier in 2009, the Food and Drug Administration (FDA) issued a final regulation regarding classification of amalgam as the same as other restorative materials such as gold and composites. Labeling requirements were included in the regulation.

Specifically, the FDA recommended that the product labeling include a warning against the use of dental amalgam in patients with mercury allergy; a warning that dental professionals use adequate ventilation when handling dental amalgam; and a

statement discussing the scientific evidence on the benefits and risks of dental amalgam, including the risk of inhaled mercury vapor. This statement should help dentists and patients make informed decisions about the use of dental amalgam.

From 10.4...Promote long-term monitoring (including biological measurements of exposure) and programs to reduce occupational exposure.

From 12.4...It is a matter of urgency that the oral health research community strengthens operational research in relation to use of dental restorative materials. Clinical research must emphasize risk assessment, criteria for use of restoration materials alternative to dental amalgam, development of standardized and reliable criteria for assessment of quality of restorations, occupational hazards, and development and dissemination of clinical guidelines for making dental restorations. It is critical that oral health research strengthens the measurement of the evidence of using restorative materials alternative to dental amalgam through population-wide studies. In addition, it is imperative that research documents the cost-effectiveness of non-amalgam restoration in public health care.

There is a call for dental schools and the International Association for Dental Research to encourage operational research on alternative materials for dental restoration and to coordinate such activity at international level. Effective training of dental students and practitioners is based on research. In dental schools undergraduate training must better consider the safety of the environment, characteristics of dental amalgam and existing alternatives to amalgam for restorative dental care, development of skills in application of new quality materials for restoration, and the safety of dental materials to the provider of care.

Appendix B: Material Safety Data Sheets

The United States Occupational Safety and Health Administration (OSHA) requires the provision of a Material Safety Data Sheet (MSDS) for any hazardous material that poses a threat to employees in a workplace. The purpose of the MSDS is to protect workers by supplying them with the most crucial facts about the hazardous material at their jobsite, such as the physical properties of the material, proper storage and handling techniques, known health risks, and essential emergency procedures.

Thus, manufacturers of amalgam fillings must create these information sheets, and Appendix B features excerpts from MSDS sheets provided with dental amalgam products.

Also, the ADA has owned two patents on amalgams since 1977-78:

1. United States Patent 4,018,600 Apr. 19, 1977.
2. United States Patent 4,078,921 Mar. 14, 1978.

MSDS Sheet for Dispersalloy®

[Dispersalloy® has an MSDS for each of its two components. Dispersalloy® Dispersed Phase Alloy and Mercury - Dated Revised 9/24/97. This MSDS was posted at http://www.caulk.com/MSDSDFU/DispersDFU.html, but within about 6 months, this site was removed. (Note that 'Contraindication' means that the material 'should not be used in the following circumstances.')]

Side Effects/Warning

Prior to use, read the MSDS information and product instructions for this item. Exposure to mercury may cause irritation to skin, eyes, respiratory tract and mucous membrane. In individual cases, hypersensitivity reactions, allergies, or electrochemically caused local reactions have been observed. Due to electrochemical processes, the lichen planus of the mucosa may develop. Mercury may also be a skin sensitizer, pulmonary sensitizer, nephrotoxin and neurotoxin. The use of amalgam is contraindicated;

1. In proximal or occlusal contact to dissimilar metal restorations.
2. In patients with severe renal deficiency.
3. In patients with known allergies to amalgam.
4. For retrograde or endodontic filling.
5. As a filling material for cast crown.
6. In children 6 and under.
7. In expectant mothers.

Mercury expressed during condensation and unset amalgam may cause amalgamation or galvanic effect if in contact with other metal restorations. If symptoms persist, the amalgam should be replaced by a different material. Removal of clinically acceptable amalgam restorations should be avoided to minimize mercury exposure, especially in expectant mothers.

Precautions

The number of amalgam restorations for one patient should be kept to a minimum. Inhalation of mercury vapor by dental staff may be avoided by proper handling of the amalgam, the use of masks, along with adequate ventilation.
Avoid contact with skin and wear safety glasses and gloves.
Store amalgam scrap in well sealed containers. Regulations for disposal must be observed.

Although the previous literature does provide sufficient literature on the risks of mercury amalgam to patients, staff and the environment, it does not adequately outline specific evidence based protocols to achieve some of the suggestions. For information that helps us attain the level of safety suggested from the previous articles, the following articles were used.

Summary of Additional MSDS Sheets

All of the quotes below are taken directly from additional Material Safety Data Sheets:
From Kerr Contour (CA, USA) and others…

- "This product contains mercury, a chemical known to the State of California to cause birth defects or other reproductive harm."

From Ana 90 Duett (Sweden)…

- "Mercury may accumulate in the body which may cause adverse health effects."

From Kerr Sybraloy (CA, USA) and others…

- "Mercury should not be allowed to enter sewers."

From Goldsmith (NJ, USA)…

- "Repeated low exposure or very high single exposure can cause Mercury poisoning. Symptoms include tremors (shaking), trouble remembering and concentrating, gum problems, increased salivation, loss of appetite and weight, and changes in mood or personality."
- "Mercury may lower sex drive."

From Ivoclar Vivadent (NY, USA)…

- "Mercury can cause urinary problems, visual disturbances, tremors, salivation, stomatitis, loss of teeth, blue lines on gums or neurotoxic/nephrotoxic effects."
- "Do not touch spilled mercury. Collect the mercury droplets using specialized mercury vacuum cleaner."

From Original D Wykle (NV, USA)…

- "Separate work and street clothing. Store work clothing in special lockers. Showers to be taken before chaning (sic) into street clothes. Provide pre-placement and periodic medical exams for those regularly exposed to mercury with emphasis directed to CNS-central nervous system, skin, lungs, liver, kidneys, and G.I. tract."

From OralloyMagiCaps (Switzerland)…

- "Mercury: Poison by inhalation. Human gastrointestinal tract and central nervous effects."

From Bethlehem Apparatus Company (PA, USA)…

- "Mercury is highly toxic, irritating and causes sensitization and neurological symptoms."
- "Mercury causes severe, adverse health effects after chronic exposure to low vapor levels. Emergency response efforts must be directed to removal of all traces of this product."
- "The principal target organ associated with chronic Mercury exposure via inhalation is the central nervous system. Such exposures lead to the

development of 'Erethism.' This syndrome consists of subtle or dramatic changes in behavior or personality: depression, fearfulness, restlessness, irritability, timidity, and indecision. These psychic and behavioral characteristics are often accompanied by insomnia, drowsiness, headache, fatigue. In advanced cases, memory loss, hallucinations, and mental deterioration may occur."

- "This product is reported to cause reproductive effects in humans. Impotence has been reported in over-exposed males. Women occupationally exposed have reported menstrual disturbances, reduced ovulation, and spontaneous abortions. Mercury is excreted in breast milk."
- Pre-existing respiratory problems, dermatitis, central nervous system disorders, kidney problems, and liver dysfunction can be aggravated by exposure to this product."
- "Mercury can be harmful or fatal to contaminated plant or animal life."

From Ivensys (MA, USA)…

- "Chronic exposure appears more common than acute and is primarily associated with central nervous system damage which can be permanent (ex. paresthesia of the hands, lips, feet). Early signs of toxicity include weakness, fatigue, anorexia, weight loss, and gastrointestinal disturbances. If exposure levels are high, characteristic tremors of the fingers, eyelids, and lips occur with progression to generalized tremors of the entire body. Psychic disorders are noticeable and characterized by behavior and personality changes, increased excitability, memory loss, and depression."

From Schein (England)…

- "To promote safe handling, each customer or recipient should (1) notify its employees, agents, contractors, and others whom it knows or believes will use this material of information regarding hazards or safety (2) furnish this same information to each of its customers for the product and (3) request its customers to notify their employees, customers, and other users of the product of this information."

from SDI (Australia)…

- "Toxic by inhalation."

From SILMET (Israel)…

- "The number of amalgam restorations for one patient should be kept to a minimum."

Appendix C: Transitioning to Mercury-Free Dentistry

This appendix offers documents to assist in transitioning to mercury-free dentistry.

Information from IAOMT (International Academy of Oral Medicine and Toxicology)

"Safe Amalgam Removal" available on the internet at http://iaomt.org/articles/files/files288/Safe%20Removal%20of%20Amalgam%20Fillings.pdf

"Protecting Yourself from Dental Clinic Contaminants" available on the internet at http://iaomt.org/articles/files/files301/Dental%20Office%20Contaminants.pdfand and

"The Case against Amalgam Fillings" available on the internet at http://iaomt.org/articles/files/files193/The%20Case%20Against%20Amalgam.pdf

Information from Nordic Countries

Because the Nordic countries have phased out mercury amalgam fillings, the following paper outlines possible alternatives for amalgam fillings:

"Mercury Free Fillings/ Phase out of Amalgam in Sweden" available on the internet at http://www.who.int/ifcs/documents/forums/forum5/pm9_05.pdf . This Swedish document explains: "The first step in minimizing the mercury risk to staff, patients and the environment from amalgam fillings is to end the placement of them. This is the only sure technique that protects the staff from the exposures outlined by the FDI and this is our first policy to reduce the amalgam based mercury exposure to the staff, the patients and the environment."

Also to be considered is the following statement on dental amalgam by Erik Solheim, Norway's Minister of Environment and Development in 2007: "Mercury is among the most dangerous environmental toxins. Satisfactory alternatives to mercury in products are available, and it is therefore fitting to introduce a ban."[233]

This means there is no placement of mercury fillings in children, pregnant and nursing mothers, people with known or potential kidney disease, known or unknown mercury hypersensitivity, and/or people with different metals in their mouth.

Lastly, the Nordic countries have worked together to create a publication entitled "Mercury reductions are feasible" which contains pertinent information about ending dental amalgam. The document is available by visiting their website at www.norden.org, selecting the language of translation on the top left of the screen, and then by entering the title of the publication ("Mercury reductions are feasible") in the search box on the right side of the screen.

Appendix D: Human Health Risks from Dental Amalgam

This appendix is created as a reference page for scientific research identifying health risks of mercury.

1) Portions of this paper were borrowed with permission from a detailed fact sheet by the International Academy of Oral Medicine and Toxicology (IAOMT) containing references to hundreds of health studies related to dental amalgam. The IAOMT fact sheet can be read online at http://www.iaomt.org/articles/category_view.asp?intReleaseID=342&catid=30
An additional list of studies compiled by IAOMT is located at http://www.iaomt.org/testfoundation/amalgam.htm

2) Through continued surveillance of the scientific literature, specific groups have been identified as being at increased health risk from mercury exposure. These include

- Patients at risk for cardiac disease, stroke and/or high blood pressure: "The Role of Mercury Toxicity in Hypertension, Cardiovascular Disease and Stroke," Mark C. Houston, MD MS, Journal of Hypertension, 2011:13 621-627 available at http://onlinelibrary.wiley.com/doi/10.1111/j.1751-7176.2011.00489.x/full
- Patients at risk for neurological disease including Alzheimer's and Autism: "Does inorganic mercury play a role in Alzheimer's" Joachim Mutter, et. al. 2010… available at http://iris.lib.neu.edu/cgi/viewcontent.cgi?article=1007&context=bouve_fac_pubs&sei-redir=1&referer=http%3A%2F%2Fscholar.google.ca%2Fscholar_url%3Fhl%3Den%26q%3Dhttp%3A%2F%2Firis.lib.neu.edu%2Fcgi%2Fviewcontent.cgi%253Farticle%253D1007%2526context%253Dbouve_fac_pubs%26sa%3DX%26scisig%3DAAGBfm22crRnLUh4bivFTEXjtMZZ5c5UaQ%26oi%3Dscholarr#search=%22http%3A%2F%2Firis.lib.neu.edu%2Fcgi%2Fviewcontent.cgi%3Farticle%3D1007%26context%3Dbouve_fac_pubs%22
- Patients at risk from maternal exposure: Acta Neurobiol Exp 2009, 69: 189–197, "A prospective study of prenatal mercury exposure from maternal dental amalgams and autism severity, " David A. Geier, Janet K. Kern, and Mark R. Geier available at http://www.amalgamskadefonden.se/files/documents/Autism_hos_barn_till_modrar_med_amalgam.pdf)
- Patients at risk for periodontal disease: "Mercury From Amalgam Fillings: A Major Factor in Periodontal Disease and Oral Health Problems." Available at http://www.flcv.com/periodon.html)
- Patients at risk from experiencing tremor, cognitive impairment, coordination impairment, color vision impairment, mood issues, and immunological impairment: SNC-Lavalin Environment. "Mercury exposure and risks from dental amalgam, part 1: Updating exposure, reexamining reference exposure levels, and critically evaluating recent studies." Final Report to the International Academy of Oral Medicine and Toxicology. Ref: 10738. (November 8, 2010). Available at http://www.iaomt.org/articles/files/files329/Amalgam%20Risk%20Assessment%20Part%201.SLE%20reference%2010738.Final2.pdf

3) Comprehensive Paper sent to FDA by Bernard Windham entitled "Mercury Exposure Levels from Amalgam Dental Fillings" available at http://www.fda.gov/ohrms/dockets/dailys/02/Sep02/091602/80027dde.pdf

Appendix E: Health Canada Documents

This appendix references documents produced by Health Canada.

Point seven from Health Canada's recommendations on amalgam states, "Dentists should provide their patients with sufficient information to make an informed choice regarding the material used to fill their teeth, including information on the risks and benefits of the material and suitable alternatives."

It is incumbent on dental health practitioners to notify patients who are defined in the risk groups listed in Appendix D, that there is an associated risk with mercury amalgam fillings. It is also the responsibility of dentists as health professionals to refer these patients to appropriate health professionals for assessment and treatment. This is the basis of the second policy to ensure safety with respect to mercury amalgam fillings.

The remainder of this appendix describes the techniques that address Health Canada's fourth recommendation which states "In placing and removing amalgam fillings, dentists should use techniques and equipment to minimize the exposure of the patient and the dentist to mercury vapor, and to prevent amalgam waste from being flushed into municipal sewage systems." These techniques naturally protect the dental staff as well.

To achieve the requirements currently suggested by Health Canada, the following regulations would have to be recognized:

- No polishing of amalgam fillings.
- Safely remove all remaining unused amalgam product in the dental office.
- Use seamless flooring. No rug.
- Ensure all amalgam contamination is rinsed from the instruments before ultrasonic treatment and sterilization to prevent increased vaporization. Unfortunately this will mean a small exposure of mercury to the municipal waste system.
- In the removal of amalgam fillings in whole or in part the following techniques and equipment are employed to protect the patient, the dental team and the environment:

  1) Patient draping to protect from the contamination of amalgam dust and debris.
  2) Patient facial protection that can include full safety glasses, facial drape, extended rubber dam and/or separate O2 supply.
  3) Properly placed Nitrile Rubber Dam use. Use of chelator cream on dam that is proximal to amalgam to be removed (presently using HgX cream). May consider replacing the dam after the removal of the amalgam and before the teeth are restored if there is significant amalgam contamination.
  4) Oral pre and post-rinse with mercury binding agent, (presently using Oral Detox Pro).
  5) Saliva Ejector behind rubber Dam.
  6) Copious amounts of water when cutting...Never cut dry... Never!!!
  7) Utilization of superior high volume suction. (Clean-up) with proper post op handling as per manufacturer's suggestion.
  8) Utilization of horizontal Hg filtration suction. Replace the filters annually.
  9) Use a thin sharp bur and "chunk out" the filling to minimize the amount of amalgam drilled. Amalgam chunks to be collected, stored in sealed containers and transported to recycle/safe disposal facilities.
  10) Dentist and assistant use sleeved drape that is disposed after the removal of the amalgam.
  11) Dentist and assistant use nitrile gloves.
  12) Dentist and assistant use Hg mask. (Presently this can be done by using Mercury vapor Proof masks from Mercury Safety Products Ltd. As per manufacturer's instructions, use a conventional mask over the mercury mask. The mask can be used for one month. Each mask is labeled and dated for each staff member.) Particulate masks rated at .1 um are used over the mercury masks. Dental staff also wear disposable surgical hats and shields.
  13) Outside venting of the suction unit.
  14) Three Large CFM air ventilators in the office with a fresh air intake on the HAV system.
  15) All Hg contaminated sundries and teeth must not be placed in biohazards to prevent the vaporization of the mercury in the incineration process. Presently, there are no storage facilities to send this waste to, so the best practice is to send it to the landfill. As the 2013 UNEP treaty on mercury use is developed, there will have to be facilities

designed to store this waste in bunkers indefinitely. Until this is achieved, the best choice and least environmentally offensive disposal is the landfill.
16) These Hg contaminated sundries will be placed in a labeled waste container with a tight lid and the placement of these sundries will only be carried out with a mercury vapor mask. This waste must be disposed of daily in sealed plastic bags.
17) Chair side traps shall be replaced and discarded weekly, and if there is mercury contamination, they shall be placed in the sealed mercury waste container. In rooms where mercury removal may occur, the removal of traps shall only be carried out with a mercury mask and nitrile gloves.
18) The amalgam separator shall be checked monthly along with the integrity of the suction and compressor system.
19) All leaks and issues shall receive immediate attention.
20) The amalgam separator shall be changed every six months at the end of August and the end of February. The screen of the suction unit is also cleaned at this time in a closed container (pail), and after the complete maintenance of the separator and the screen, the contents of the pail will be sucked up by the suction, and thereafter the pail disposed of. This procedure is to be carried out with full protection including nitrile gloves, mercury mask, and full sleeve draping.
21) Proper exchange of the amalgam separators shall be carried out as per the manufacturer's instructions.
22) Annual inspection of mercury levels at various points of the dental clinic, including the traps, the ventilation system, the suction unit, mercury waste bin, and the amalgam separator shall be carried out using the Jerome Mercury detector.
23) The staff will be provided with nutrients known to increase the excretion of mercury, such as HeartGems, 1 tab daily.
24)There will be occasional testing of mercury exposure to the staff. This may be achieved a number of ways, and the technology to do this is constant flux. Presently, protocols set out by Pure North Health Group from Calgary and Quicksilver Labs in Colorado are recommended.
25) Updates on new equipment and techniques will be maintained and available for the safe handling of amalgam filling material and relate them to the staff. IAOMT and IABDM have superior continuing education courses on this material.
26) Patients will be educated on the restorative choices that are available.

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This document is a compilation and interpretation of material from reliable resources. There is no copyright on the original contents herein, and duplication by any organization or individual is allowed.

In addition to the documents referenced in the text body from IAOMT.org and IABDM.org, the following articles were instrumental in creating this document:

Review Article
A Safe Protocol for Amalgam Removal
Dr. Dana Coloson & Associates, 1950 Yonge Street, Toronto, ON, M4S 1Z4, Canada

Journal of Environmental and Public HealthVolume 2012 (2012), Article ID 517391, 4 pagesdoi:10.1155/2012/517391

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All charts, tables, graphics, and text from other sources included herein are for research purposes only, and should not be reproduced without permission from the original

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- http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2006/07/07/BAG7OJQPDC1.DTL&ao=all
- http://www.redorbit.com/news/science/804668/communities_fight_crematorium_expansion_due_to_toxic_emissions/
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