Toxics Link
for a toxics-free world

LURKING MENACE
Mercury in the health-care sector

The unregulated use of mercury in the health-care sector and a lack of awareness about its toxicity is threatening the well-being of the environment and communities

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About Toxics Link

Toxics Link is an environmental NGO, dedicated to bringing toxics related information into the public domain, both relating to struggles and problems at the grassroots as well as global information to the local levels. We work with other groups around the country as well as internationally in an understanding that this will help bring the experience of the ground to the fore, and lead to a more meaningful articulation of issues. Toxics Link also engages in on-the ground work especially in areas of municipal, hazardous and medical waste management and food safety among others. We are also involved in a wider range of environmental issues in Delhi and outside as part of a coalition of non-governmental organizations.

Srishti Toxics-Free Health Care Programme, of Toxics Link has the goal of ensuring that responsible toxics free health care practices are followed and safer technologies for medical waste are adopted in the country.

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Contents

Executive summary

The country has been working on improving medical waste management for around a decade; and during this long journey it has witnessed many policy changes and a very positive change in the way waste is managed by the health-care sector.

During this entire process, infectious waste in health-care establishments (which constitutes around 10% of hospital waste) has been addressed. The remaining 5% (the hazardous portion) now needs to be dealt with. The hospitals which generate hazardous waste have never been made accountable to the Hazardous Waste (Management and Handling) Rules. Even the basic standards for safe use of mercury issued by the Indian Standards Institute are not in place in any hospital.

Mercury, which is used widely in the health-care sector in thermometers, sphygmomanometers, dental amalgams, laboratory reagents, etc, is a very potent neuro- and nephro-toxic substance. The health impacts of this heavy metal have been widely documented.

In September 2003, Toxics Link released the first report on mercury in India, compiled for the UNEP Global Mercury Assessment. Toxics Link is part of BAN- Hg working group (Basel Action Network and the Mercury Policy Group).

This report documents the usage of mercury instruments and products in the health-care sector, the available alternatives and their acceptance, the handling procedures of mercury, its disposal, lackadaisical handling by health-care staff, etc.

This study presents a very grim picture of the way mercury is handled and disposed off by the hospital staff. Mercury equipment breaks very often, but the staff is hardly trained or equipped to deal with any such event. Mercury is handled without any protective gear and is disposed off either with incinerable waste, general waste or via drains, all of which would lead to its entry into the food chain.

Data shows that an average sized hospital can release, conservatively, around 3 kgs of elemental mercury in the environment in an year. With very conservative estimates a city like Delhi would be releasing around 51 kgs of mercury each year through dental practices alone. The city's total release would come from hospitals, dental clinics, crematoriums and laboratories. The problem is compounded as all the generation sources are scattered and non-regulated. Since there are no laws and guidelines governing the releases of mercury no one seems accountable.

The two properties that make mercury extremely unmanageable are bio-accumulation and bio-magnification. Bio-accumulation is the retention of a toxic substance in the tissues, especially muscles. The bio-accumulation factor from water to edible fish tissue exceeds 10 million for certain species of fresh and ocean water fish, thus increasing the potential for mercury poisoning. Nursing infants are the highest in the food chain and can be exposed to dangerously high levels of this element.

Viable alternatives exist for most of the mercury usages, yet, mercury use continues in the country without any regulation. The use of mercury-free products is a cost effective choice when the direct and indirect costs of the products are considered. On the basis of purchase price alone, the cost of mercury-free equipment is generally higher than mercury based products.

However, when other direct and indirect costs are considered, mercury-free equipment is found to be cost-effective for hospitals. Direct costs to hospitals include not only the purchase price but also costs associated with the clean-up of spills, training, storage, disposal and potential health risks to staff, patients, and visitors. Indirect environmental and health costs to the general public and wildlife may also be significant. Small spill clean-ups usually cost around $1000 and large spills can go into the tens of thousand of dollars.

Internationally, there is a shift towards mercury-free alternatives and strict regulations are in place on mercury emissions, but in India, mercury in the health-care sector is hardly a concern for either the policy makers or the sector itself.

There is an urgent need to bring in some policy for gradual shift from mercury equipment to safer alternatives. Health-care staff needs to be trained to handle this toxic metal safely and the disposal and emission issues need to be addressed.

1 Section 1: Overview

Mercury is the only metal which is liquid at ordinary temperatures; in fact it is liquid at 298 K. Mercury is sometimes called quicksilver because of its silvery-white appearance. It rarely occurs free in nature and is found mainly in cinnabar ore (HgS) in Spain and Italy. It is a heavy, odourless, lustrous liquid metal that sinks in water. It is a rather poor conductor of heat as compared with other metals but is a fair conductor of electricity.

Like gold and silver, mercury is a heavy metal that is extremely malleable, expanding and contracting according to temperature. Its unique properties are suited to numerous technological and manufacturing products and processes. In dentistry, for instance, mercury is used in fillings because of its strength and ability to accommodate temperature ranges of the foods and liquids we eat or drink.

The same holds true for other products subjected to temperature fluctuations, including thermometers, switches, thermostats and fluorescent light bulbs or tubes. Mercury also is used to produce some chemicals, pharmaceuticals and cosmetics. It alloys easily with many metals, such as gold, silver, and tin. These alloys are called amalgams. Its ease in amalgamating with gold is made use of in the recovery of gold from its ores.

Various industrial processes and the health-care sector use a lot of mercury and if mercury releases are not controlled, it readily escapes into the environment. Mercury can volatilise and enter air and through air it can enter water and soil system. If the liquid effluent has mercury, it can directly deposit it in water and soil. Bacteria found in soil and water can change mercury to its organic form, which is called methyl mercury.

Dealing with mercury

As mercury is very volatile, dangerous levels are readily attained in the air. Mercury gives off vapours even at room temperature. When at equilibrium at room temperature with the source of mercury, the vapour concentrates are 200 times the threshold limit value. The vapour pressure almost doubles for a temperature rise of about 10ºC. Mercury vapour should not exceed 0.1 mg/m^3 in air. It is therefore important that mercury be handled with care. Containers of mercury should be securely covered and spillage should be avoided. Mercury should only be handled in a well-ventilated area. Small amounts of mercury spillage can be cleaned up by addition of sulphur powder. The resulting mixture should be disposed of carefully. One cannot destroy this pollutant and the only way out is minimising and slowly eliminating usage and containing any leaks or spills as soon as possible.

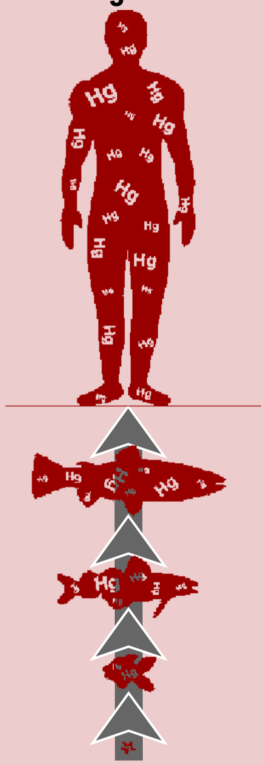
The mercury problem: a volatile metal

Mercury is the only heavy metal that can exist in three forms – solid, liquid and vapour. It is a potent renal and neuro-toxic substance. Mercury continually released into the environment will increase its levels since it does not break down. When the metal in the earth is disturbed and/or used by humans, it can ultimately be transformed into methyl mercury, a deadly compound.

Mercury occurs naturally and is found in very small amounts in oceans, rocks and soils. It becomes airborne when rocks erode, volcanoes erupt and soil decomposes. It then circulates in the atmosphere and is redistributed throughout the environment. Large amounts of mercury also become airborne when coal, oil or natural gas is burned as fuel or mercury-containing garbage is incinerated. Once in the air, mercury can fall to the ground with rain and snow, landing on soils or water bodies, causing contamination. Lakes and rivers are also contaminated when there is a direct discharge of mercury laden industrial waste or municipal sewage. Once present in these water bodies, mercury accumulates in fish and may ultimately reach the dinner table. Although mercury has been a very useful element, due to its unique properties, it poses a very real health risk-from direct exposure to mercury, as well as from eating contaminated fish.

The two properties that make mercury extremely unmanageable are bio-accumulation and bio-magnification. Bio-accumulation is the retention of the toxic substance in the tissues, especially muscles. The bio-accumulation factor from water to edible fish tissue exceeds 10 million for certain species of fresh and ocean water fish, thus increasing the potential for mercury poisoning. Bio-magnification is the process by which the toxic metal increases in concentration as it moves up the food chain (up to 100,000

Bio-magnification



Fast facts

- Mercury is the most toxic substance that people are exposed to.[1]
- Mercury can pass the skin barrier, blood-brain and the placental barrier and thus cause devastating effects on the functioning and growth of the brain and the growing foetus.
- The most likely routes of exposure are inhalation of inorganic mercury vapour after a spill or during a manufacturing process, or ingestion of methyl mercury from contaminated fish, absorption through skin
- Mercury can be found throughout hospitals in products such as thermometers, sphygmomanometers, dilation and feeding tubes, batteries, fluorescent lamps, thermostats, and bleach.
- Mercury vapour from amalgam is the most dangerous form of mercury, most rapidly crossing the blood-brain barrier and mother's placenta, and ensuring adverse developmental effects at lower levels than other forms.[2]
- Mercury can pose a significant health threat when spilled in a small, poorly ventilated room.
- There is approximately 1 gram of mercury in a typical fever thermometer. This is enough mercury to contaminate a lake with a surface area of about 20 acres, to the degree that fish would be unsafe to eat (Appendix 2). Blood pressure equipment has approximately 60 grams of mercury.
- Medical and solid waste that contains mercury or has been contaminated by mercury is considered hazardous waste and should be kept out of the waste stream.
- At present, no known treatment exists to reverse the damage caused by this element.

times the original levels, in some cases). Nursing infants are the highest in the food chain and can be exposed to dangerously high levels of this element.

Human uses

Mercury has been used for hundreds of years for a wide variety of purposes. Historical uses, which are no longer prevalent, include: preparing felt for hats, controlling mildew in paints, killing weeds as a component of herbicides, and various medical uses, such as teething powder, antiseptic ointments and syphilis treatment. Its toxic effects on workers in hat factories in the late 1800's led to the term "mad as a hatter." Mercury is still used for folk medicine and ceremonial purposes in several cultures. In the house, mercury can be found in fluorescent lights, thermostats, thermometers, and even some children's toys. At school, mercury may be found in science and chemistry classrooms, the nurse's office and electrical systems. Mercury is also found in some skin lightening creams (Appendix 1).

Alternatives and laws

Most mercury-containing equipment have a mercury-free alternative. Although some mercury-free alternatives may initially cost more, facilities often find that their initial capital costs are outweighed by the total costs associated with mercury cleanup equipment, spill costs and liabilities, and handling and disposal costs and liabilities.

Concern about the dangers of atmospheric mercury has been growing since the 1980's. Legislation to address mercury-containing products has been in existence since the early 1990's. There have been a lot of national as well as international initiatives to phase-out mercury, especially in the health-care sector. In 1993, Sweden banned or phased-out the manufacture, import, or sale of thermometers, barometers, manometers, tilt switches, float switches, pressure switches, thermostats, relays, and other types of measuring instruments. Other European countries like Norway, Denmark have banned or restricted the import, sale, and/or use of various mercury containing products. Even in other parts of the world, the gravity of the mercury problem is being realised which has resulted in moving away from it.

Footnotes

[1] ATSDR/EPA Priority List for 2003:Top 20 Hazardous Substances www.atsdr.cdc.gov/clist.html

[2] www.earthlink.net/berniew1/fetaln.html

2 Section 2: Research objectives and methodology; findings

Overview

There are no mercury emission standards in the Bio- medical Waste (Management & Handling) Rules, 1998. Emissions from the medical waste incinerators are not tested for mercury levels. Mercury is not even tested for in the effluent discharged by the hospitals, though there are limits to this heavy metal listed in the standards for water discharged to sewers connected to treatment plants (in the EPA, 1986). Mercury is hazardous and is still easily accessible to the health-care sector and even households which have limited or zero know- how about the problems with mercury. Once the people get exposed to spill mercury (due to breakage of equipment containing it) they don't even know how to manage it to avoid exposure.

Mercury is used in thermometers, sphygmomanometers, dental amalgams, some reagents, etc. Despite the fact that safer alternatives to most of these exist, people are still hesitant to use the alternatives on various pretexts. This report tries to understand the resistance to this shift and makes an attempt to change the existing situation.

Objectives

- Document the usage of mercury in the hospitals;
- Understand the risk perception of the healthcare staff with respect to mercury;
- Create awareness on the hazards of mercury;
- Raise awareness for replacement of mercury with alternative products;
- Advocate for safer work practices for healthcare staff, through formal training, spill clean up mechanisms, gradual phase out, etc;
- Advocate for a policy on usage, handling etc. of mercury in healthcare settings and eventual phase of mercury products.

Methodology

- Selection of five health-care institutions in the city;
- Interviews with nurses to gather data on breakage rate of thermometers, sphygmomanometers and other mercury instruments and to study the awareness level in the hospital regarding spill management;
- Interview with purchasing units of the health-care establishments to study the difference between the cost of digital and mercury equipments, procurement information and breakage rates;
- Conversations with manufacturers, dealers and retailers about taking back of mercury collected from the hospitals, market trends, etc;
- Survey of dental clinics to explore reasons for use of amalgam/alternative for dental fillings. And also, cost difference between non-mercury fillings and mercury amalgams fillings, experiences with all types of fillings, using questionnaires and through conducting interviews.

The Toxics Link team contacted some reputed hospitals and dentists in New Delhi for carrying out the study. A volunteer assisted us in the study by studying select hospitals in Patna. In New Delhi five private hospitals were visited as part of this survey. All of them were following improved bio-medical waste management practices and segregation was in place. Waste was being disposed off through common bio-medical treatment facilities.

Different areas of the hospitals were covered. Nursing Stations were one of our main information points as mostly nurses deal with the mercury containing instruments. We spoke to about 100 nurses in various age groups and with varied experiences. Four hospitals out of the five visited had nursing schools attached to them and hence there were nursing students in the wards at all times.

The team also contacted some reputed hospitals and dentists in Patna for carrying out a preliminary study. Seven hospitals and 12 dentists were visited as part of this survey. Eighty-four hospital staff were interviewed.

Though the hospitals we went to use several mercury containing instruments our focus for the present study was on thermometers and sphygmomanometers as these are the most commonly used instruments that contain mercury.

Case studies: hospitals

Case study 1

Hospital A is a large hospital in Delhi. It has around 500-beds and different specialty wings. The hospital has acquired ISO 14000 and under it, plans to phase-out mercury use in the hospital by June 2004. Waste managers have been proactive in seeking ways to reduce and properly handle mercury-containing items and devices.

The hospital has replaced its mercury thermometers with digital thermometers. It reports that mercury spills or problems with mercury-containing devices are quite rare. The medical/hospital staff is happy with the digital thermometers, but some of them do mention some confusion due to a lack of training on the usage of these digital thermometers. The hospital has not replaced its sphygmomanometers and still uses mercury-containing units. Hospital staff reports that spills from the blood pressure units are rare.

Staff training: Frequent training is given to ensure that staff is properly segregating waste. Staff has also been trained to handle mercury spills.

The maintenance department receives 60 blood pressure apparatus for maintenance each month, of which 5-6 pieces require re-filling, while the rest need calibration. The department purchased one kg of mercury in July last year to be used in filling of blood pressure apparatus. One kg mercury lasts for around five to six months. The mercury samples collected from spills and broken equipment is never refilled in the apparatus (because of the ISO standards). The hospital had collected mercury samples for around a year, the total of which came to around 1,600 grams. The entire mercury was stored under water and sold to a mercury thermometer manufacturer, who paid them by weight.

Case study 2

Hospital B is another large hospital in Delhi with around 500 beds, also having almost all specialty wings.

The hospital is using mercury- containing instruments and there are no immediate plans to phase them out. The hospital does not have any written policy on mercury spill management. The breakage rate of mercury thermometers is quite high – about 4-5 every month in each ward. The spill clean-up is done most of the times by the housekeeping or the ward boys who are unaware of the hazards of mercury. There are hardly any precautions taken while cleaning. Some of the nurses, though aware of the correct procedure of clean-up, never follow them.

Some of the staff nurses have used digital thermometers and even though they think it is easier to use, they found it inaccurate. Non-invasive blood pressure (NIBP) is also being used in some wards, but again though they are considered to be very convenient, the accuracy is an issue sometimes.

Staff training: There are regular training sessions in the hospital. Majority of the nurses are aware of the hazards of mercury, as they have read about it in their nursing school.

80-100 pieces of thermometers are purchased each month to meet the demand due to thermometer breakage. About 10-12 blood pressure units are bought each year.

250-300 pieces of sphygmomanometer came to the maintenance department for repair in 2003, out of which about 100 came for mercury related issues. The mercury re-filling in the BP units was done in the maintenance department of the hospital. The mercury was handled without any protection during the process. Used mercury was sieved though bandage for removing dust particles and then used for filling in the BP units. The total requirement of loose mercury for refilling purpose was about 500 gm annually.

Case study 3

Hospital C is a 550-bedded hospital. With no definite mercury policy in place, there is hardly any care taken while handling mercury. The mercury containing equipments are being used even in this hospital and there are no plans to substitute them in the near future.

The hospital has only one or two thermometer breakages per ward compared to the figure of 4-5 in other hospitals. All patients have separate thermometers while they are in the hospital, which is given to them on their discharge.

The breakage of thermometer is not very high because there are some training sessions regarding mercury organised in the hospital. Mostly nurses clean up the spill; they wear protective gear while doing it.

Staff training: There are regular training classes in the hospital, which also include sessions on mercury.

The hospital purchased about 550 thermometers in a month and 90% of these were given to the patients on their discharge. About 20 BP instruments were bought in a month.

Case study 4

Hospital D is a 300-bedded hospital. No written mercury policy is in place in this institution. The hospital is not convinced about the accuracy of the digital products and therefore rely on using mercury-containing instruments.

The survey responses suggested that, while some hospital employees are aware of proper procedures for handling mercury wastes and spills, most of them are unaware that broken thermometers and other mercury-containing items must be disposed off as hazardous wastes and not as bio-medical wastes. Some hospital staff mistakenly believe that because broken thermometers are sharp, they should be disposed of in a sharps container.

Though the hospital has never used digital products, the doctors express apprehension about the use of the same. Doctors measure the BP of the patient and they feel that a precise reading is obtained by the mercury apparatus, and not through digital devices (personal experience of using at homes, etc).

Staff training: Regular training sessions are organised to keep the staff efficient.

Around 70 thermometers are purchased every month to replace broken thermometers. Requirement for BP instrument is around 2-3 per month. The BP apparatus was initially mounted on a frame and thus lasted for a longer duration. However, after being dismantled the stores has received request of new ones frequently.

The Stores Department purchases around 500 gms of mer-

There is still a general belief among the dentists that a mercury amalgam lasts longer. But according to some, the composites available in the market are as good as amalgams with respect to their longevity

cury, which generally lasts for a year. It is given to the bio-medical engineering department, which uses it for filling up BP apparatus.

Case study 5

Hospital E is a small hospital with capacity of around 70 beds. The hospital is using mercury thermometer as well as mercury blood pressure units. The hospital is quite active on the waste management system but there is no definite policy for mercury yet.

Almost all the nurses were aware of the dangers of the element and hence are very careful while handling mercury- containing instruments. The thermometer breakage in the hospital is very less. In ICU as well as OT, NIBP was used for body temperature and blood pressure measurement. Mercury equipments were also kept in these places, since at times NIBP gave faulty readings.

Staff training issues: There are no regular training sessions, but at the time of joining, the nurses do go through a small session on waste management and segregation. Though they are asked to handle the thermometer safely, not much stress is put on the procedure of cleaning.

The staff nurses turnover is very high. There are no trainee nurses at any point in the hospital.

Only 2-3 thermometers are bought each month. Around 12 BP instruments are purchased, mainly because of new divisions. 20-25 BP instruments needed repair annually. The hospital does not do any mercury related repair job in the hospital. The supplier does the repair under an annual contract. Even the mercury collected from spills is given to the supplier.

Hospitals in Patna

The hospitals visited in Patna included large hospitals with around 1,600 beds to small units with around 40 beds. All the hospitals, except one, did not even have a proper bio-medical waste management system in place.

Mercury containing instruments are used in all the hospitals. Only one small 50-bedded hospital has started using electronic thermometers. There is no mercury policy in any of the hospitals. The breakage rate of mercury thermometer is high, around 30-40 per month (some of the hospitals refused to give the figures). The spill clean up is done mostly by the nurses or the sweepers. There are no precautions taken while cleaning and no protective gears are used during mercury handling and disposal.

Staff training: There are no regular training sessions in most hospitals.

Dental clinics

In total, 15 dentists were interviewed, covering South Delhi and East Delhi. Although all the dentists are aware of the hazards of mercury, only few of them believe that amalgam is harmful. Half of these dentists prefer to work with composites. The reasons for their choice vary:

- Most of the dentists using composites have opted for it because of its aesthetic property;
- Few of the dentists, who are using only amalgam, do not have the clientele that can afford the high price of composites;
- There is still a general belief among the dentists that a mercury amalgam lasts longer. But according to some, the composites available in the market are as good as amalgams with respect to their longevity.

Mercury amalgams for dental use can be obtained in two ways. The first, and the most widely used, way in India is to buy silver alloy and mercury separately and mix them. The second way is to buy capsules containing pre-measured amounts of mercury, silver, zinc and other alloys. The capsules are available in three sizes: single (400 mg of material), double (600 mg), or triple (800 mg). A membrane inside the capsule keeps the mercury separated from the silver, zinc, and other alloys. Once the mercury is in contact with the other materials, it bonds to them rapidly and the mixture begins to harden quickly.

As much as 50% of the amalgam may remain unused after the decayed area is filled. The disposal of amalgam depends on how it was used. The excess amalgam that is unused after a tooth is filled is called 'non-contact' amalgam: it was never placed into a tooth and was never in contact with any human tissue.

'Contact amalgam' is amalgam that has been in contact with human teeth or tissue. This material is generated when dentists remove old fillings, when they extract teeth that contain amalgam, and when they polish a new filling to remove the excess amalgam.

While individual dentists may think they are only discharging trace amounts of mercury, in reality they do not know how much mercury they generate. And when you take into consideration all dentists in the town, city, or state, the quantiy really adds up!

The calculation for the quantity of non-contact amalgam generated takes into account the following: Dentists will work 48 weeks per year; they will use the smallest size capsule (400 mg total, 200 mg of mercury); Assuming Delhi has 1000[1] dentists; and an average of 15% excess amalgam is generated per filling for both capsule and the other form of making amalgam.

A calculation of the amount of non-contact amalgam generated by Delhi General Practice Dentists in a year[2]

200 mg mercury per filling x 8 fillings per week x 48 weeks per year x 0.15 (excess) x 1gm per 1,000 mg = 11.52 gm of mercury per dentist per year.

11.52 gm mercury per dentist per year x 640 dentists* = 7,372.8 gm of mercury per year of non-contact amalgam
(* A state like Delhi might have 1,000 dentists registered to practice in Delhi. It can be assumed that out of these only 80% are active and also that only 80% out of the active are using amalgam as the filling material.)

Research in this field suggests that the amount of excess amalgam remaining after a filling is completed, may be as much as 50%. Also, in our study we found that general dentists placed an average of 25 new fillings per week. Assuming the above calculation to represent the minimum amount of non-contact amalgam generated each year, the maximum amount can be calculated to be 76,800 gms year.

% amalgam not used in filling	Avg number of placements (per week)	Gms of Hg waste per year (from non-contact amalgam)
15%	8	7,372.80
50%	25	76,800.00

Contact amalgam waste is generated when old fillings are replaced, teeth with amalgam are removed, or when new fillings are polished. When old amalgams are drilled out of a patient's tooth, the amalgam tends to come out of the tooth in many sizes from fine dust particles to small chips. It would be difficult to determine how much material is being lost to the sewer and how much is going into the waste bin. A rough estimate can be made to get a range of the amount of amalgam that may be going to the waste. A study states that 25% of the removed amalgam material goes to the sewage system. It was found that general practice dentists remove an average of 2 amalgams per week, with each amalgam filling having 200 mg mercury each. Applying these numbers, as much as 9,216 gm of contact amalgam waste may be generated each year.

A calculation of the amount of contact amalgam generated by General Practice Dentists in a Year[3]

200 mg mercury per filling x 2 fillings per week x 48 weeks per year x 0.75 x 1gm per 1,000 mg = 14.4 gm of mercury per dentist per year.

14.4gm Hg/dentist/year x 640 dentists = 9,216 gm

According to studies[4], anywhere from 0-50% of this removed amalgam is lost to the sewer, and anywhere from 50-100% of the amalgam may be disposed of as waste. Based on these assumptions, it could be estimated that the amount of contact amalgam going into waste each year may range from 4,608 gm (50% of contact amalgam generated) to 9,216 gm (100% of contact amalgam generated). It should be noted that no definitive conclusions can be drawn from these calculations before additional research is conducted to determine the extent to which dentists may be disposing of contact amalgam

The above calculations do not include whole extracted teeth with amalgam fillings that are removed. Dental school facilities are also not included. To accurately estimate the total amount of mercury waste from dental offices, it would be necessary to conduct a comprehensive study. The generation of mercury-bearing wastes from dental offices could be substantially reduced if fillings made from composite materials were to become more popular.

Mercury thermometer breakage is never handled carefully, some of the major ways in which spills are handled are sweeping it down the drain, collecting it in a container and discarding it as general waste, collecting and putting it in yellow bags was rarely the case

Recycling both contact and non-contact amalgam waste from dental facilities is only a short-term option for reducing mercury emissions from dental sources. The ultimate aim should be to totally eliminate mercury from dental clinics.

Findings

Thermometer

- The maintenance department of the hospitals calibrates all the thermometers of the hospital once in a while. Since mercury thermometers can not be calibrated, they are simply discarded in the trash. There is no policy on the disposal of this waste;
- Most health-care staff discards broken thermometers with glass waste, since, for them, the broken glass is the major hazard in it, rather than the mercury inside;
- Hospitals with nursing schools, register a higher breakage rate. This can be attributed to a lack of experience. With senior staff breakage rate reduces;
- One of the reasons mentioned for breakage of clinical thermometer was that it is kept in a glass bottle and when they are putting it in, it breaks. They have to be extra careful as the glass bottles have a hard bottom. One of the hospitals has replaced the glass bottles with plastic ones;
- Mercury thermometer breakage is never handled carefully, some of the major ways in which spills are handled are sweeping it down the drain, collecting it in a container and discarding it as general waste, collecting and putting it in yellow bags was rarely the case. Only some people collect and store mercury. St. Stephen's hospital collected around 1.6 kg of mercury over the last two years (since last year they have switched over to digital thermometers) and sold it to a recycler;
- Average monthly breakage rate of thermometers in a 500-bedded hospital is around 70.

Sphygmomanometers

- Most hospitals calibrate the BP apparatus in-house. The Maintenance Department does this in most cases, and generally, the person doing it has adopted methods used by his/her predecessor. It's without any formal training on the the methods of calibration or the hazards of mercury. According to some experts the mercury vapour level in such calibration rooms is much higher than the permissible limits;
- One of the hospitals encased their BP machines and found that the breakage rate came down. On removal of the case, they started recording breakage again;
- Nurses found it difficult to read the scale exactly, thus they have a practice of rounding of the figure to the nearest big mark;
- Manual techniques may suffer from observer bias. Differences in auditory acuity between observers may lead to consistent bias.

Dental fillings

- People doing composites observed that amalgam fails at the aesthetic front because of poor colour matching. Amalgam is not possible in the cavities of the anterior teeth. Even at the posterior end, aesthetically mercury is a poor choice over alternatives, which offer very good colour matching;
- Mercury tends to vapourise from the amalgam and gets impregnated in the gums. After few years some patients might develop a white silvery line on their gums, which is called amalgam tattoo. According to some researchers, this proves that there is mercury release from dental amalgams;
- Initially there were problems of sensitisation with composite fillings, but now since people have started giving liners (a layer of material which gives thermal insulation), this problem has been solved a great deal. (Amalgam fillings do not have this problem because metal particles in the filling get corroded and the products of corrosion cover its surface and insulate it from the environment);
- Earlier patients frequently came back with fractured fillings in case of composites. But over the last few years the quality has improved and both dentists and patients are not facing such problems, and have developed confidence in these alternates;
- Composite fillings cost double than their amalgam counterparts and thus cost is the major factor that influences the type of filling. But because composites are aesthetically sound there is an obvious inclination towards these in middle and upper middle class locations and vice versa in the lower income group;
- Children are generally given a 'miracle mix' or glass anomer fillings to avoid mercury toxicity. Composites are not done in children because it takes much longer time and the procedure is tedious;
- No protective gear is worn while handling mercury in the dental procedures.

Occupational safety

- Health-care staff knows about the toxicity of mercury, but the gravity of the danger is not appreciated by most. The conception is that the amount found and used in the health-care sector is too low to cause any harm.
- Around 89% of the nurses interviewed were aware of the hazards of mercury, though only 60% followed some safety

guidelines in case of a spill. Only about 18% followed the correct procedure;

- In hospitals most people do not wear any protective gear while handling mercury;
- In the process of preparing amalgam in the dental sector, generally no protective gear is worn. When silver powder is mixed with mercury liquid, a solidified mix is formed, which is then put in a gauze piece and strained manually to squeeze out excess mercury (called squeezing), then this material is taken in palms and rubbed to get a uniform mix without any air bubbles (process is called mulling). This is done by dental assistants who are unaware about the hazards of mercury. Dentists admit that even after knowing the hazards they themselves sometimes avoid using protective gear. Amalgamators are available for preparing amalgams and avoiding any undue exposure, yet manual mixing is still prevalent.
- Most dentists recalled witnessing mercury spills during their student life;
- Mercury reacts with gold and silver jewellery to form amalgams; lot of nurses have experienced this phenomenon and thus are very careful about their jewellery before dealing mercury;
- A nurse had experimented with reversing the process of amalgamation by heating her bangle, and till date thinks she was successful to some extent, oblivious of the fact that she narrowly escaped death. Mercury has a very high vapour pressure and on heating, (especially in closed, badly ventilated room) the mercury vapour released can be enough to cause death by inhalation;
- People involved in calibrating mercury thermometers can be at high-risk of mercury exposure because most of them do this without any protective gear, and the method involves higher levels of mercury vapours and more exposure time;
- No documented cases exist for occupational mercury exposure in India. The reason is not non- existence of such cases, but simply the ignorance about the hazards of mercury. People are not aware of the hazards of mercury (long and short term), thus even if they might experience some of them, they might not be able to relate with them.

Disposal of mercury from various sources

- As much as 9,216 gm of contact amalgam waste may be generated each year in Delhi. It is estimated that the amount of contact amalgam going into waste each year may range from 4,608 gm (50% of contact amalgam generated) and the same amount may be going into the drain;
- Findings of a study on wastage of mercury form dental clinics, applied to the Delhi context suggest that the minimum and maximum amounts of non-contact amalgam generated each year could approximately be 7.3 to 76.8 kg;
- Delhi may be generating around 51 kgs of mercury from amalgams each year, which is thrown in the general bins or drained into sewers;
- An average sized hospital in Delhi may record a breakage rate of 70 thermometers in a month and thus contribute around 840 gms mercury per year through thermometers alone. Taking into account BP apparatus and assuming a leakage of only around 1/3rd of the total amount of mercury in it (60 gms), and assuming two spills a month, around 480 gms of mercury may be wasted. Considering mercury wastage of a hospital only due to thermometers and sphygmomanometers and ignoring all other sources, a hospital is accountable for an environmental mercury burden of 1,320 gms/year. Similar hospital with a dental wing may release 2.8 kgs of mercury;
- Some of the dentists interviewed do collect the residual amalgam or mercury separately. Since there are no regulations regarding this waste disposal, they are clueless on the proper disposal. The waste keeps lying in some dental offices for long periods and eventually gets thrown in municipal waste.

Footnotes

[1] Repeated attempts to get the exact number of dentists registered in Delhi failed. The state dental council said it does not have the figure. Hence it is a rough estimate.

[2] Based on the study done by Florida center for solid and hazardous waste management

[3] Based on the study done by Florida center for solid and hazardous waste management

[4] Based on the study done by Florida center for solid and hazardous waste management

3 Section 3: Sources of mercury

There are a number of ways by which mercury enters our environment, some are natural but many are the result of human activity.

Industrial uses and consumer products containing mercury can be significant sources of mercury released into the environment. Air emissions from coal-burning power plants, trash incinerators, medical waste incinerators and hazardous waste combustors are major contributors.

But not all mercury comes from emissions into the air. It can also come directly from such sources as municipal and industrial sites, hospitals, dental office wastewater or the breakage or disposal of mercury-containing products such as fluorescent lights, thermostats and thermometers.

Either way, through air or directly, once the mercury is in soil, a lake, pond, or stream, it can be transformed to its most toxic form, methyl mercury, which builds up in fish and animals that eat fish, for example, loons, otters and human beings.

There is clear evidence that mercury impacts on the environment have considerably increased globally due to human activities. The most significant environmental releases of mercury are air emissions, but mercury is released in other ways, including discharges from various sources to water and land. The relative contributions to the releases of mercury from different source types vary between countries.

Some examples of major sources of anthropogenic releases of mercury are:

Releases from mobilisation of mercury impurities:

▲ Coal-fired power and heat production (largest single source to atmospheric emissions)
▲ Energy production from other fossil carbon fuels
▲ Cement production (mercury in lime)
▲ Mining and other metallurgic activities involving the extraction and processing of virgin and recycling mineral materials, for example production of:
  ❖ iron and steel
  ❖ ferro-manganese
  ❖ zinc
  ❖ other non-ferrous metals
▲ Petroleum production

Releases from intentional extraction and use of mercury:

▲ Mercury mining
▲ Small-scale gold mining (amalgamation process)
▲ Chlor-alkali production
▲ Use of fluorescent lamps, instruments, dental amalgam fillings, etc.
▲ Manufacturing of products containing mercury, for example:
  ❖ thermometers
  ❖ manometers and other instruments
  ❖ electrical and electronic switches
▲ Biocides (for example,seed-dressing, pesticides and slimicides)
▲ Use of other products, such as batteries, fireworks and laboratory chemicals

Releases from waste treatment, cremation, etc. (originating from both impurities and intentional use of mercury):

▲ Waste incineration (municipal, medical and hazardous wastes)
▲ Landfills
▲ Cremation
▲ Cemeteries (release to soil)
▲ Recycling and storage

Major sources of mercury releases

Man-made sources of mercury pollution

Source	Percentage
Coal-fired power plants	33%
Industrial boilers	17.9%
Municipal waste combustors	18.7%
Medical waste incinerators	10.1%
All other sources	20.5%

From EPA 1999 Mercury Study Report

Bio-medical sources

The most obvious sources of mercury in biomedical research facilities are thermometers, blood pressure gauges, clinical reagents and laboratory chemicals. Mercury is used or present in many other items that may be less obvious such as drugs and bio-logics, fluorescent light tubes, switches and other electrical devices. It is also present as an unintended contaminant in a wide variety of commercial products such as animal bedding and bleach and may concentrate in plumbing. Dental amalgams may be another significant source of mercury in the environment.

Routes of mercury exposure

According to WHO these are the general sources of mercury in the body (µg / day):

- ▲ Air: 0.040
- ▲ Fish 2.34
- ▲ Non-fish food: 0.25
- ▲ Drinking-water: 0.0035
- ▲ Mercury vapour from dental amalgams: 3-17

Mercury vapour from dental amalgam alone is, on a group level, a bigger source than all the other sources together. Breast milk from fish-eating mothers can be quiet high in mercury.

Natural Sources

Mercury is a naturally occurring element that is present in trace amounts throughout the environment. Much of it is isolated in coal and other geological deposits.

Mercury emission from crematorium

Mercury is ever-present in the environment as a consequence of both natural and industrial emissions. One source of mercury in the atmosphere is from crematoria. Dental amalgam consists of 50% metallic mercury, and although the risk of mercury poisoning to dentists and their assistants is recognised, little attention has been paid to the final disposal of filled teeth. Cremation of those with amalgam fillings adds to air emissions and deposition onto land and lakes. A study in Switzerland found that in the small country, cremation released over 65 kg of mercury per year as emissions, often exceeding site air mercury standards, while another Swiss study found mercury levels during cremation of a person with amalgam fillings as high as 200 micrograms per cubic meter (considerably higher than U.S. mercury standards). The amount of mercury in the mouth of a person with fillings was on average 2.5 grams, enough to contaminate 5 ten-acre lakes to the extent there would be dangerous levels in fish. A Japanese study estimated mercury emissions from a small crematorium to be 26 grams per day. A study in Sweden found significant occupational and environmental exposures at crematoria. Not only may this be a risk to the health of the general population but also to those who are occupationally involved.

A study of assessing hair mercury in a group of staff at some of the British crematoriums found that the group's hair mercury were significantly high. National emission standards that require gas cleaning at new or large crematoria are in place in Austria, Belgium, Germany, Netherlands, Norway, Sweden and Switzerland.

There has been no study regarding this in India; but as majority of dead bodies are cremated in India,one can easily assume that the emissions would exceed the safety standard.

Section 3a

Contamination in India

Chlor-alkali industries are still the major source of mercury release in atmosphere and surface water. Other industries, which contribute to mercury pollution in India are coal-fired thermal power plants, steel industries and cement plants. Plastic industry (mercury is used as a catalyst), pulp and paper industry, medical instruments and electrical appliances. Certain pharmaceutical and agricultural products account for additional consumption of mercury. India consumes 75 million tonnes of coal every year in various thermal power plants. Coal contains mercury and its combustion as a source of energy is often cited as a significant source of mercury emission. Mercury levels are reported to be extremely high in the working environment of these industrial processes including thermometer factories, and even medical practices such as dental clinics. The effect of mercury on human health and the working environment in the industry has not been taken seriously. The hazardous working conditions and dangerous waste management practice is still continuing in several industries related to mercury.

Although it is well recognised that mercury is wide spread in the Indian environment and that exposure occurs primarily through consumption of fish, information about its distribution in the blood system or hair mercury levels in the Indian population is lacking. Hence, it has become difficult to fully evaluate the public health significance of the mercury problem. Recent evidence has come to light that exposure to mercury is widespread and occurs at levels exceeding health based recommended value among the Indian population. India's population was unaware of mercury hazards for last few decades. The awareness regarding hazards caused by mercury pollution is now increasing among Indians.

Environmental load

The presence of mercury in the environment (air, water and land) in India can be traced back to the 1970's, when various studies conducted showed the presence of mercury in our environmental bodies.

Water

Both surface and ground water have become increasingly contaminated with wastes and pollutants from industry, agriculture and household. Over the years, water pollution has increased the concentration of mercury in Indian waters. Ground water provides about 80% of drinking water needs in India. A 1999 study tested and analyzed ground water samples from eight places in three states — Gujarat, Andhra Pradesh and Haryana — where mercury contamination has been reported. The results are shocking: the mercury levels found are dangerously high in all the samples. The critical areas from where samples were collected were:

Industrial units have jeopardized the groundwater resources mainly by indiscriminate disposal of hazardous wastes and effluents. A fair share of the effluents is also being dumped into the ground

Patancheru (Andhra Pradesh): In Patancheru Industrial Area (PIA), Medak district, the level of mercury was *115 times the permissible limit.* In Patancheru, most of the 400 industrial units don't treat their effluents properly, so they dump them in the open or inject them directly into the ground, as suggested by the report. Most of the industrial units here deal with pharmaceuticals, paints, pigments, metal treatment and steel rolling. They use organic and inorganic chemicals as raw materials, which are reflected in appreciable amounts in the effluents.

Panipat (Haryana): In a tested sample of groundwater from Panipat, the mercury level was found to be *268 times the permissible limit.* The presence of chemicals was found to be more than what is permitted for industrial units. Most of the polluting wastewater comes from the 500-odd dyeing and processing units that have mushroomed in the city. It is common knowledge in Panipat that the industrial units involved in dyeing and dye-related operations pump effluents into the ground. Much of the effluents from these units either flow into open drains or on to vacant land. The water never reaches the end of the drains but percolates into the ground much before that.

Vatva (Gujarat): "It has been common practice in Gujarat to pump effluents into the ground directly through borewells, a deliberate attempt to kill people," says the 1999 report by *Down to Earth*. Ground water within a range of 30-35 km of the Vatva Industrial Estate (VIE) in Ahmedabad district has been contaminated. Mercury level was *211 times the permissible limit in a village 15 km away fro Vatva.* The village is near a seasonal river Khari, which comes through Vatva and only carries industrial effluents and has been reduced to little more than a sewer. Other villages along the bank of the stream face a similar problem.

Ankleshwar (Gujarat): Industrial units have jeopardized the groundwater resources of the area mainly by indiscriminate disposal of hazardous wastes and effluents. A fair share of the effluents is also being dumped into the ground. A sample of water from a borewell in Chiri village, near Vapi, showed a mercury level that was about *90 times more than the prescribed limit.* Factories in VIE deal with some very hazardous chemicals, including pesticides and other agro-chemicals, organo-chlorine chemicals, dyes, acids like H-acid, liquid chlorine and chlorine gas.

Nandesari (Gujarat): The Nandesari Industrial Estate (NIE) near Vadodara is a major production center for highly toxic chemicals, like H-acid, which are not easily biodegradable. "Disposal of untreated mercury contaminated effluent from caustic soda manufacturers has heavily contaminated the groundwater in Nandesari," says a report submitted by the Union Ministry of Environment and Forests to the World Bank.

Mercury Hot Spots

Beside the above-mentioned places, there are other hot spots where various studies reported mercury pollution and contamination over time:

Ib River (Orissa): The Ib River valley area throws up numerous instances of industrial pollution. According to a report prepared by Ib Paribesh, an NGO working in the area for more than four years now, almost all the surface water has become unfit for human consumption. The contamination of groundwater resources has also reached a critical stage.

Rushikulya River (Orissa): A study by the Council of Professional Social Workers (CPSW), Bhuvaneshwar, reports that the Rushikulya River, in Orissa, is polluted by a number of effluents from various industries. However, the most hazardous pollution of Rushikulya is due to a chlor-alkali factory, which discharges its mercury bearing effluents into the river, causing pollution in Ganjam and its nearby areas. Thousands of acres of agricultural fields have lost their crops. There were tests conducted by a research team of the Department of Botany from the Banaras Hindu University (BHU). The tests reported presence of mercury in fish, trees and river water as an effluent traced to the factory.

Kalu River (Bombay): A series of investigations by Ramani Rao and Dr B.C. Haldar for the Institute of Science in Bombay in 1979 have revealed the presence of heavy metals in the aquatic environment of the Kalu River, on the outskirts of Mumbai. The river is recreating another pollution disaster. The Institute of Science investigated a stretch of 10 km from Ambivali to Titwala, along which toxic wastes from a rayon factory, a paper mill, a dye factory and a chemical plant pour into the river.

Heavy metal contents of pycreus plants, the most abundant at Ambivali, showed unusually high concentrations. "The leaves of these plants contain 3 to 110 ppm of mercury. The rhizomes of the same plants contained 6.9 to 53.3 ppm," reveals the report of the Institute of Science. There is 5 ppm of mercury in the milk of milch cattle that graze on the pycreus plants. A child drinking a litre of this milk every day consumes 35 ppm mercury in a week. Over a period of several months this can lead to an accumulations of over 0.3 mg of mercury, which is well above the safe level. Further studies carried out by the Institute of Science show that the problem of toxic chemicals may also be spreading to other areas in and around Mumbai.

Kodaikanal (Tamil Nadu): URS Dames & Moore had been commissioned by Hindustan Lever Ltd (HLL) to conduct an environmental site assessment and preliminary risk assessment for mercury at its wholly owned thermometer manufacturing facility located at Kodaikanal, in Tamil Nadu. This followed publicity by Greenpeace and the Palni Hills Conservation Council after their discovery of glass scrap illegally disposed off by the manufacturing facility in a scrap yard in Kodaikanal town. The thermometer plant in Kodaikanal, one of the largest thermometer-manufacturing factories in the world, has been guilty of dumping mercury-containing glass waste. Till date**, the factory has produced 165 million thermometers with 125,000 kg of mercury with a breakage rate of 30 to 40 per cent**. The company, in its report to the Tamil Nadu Pollution Control Board, assesses the amount of mercury released into the environment from its factory site in Kodaikanal at *539* kg (stating a statistical variance of between 43 kg minimum to 1,075 kg maximum).

The glass scrap from the mercury-contaminated area contained residual mercury and until 1990 was dumped in the compound. During the monsoon season, the mercury used to be washed away into water bodies due to run-off, contaminating the water bodies in the area, especially the rivers.

Bhopal (Madhya Pradesh): The Peoples Science Institute (PSI) in Dehra Dun has found high levels of mercury in the groundwater sources of Bhopal, especially near the closed Union Carbide factory. The water is dangerous for human consumption, as the area of ground water contamination is increasing. Water samples from various localities were taken for testing. Analysis of the samples showed concentrations of mercury as high as 2 ppm in some places, which is above national and international standards.

Golden Corridor (Gujarat): The Paryavaran Suraksha Samiti (PSS) in 2002 collected samples from over 20 villages affected by industrial pollution in the Golden Corridor of Gujarat to investigate the water situation. The samples were also tested and analysed for mercury. The results of mercury concentration in the villages near the industrial areas were shocking: in Haria village and Atul Complex, the mercury level was shockingly high, at 12 ppb – 1,200% more than the permissible limit of 0.001 ppm. Another sample in Ankleshwar showed mercury at a high level of 2 ppb – 200% above the standard. Samples in Vadodara- Nandesari ECP Area also showed high mercury levels, at 6 ppb and 1.3 ppb, which are, respectively, 600% and 30% more than the prescribed standards.

Delhi: A recent study conducted by the Environmental Science Department of the Guru Gobind Singh Indraprastha University, reveals that the concentration of contaminants like arsenic, mercury, nitrates, etc, in Delhi's ground water exceeds permissible limits. The study entailed 50 samples of groundwater being lifted from random spots along a 22 km stretch between Palla and Okhla. The mercury concentration in some samples was as high as 4.6 ppm. This alarming presence of mercury in groundwater can be traced to the continuous discharge of sewage and industrial effluents into the Yamuna and, subsequently, into the groundwater aquifer which, being sandy in nature, allows mercury to leach at a rapid rate.

Mercury in Indian rivers

A brief compilation by the Industrial Toxicology Research Centre (ITRC) of the heavy metal analysis (including mercury) of India's major rivers was presented in 2001 in the 'High Powered Committee on Management of Hazardous Wastes'. The levels of various heavy metals including mercury were monitored in different water bodies by the ITRC, such as the Ganga river system including the main channel, its tributaries, viz, Yamuna, Gomti, Kalinadi, Ramganga, Ghaghra, Son, Gandak and Hugli estuarine system.

Surface and groundwater sources including minor streams, wells, hand pumps, ponds, reservoirs, lakes, etc, which are used for drinking water supplies in the north and north- eastern states of India were also analysed. Since there are no prescribed permissible limits of heavy metal for surface waters, the levels are compared with those of drinking water. The permissible limit for mercury in drinking water is 0.01 mg/l.

The river Ganga: From 1986-1992 water samples were collected each month from 20 different locations: Rishikesh, Haridwar, Garhmukteshwar, Trighat, Buxar, Rajmahal, Behrampur, Palta, Dakshineshwar, Uluberia, as well as upstream and downstream of Kannauj, Kanpur, Allahabad, Varanasi and Patna. During this six-year period, some 1,400-river water samples were analysed for levels of 10 different metals including mercury. The concentration levels for mercury in the river Ganga was found to be as high as 0.1 mg/l.

Tributaries of Ganga: From 1986-1992, water samples were collected each month from the seven major tributaries of Ganga and analysed for different metals levels.

Tributary of Ganga	Mercury (in mg/l)
Gomti (Udyarghat)	0.003
Gandak (Patna)	0.02
Ghaghra (Saran)	0.06
Kalinadi (Kannauj)	Not detectable
Ramganga (Kannauj)	0.02
Yamuna (Allahabad)	0.10
Son (Koelwar)	0.05
Hugli estuary water	0.29

4 Section 4: Mercury usage and alternatives in health-care

Mercury or mercury compounds are found in many instruments regularly used in medical institutions such as blood pressure monitors, dental amalgam, thermometers and thermostats. Mercury and mercury-containing products are used in patient areas and pathology labs, in clinical procedures (such as X-rays), and in medicines and vaccines (Appendix 3) At least 20 different medical products contain mercury, and many mercury-containing solvents and degreasers are found in labs, housekeeping departments, kitchens, and maintenance areas. Storage rooms may also be filled with used, damaged, or outdated equipment or supplies that contain mercury. Mercury is an ingredient in some proprietary formulas used to manufacture medical and industrial supplies. For a complete list of instruments, products, and laboratory chemicals used in hospitals that may contain mercury, see Appendix 4.

Non-medical uses of mercury are also present in a variety of products: cleaning solutions, preservatives, paints, and anti-fouling agents for wood and other surfaces. Some uses of mercury are purely playful or convenient, such as singing greeting cards, lighted shoes, and toys. Patients, visitors, and employees bring these products into the facility.

Affordable alternatives

Most of the mercury that enters the environment comes from human use. It has been used in thousands of industrial, agricultural, medical and household applications. But now majority of products that use mercury purposefully have acceptable alternatives. The following list of alternatives should not be assumed to be complete. These are provided only as examples of mercury-free alternatives that are currently available for use in health care facilities.

Alternatives for mercury-containing thermometers

- ▲ Electronic (digital)
- ▲ Infrared
- ▲ Chemical Strip
- ▲ Glass filled with alcohol, gallium, indium or tin

Alternatives for mercury-containing sphygmomanometers

- ▲ Aneroid
- ▲ Electronic

Alternatives for mercury-containing gastrointestinal tubes

- ▲ Bougie tubes (tungsten)
- ▲ Cantor Tubes (tungsten)
- ▲ Miller Abbott tubes (tungsten)
- ▲ Feeding tubes (tungsten)

Alternatives for mercury-containing laboratory chemicals

The mercury compound in a chemical formulation may be an active ingredient, a preservative, or a contaminant introduced during manufacturing. Identify why mercury is present and a replacement may be able to be identified. Hospital purchasing agents should contact suppliers and request mercury-free reagents.

Alternatives for mercury-containing pharmaceutical products

In many cases mercury-free preservatives are available.

Dental amalgam

Metal ceramic crown, glass inomer, synthetic polymer, gold alloy etc. are available alternatives

Electrical applications

Mercury is used in temperature-sensitive switches and in mechanical switches. These are used in products like thermostats and silent switches. Mercury tilt switches have been used in thermostats for more than 40 years. A small electrical switch may contain 3,500 milligrams of mercury; industrial switches may contain as much as eight pounds of mercury. Now, there are numbers of alternatives available to these products such as electronic thermostats, float control, temperature sensitive switches.

Mercury-containing chemicals

Chemical reagents used with regularity in a wide range of laboratory testing are likely sources of mercury contaminations. After concern shown by several environmental organisations, these mercury reagents are substituted with other chemical alternatives.

Mercury free alternatives exist for most mercury-bearing products. In fact, cost does not appear to be a significant barrier to the replacement. The use of mercury free products is a cost effective choice when the direct and indirect costs of the products are considered. There are many factors that hospitals need to consider in their purchasing specifications including: safety, ease of use, efficacy, warranty and time saving.

On the basis of purchase price alone, the cost of mercury free equipment is generally higher than mercury based products. However, when other direct and indirect costs were considered, mercury free equipment was found to be cost effective for

Mercury containing chemicals and alternatives[1]

Chemical	Alternatives
Mercury(II) Oxide	Copper catalyst
Mercury Chloride	None identified
Mercury(II) Chloride	Magnesium Chloride/ Sulfuric Acid or Zinc, Freeze drying
Mercury Nitrate (for corrosion of copper alloys) for anti fungal use	Ammonia/copper sulfate, Mycin
Mercury Iodide	Phenate method
Sulfuric Acid (commercial grade mercury as impurity)	Sulfuric acid from a cleaner source
Zenker's Solution	Zinc Formalin
Mercury (II) Sulfate	Silver Nitrate/ Potassium/Chromium (III Sulfate)

hospitals. Direct costs to hospitals include not only purchase price but also costs associated with clean-up of spills, training, storage, disposal and potential health risks to staff, patients, and visitors. Indirect environmental and health costs to the general public and wildlife may also be significant.

A typical thermometer contains ½ to 3 grams of mercury. A typical household mercury fever thermometer contains approximately 1 gram and a typical barometer contains 454 grams of mercury. The cost of cleaning up a spill will vary by the size of the spill and the degree of exposure of property and people. Small spill clean-ups usually cost around $1000 and large spills can go into the tens of thousand of dollars.[2]

When adequate mercury alternatives are not available and mercury must be used, it may be possible to recycle it. Recycling is the second priority of mercury pollution prevention. Practicing source reduction in combination with recycling the mercury already in the waste stream can have a significant impact on reducing mercury levels in the environment. But the final aim should be to completely eliminate mercury from the health sector.

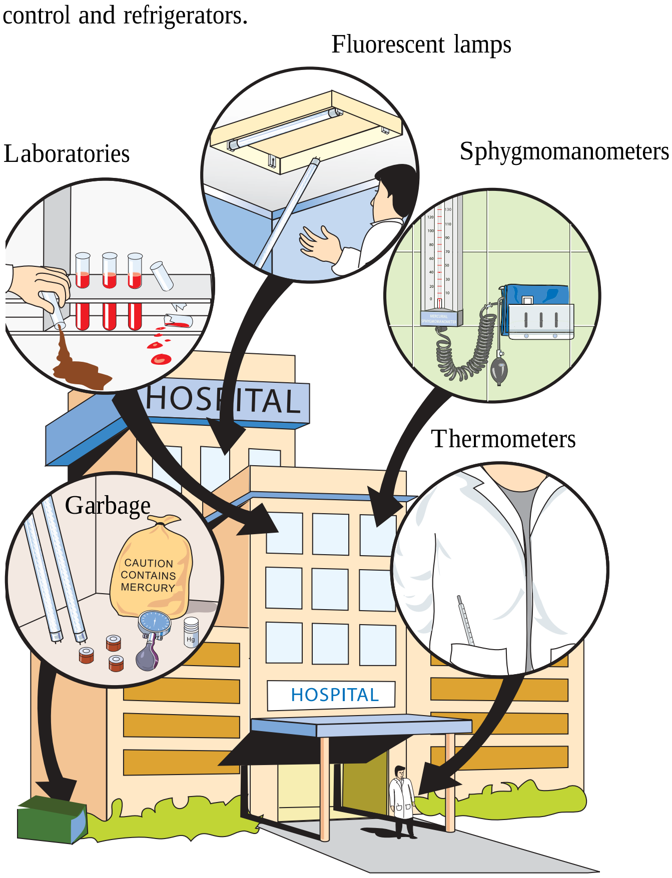
Section 4a: Thermometers

A thermometer is a device used to measure temperature or temperature changes. Thermometers measure temperature, by using materials that respond in some way when they are heated or cooled. In a mercury or alcohol thermometer the liquid expands as it is heated and contracts when it is cooled so the length of the liquid column is longer or shorter depending on the temperature. Modern thermometers are calibrated in standard temperature units such as Fahrenheit or Celsius.

There are many different thermometers relying on different principles. These include:

- Thermistors
- Thermocouple
- Mercury-in-glass thermometers
- Bi-metal mechanical thermometers
- Silicon bandgap temperature sensors
- Infrared thermometers

Thermometers containing mercury are used in several places in a hospital. Apart from the fever thermometer in wards, they can be also found in the blood banks, incubators, water baths, and labs. Thermostats containing mercury can be found in ovens (laboratories), nursing incubators, room temperature control and refrigerators.



Sources of mercury in a hospital

Fever thermometers

Our body always responds to changes in temperature, but we cannot be accurate about the degree of change without measuring it. And that is what a thermometer does; it measures the degree of hotness or coldness in a body. The most common method of measuring body temperatures is with a mercury-in-glass thermometer whose tip is inserted either into the mouth (oral temperature), under the armpit (axilliary temperature) or into the rectum via the anus (rectal temperature).

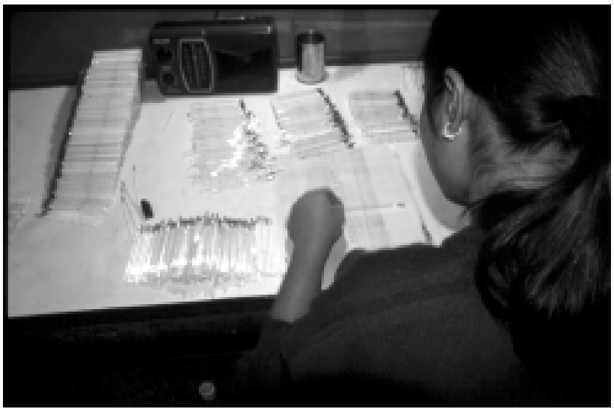
Mercury thermometers follow the simple principle that liquids change their volumes relative to their temperature. As temperatures rise, the mercury-filled bulb expands into the capillary tube. Its rate of expansion is calibrated on the glass scale. Traditionally, mercury has been used because it has a large liquid range [melting point = -38°C; boiling point = 35° C] as well as a linear, and fairly large coefficient of expansion.

There is about 0.7 grams of mercury in a regular fever thermometer and three grams in larger thermometers. Though the amount may seem small, it is enough to pollute a small lake.

Key findings of the study

32 samples of the 21 brands were tested. Three of these were of the enclosed scale type where the readings are marked on a card placed within the thermometer, 14 of the solid stem type, where the readings are marked on the glass itself and four were digital, where the temperature is shown electronically. The enclosed scale and solid stem thermometers were tested according to the appropriate Indian Standards (IS). Since the IS does not cover digital thermometers, they were tested for accurate temperature and marking packing based on the method for the solid stem thermometer.

- None of the enclosed scale and solid stem thermometer brands confirmed to the test for accurate temperature. Among the digital thermometers, Becton-Dickinson (flexible) and Microcare brands showed inaccurate temperature. Only Omron, the digital thermometer, showed accurate temperature. At higher temperatures, a greater number of samples did not conform in most brands.
- None of the enclosed scale or solid stem thermometer brands showed the correct temperature within the stipulated time.
- Hicks (Oval) and Safety among the enclosed scale thermometers and Angels, Animex Exacta, Doctor, Swan's Doctor, Enbee Super, Hicks, Kaushal, Akutem, NIK, Thermomate and Wrtheim among the solid stem type did not have the correct dimensions.
- The constriction above the bulb that restricts movement of mercury did not function properly in all the enclosed scale and solid stem thermometer brands.
- None of the thermometers conformed to the standards of markings. Illustratively, the enclosed scale and solid stem thermometers (except Enbee Super) did not carry the code for batch of manufacture.



How accurate are mercury thermometers?

In a study done by CERC, around 15 brands of mercury thermometers were tested for different parameters including accuracy. According to the study, published in *Insight: The consumer Magazine* (July 2000), all of them recorded inaccurate temperature. This clearly shows that the mercury thermometer, which is considered a golden standard, may not be so.

The mercury thermometer, right from production to its usage and final disposal, poses a health hazard to the workers/consumers. The toxic manifestations of mercury depend on the mode of exposure. Acute inhalation of mercury vapours, which generally happens in occupational exposure, causes many health problems. These include nausea, vomiting, skin allergies, increased blood pressure, bronchitis and effects on the central nervous system causing tremors, spasms, loss of memory, etc.

Mercury fever thermometers are a significant source of mercury in the environment, and if a broken thermometer isn't cleaned up properly, the mercury can get into the air and pose a health risk in the user's home. In fact, mercury based thermometers are being phased out internationally.

Alternatives to mercury thermometers

Several types of non-mercury thermometers are available commercially. These include:

- Digital electronic thermometers
- Glass alcohol thermometers

Digital electronic thermometers: It is now common to measure temperature with an electronic thermometer which functions with the help of some in-built sensors. The most common sensor used in an electronic thermometer is a thermo-resistor (or thermistor). This device changes its resistance with changes in temperature. A computer or other circuit measures the resistance and converts it to a temperature, either to display it or to make decisions about turning something on or off.

Glass alcohol thermometers: These thermometers use the same principle as mercury except the mercury is replaced by

Thermometer Efficacy[3]

Type	Accuracy	Time required for reading	Calibration	Temperature range	Battery	Cost (in Rs)
Mercury	Requires some skill to account for meniscus[4] in reading	Oral: 3 minutes Rectal: 3 minutes Axilliary: 4minutes	N.A.	94-108°F	N.A.	15-50
Liquid-in-glass	Requires some skill to account for meniscus in reading	Oral: 3 minutes Rectal: 3 minutes Axilliary: 4minutes	N.A.	94-108°F	N.A.	–
Digital	Digital display standardises measurements, eliminating user error	Oral: 4 seconds Rectal: 15 seconds Axilliary: 10 seconds	N.A.	84-108°F	3AA alkaline cells good for 5,000 to 6,000 readings	100-350
Tympanic	Digital display standardises measurements, eliminating user error	Ear: 1 second	6-12 months	Varies significantly	3-volt lithium or 9-volt alkaline good for 5,000 to 8,000 readings	1,500
Dot matrix	Easier to read than a mercury column	Oral: 1 minute Axilliary: 4minutes	6-12 months	94-104.8°F	N.A.	–

Other considerations:

Mercury and liquid-in-glass thermometers: Often not left in place long enough to obtain accurate reading. Can be easily broken as a result of rectal perforation, especially for neonates and young children

Digital and tympanic thermometters: Quick, accurate readings. Minimally invasive- works well with children. Requires probe covers for hospital use

Dot matrix thermometers: Single use prevents cross-contamination, increases waste generation. Ideal for isolation patients.

red coloured alcohol. Both the thermometers, like mercury thermometers, can be used to take oral, rectal or axilliary (armpit) temperature. Digital electronic fever thermometers are readily available at retailers. Newest entrants to the list include Ear canal thermometers and Flexible "forehead thermometers".

A recent statement by the American Medical Association reviewed the benefits and drawbacks of the more readily available types of fever thermometers. According to them, both glass mercury thermometers and digital thermometers give an accurate reading. But digital thermometers offer the advantage of ease of use and reading.

International initiatives to move away from mercury thermometers

Norway: There are prohibitions against production, import, export and sale of mercury thermometers. Old thermometers are considered hazardous waste and have to be delivered to hazardous waste facilities.

Sweden: The import, manufacture and sale of clinical mercury thermometers were prohibited from January 1992.

USA: Several states of USA have banned the use of mercury fever thermometers, and most major retailers do not sell them.

Denmark: There is a general ban on sale of mercury containing thermometers. Exemptions from this ban are primary EU approved thermometers.

Section 4b: Sphygmomanometers

Blood pressure is generated by the activity of the heart and blood vessel system and is widely accepted as a measure of cardiovascular performance. Therefore blood pressure levels and variations are considered to be an indicator of cardiovascular function and overall health. Sphygmomanometers are the commonest form of blood pressure measuring apparatus used in every clinic and every ward of the hospital.

Most blood pressure devices use an air filled cuff to temporarily block blood flow through the artery, then apply a particular technique to obtain blood pressure while the cuff deflates. The most common techniques for pressure measurement are the auscultatory method (listening for characteristic blood flow sounds) or oscillometric technique (using a pressure transducer).

The auscultatory method of measuring blood pressure refers to listening to sounds produced by blood turbulence within the artery. The occlusive cuff is pumped up to about 180 mm Hg, then bled off at about 3 mm Hg/s. When the arterial pressure exceeds the cuff pressure, blood squirts through the partially occluded artery and creates turbulence, which creates Korotkoff sounds. A stethoscope placed distal to the cuff over the brachial artery detects the tapping noise that signals systolic pressure. When the cuff pressure decreases, the artery remains open the entire cycle. The sounds disappear, which indicates diastolic pressure. A piezoelectric sensor placed within the cuff replaces the stethoscope for automatic detection.

The oscillometric method relies on detection of variations in pressure oscillations due to arterial wall movement beneath an occluding cuff. Empirically derived algorithms are employed, which calculate systolic and diastolic blood pressure. Manufacturers develop their own algorithms by studying a population group

Major findings from the case study

- Hospitals having nursing schools attached to them, register very high (5-6 per ward/month) breakage rate.
- Major reason of breakage of clinical thermometers in wards is the instrument slipping out of hand while shaking it to bring the temperature down.
- Another reason mentioned for breakage is that it is kept in a glass bottle and when they are putting it in, it hits the hard bottom and breaks. One of the hospitals has replaced the glass bottles with plastic ones and has found breakage rate going down.
- Mercury thermometer breakage is never handled carefully, some of the major ways in which spills are handled are- sweeping it down the drain, collecting it in container and discarding it in general waste.
- Average monthly breakage rate of thermometers in 500-bedded hospital is around 70.

Different blood pressure measurement equipments

- **Mercury sphygmomanometer:** This includes a mercury m anometer, an upper arm cuff, a hand inflation bulb with a pr essure control valve and requires the use of a stethoscope to listen to the Korotkoff sounds. Relies on the auscultatory technique.
- **Aneroid sphygmomanometer:** As for a mercury sphygmomanometer, except an aneroid gauge replaces the mercury manometer. The aneroid gauge may be desk mounted or attached to the hand bulb. Relies on the auscultatory technique.
- **Semi-automated device:** This includes an electronic monitor with a pressure sensor, a digital display, an upper arm cuff and a hand bulb. The pressure is raised manually using the hand bulb. The device automatically deflates the cuff and displays the systolic and diastolic values. Pulse rate may also be displayed. Battery powered. Uses the oscillometric technique.
- **Automated device:** This includes an electronic monitor with a pressure sensor, a digital display and an upper arm cuff. An electrically driven pump raises the pressure in the cuff. Devices may have a user-adjustable set inflation pressure or they will automatically inflate to the appropriate level, about 30 mm Hg above the predicted systolic reading. On operation of the start button the device automatically inflates and deflates the cuff and displays the systolic and diastolic values. Pulse rate may also be displayed. Devices may also have a memory facility that stores the last measurement or up to 10 or more previous readings. Battery powered. Uses the oscillometric technique.
- **Wrist device:** This includes an electronic monitor with a pressure sensor, an electrically driven pump and a wrist cuff, or the device itself may be attached to the wrist. Function is similar to the automated device, mentioned above. Battery powered. Uses the oscillometric technique.
- **Finger device:** This includes an electronic monitor and a finger cuff, or the device itself may be attached to the finger. Generally battery powered. Uses oscillometric, pulse-wave or plethysmographic methods.
- **Automatic-cycling non-Invasive blood pressure (NIBP) monitor:** This is a more sophisticated version of the automated device above, with the addition of an automatic-cycling facility to record the patient's blood pressure at set time intervals. There may also be an option to measure temperature or. Alarm limits can usually be set to alert nursing staff when one or more patient functions have exceeded the limits. Mains and battery powered. Uses the oscillometric technique.
- **Ambulatory blood pressure monitor:** This includes an upper arm cuff and an electronic monitor with a pressure sensor and an electrically driven pump that is attached to the patient's belt. The unit is programmed to record the patient's blood pressure over a 24-hour period during nor-

Sphygmomanometer Efficacy

	Mercury	Aneroid	Digital	Vital Signs Monitors
Accuracy	+/- 3mm Hg; Operator must understand and account for mercury meniscus[4] in reading; Oxidised mercury can make the column appear dirty and make reading difficult	+/- 3mm Hg; Includes a self-bleeding deflation valve for increased reading accuracy	+/- 3mm Hg; Digital display removes operator error; Automatic deflation rate improves accuracy	+/- 3mm Hg Digital display removes operator error; Automatic deflation rate improves accuracy
Calibration	Required every 6 months Adjusted only at the zero point	Required every 6 months Requires specialised tools and technical skills to calibrate the mechanism at several pressure point		Recommended every 5 years or if the device has been dropped; Usually provided at no cost by the manufac-turer
Installation	Mercury tube must be perfectly vertical in its unit and perpendicular to the ground	No specific orientation required	No specific orientation required	No specific orientation required
Use	Requires excellent technique to read the meniscus of a mercury column	Easier to read then mercury column	Digital display standardise measurements; Automatic deflation improves staff efficiency	Digital display standardise measurements; Automatic deflation improves staff efficiency
Maintenance	Without proper maintenance accuracy of the device could considerably diminished; Frequent filter replacement needed to avoid Hg column lag, a delay in Hg response, that contributes to inaccuracies	Easy to see if aneroid needle is off zero when not in use; Calibration is harder than with mercury units	Battery replacement as necessary	Battery replacement as necessary (approx 350 units)
Cost	Rs. 350-800	Rs. 650-1,000	Rs.1,500-5,000	Rs.80,000-1,00,000
Other features	–	–	Unit can also measure pulse rate	Unit can also measure temperature and pulse rate

mal activities and stores the data for future analysis. Battery powered. Uses auscultatory and oscillometric techniques.

The majority of non-invasive automated blood pressure measuring devices currently available use the oscillometric method.

Mercury sphygmomanometer

This is the commonest form of blood pressure measuring apparatus used in every clinic and every ward of the hospital. The measurement is indirect (that is, there is no sensor inside the body) and is subjective, and therefore can result in large errors, particularly if the operator is inexperienced. The pressure is usually, measured by a mercury-in-glass manometer. A rubber bag is attached to the upper arm under a cuff, which is wrapped around the arm and secured by Velcro tape. The bag is connected by tubing to the manometer and to an inflating device in the form of a bulb. The bag is inflated by squeezing the bulb until the pressure exceeds the arterial pressure. This condition is detected by a stethoscope placed over the brachial artery just below the elbow since no sound is heard from the

Most hospitals calibrate the BP apparatus in-house. It's done without any formal training on methods of calibration or the hazards of mercury. According to some experts the mercury vapour level in such calibration rooms is much higher than the permissible limits

Factors that influence the readings from the digital sphygmomanometer*

- Posture of the patient: Were both readings taken with the patient in the same position – for example, lying down, sitting up or standing up. Blood pressure varies with your posture.
- Were both readings taken on the same arm? Different arms will give different readings even if the same instrument is being used.
- Were the readings taken with the same cuff? Was the cuff part of the device the same width in both technologies? The size of the cuff, especially in relation to the patient can influence the reading.
- Did the person taking the readings know the purpose of the test? (Hawthorne effect), for example, if they knew this was to prove that the digital device might be replacing the mercury, they could have had a bias and gotten different results.
- What was the training for the person trying the digital device? Did the user truly understand how to use it?

Personal correspondence with Hollie Shaner and Jamie Hanie

closed artery. A valve adjacent to the bulb is then partially opened so that the bag deflates slowly. Sounds from the artery are first heard when the applied pressure just fails to occlude the artery at the peak of the arterial pressure cycle (the systolic pressure). This pressure is noted and the applied pressure allowed to continue falling until the artery fails to occlude even at the lowest point of the arterial pressure cycle (the diastolic pressure). This point is identified from characteristic sounds at this point, which the operator learns to recognize. The two pressures, systolic and diastolic, are recorded as the patient's blood pressure and are typically around 120 and 80 mmHg respectively.

Alternatives to mercury sphygmomanometers

The two most common alternates to the mercury blood sphygmomanometer are:

- Aneroid
- Electronic

In reality, mercury and aneroid sphygmomanometers are widely used because of their low purchase price. When both units are in proper working order, either will give acceptable results. Both styles require calibration checks at regular intervals (at least annually). For aneroid devices, the procedure requires adjusting calibration at several pressure points, not just at zero like a mercury device.

Although simpler to calibrate, mercury sphygmomanometers have some inherent disadvantages when compared with the aneroid sphygmomanometer.

- Mercury is a toxic substance that threatens humans and wildlife. As a result, spills require careful and costly cleanup.
- It requires excellent technique to read the meniscus of a mercury column. Even if both types are in good working order, the aneroid dial is easier and requires less effort to read than a mercury column.
- Maintenance of mercury devices is cumbersome. For accuracy, the mercury tube must be perfectly perpendicular in its unit and perfectly vertical to the ground. The more off-vertical, the greater the inaccuracy.
- Each mercury sphygmomanometer has a vent or filter allowing outside air to be drawn in. Without frequent filter replacement, the mercury column experiences lag. "Lag" is a delay in the mercury response, which may result in an inaccurate reading.
- Most hospitals calibrate the BP apparatus in-house. It's done without any formal training on methods of calibration or the hazards of mercury. According to some experts the mercury vapour level in such calibration rooms is much higher than the permissible limits.

Some of the hospitals, which have tried to switch over to digital sphygmomanometer, complain that when compared with mercury ones, there is a substantial variation in the readings. Even some patients have found that the readings taken by their physician (using mercury sphygmomanometer) and the readings taken by them in their home (using digital instrument) are not same. This can be attributed to various reasons, as there are many factors that contribute for accurate blood pressure measurement.

Although the initial purchase price of the mercury sphygmomanometer is lower, when clean-up estimates and high disposal estimates are included, they become much more expensive than the digital equipments. Furthermore, if one considers some of the health and environmental impacts, the cost of the mercury bearing product becomes much greater to the hospital.

Section 4c: Dental amalgam

Dental amalgam is the most commonly used dental filling material. Dental amalgam is a mixture of mercury and a metal alloy. The normal composition is 45-55% mercury; approximately 30% silver, and other metals such as copper, tin and zinc, dependent upon each manufacturers specific formula. It is obvious from the above composition that this material should rightfully be called 'mercury' fillings or 'mercury/silver' fillings. However, since the beginning of its use as a dental filling material until the present time, some 150 years or more, the use of the word 'mercury' in describing this type of filling has been studiously avoided and rather the word silver filling has been used. Could it be that the dental profession did not want the patient to know that approximately half of the material implanted in their teeth was actually one of the most toxic metals known to man? The guise is so effective that most physicians do not know that they have had mercury implanted in their teeth. Mercury is more toxic than arsenic, lead and cadmium.

The traditional materials include gold, base metal alloys, and dental amalgam. Amalgam is composed mostly of complex compounds where the mercury is bound chemically to the other ingredients. Factors favouring amalgams is the argument that the strength and durability of traditional materials makes them useful, particularly in the back of the mouth where they must withstand the extreme forces that result from chewing. Compared to the rest, it is durable, easy to use, and inexpensive.

Fundamental health flaws[5]

A 'silver filling' is a euphemism for an amalgam restoration, which a dentist places in a patient's tooth after a cavity is created by drilling out decay. Amalgam restorations consist of mercury, silver, tin, copper, and a trace amount of zinc. The dental amalgam has two fundamental flaws that adversely effect a patient's health. The first fundamental flaw is that all amalgam metals are cations[6]. The net result of the tendency for covalent, ionic and metallic bonding and Van der Waals forces[7] between amalgam cations is a weak repulsion. So there is a sustained release of mercury and other metals from the amalgam into the body. Researchers have measured a daily release of mercury on the order of 10 micrograms from the amalgam into the body. Mercury is a toxic metal; the most minute amount damages cells.

The second fundamental flaw is that there are five dissimilar metals in the amalgam. Galvanic action[8] between these metals in inevitable (the dissimilar metals form a battery). Galvanism produces electricity that flows through the body. The electric currents produced by the amalgam typically are between 0.1 and 10 microamps, compared to the body's natural electric current of 3microamps.

How mercury from dental amalgam can get into the environment

There are many ways that mercury from dental amalgam can get into the environment:

- Amalgam particles that are rinsed down the drain. From there mercury from the amalgam may enter the environment in one of three ways: It may be released directly to a waterway; It may be released to the air if the treatment plant sludge is incinerated and then redeposited to the ground or a water way; It may be released to soil if treatment plant sludge is land spread.
- If a dental practice is connected to a septic system, amalgam particles become part of the sludge in the septic tank, which is eventually pumped out and transported to a waste water treatment plant or land spread. Any mercury from the amalgam that becomes soluble will end up in groundwater.
- Placing an item that contains amalgam particles in yellow bag allows mercury from the amalgam to be released into the air if the medical waste is incinerated. The volatised mercury is then re deposited to the ground or the waterway.
- If items that contain amalgam particles are discarded with ordinary trash, there is the potential for mercury from the amalgam to leach into groundwater when the trash is placed in a landfill not designed to handle hazardous waste.
- In an older dental clinic, pure bulk mercury from past practices may have settled in sink traps. The mercury is gradually released into wastewater for many years after the use of bulk mercury has been discontinued.

A large dental amalgam may contain more than 750 mg of elemental mercury. Toxicity Characteristic Leaching Procedure (TCLP) tests have shown that amalgam can exhibit characteristic toxicity for mercury. After placement of a mercury/silver dental amalgam, there is persistent, low level release of elemental mercury vapour into the body for many years thereafter. Scientific research has proven that the corrosion of dental amalgams by chewing, exposure to oxygen in breathed air, food acids causes the continual release of elemental mercury vapour into the body 24 hours a day and the uptake of inorganic mercury in swallowed saliva that exceeds known standards of exposure by 10 to 100 times.

Studies have shown that a single 0.4 cm^2 ocdusal amalgam can release 15 microgram (mcg) of mercury vapour per day. Human autopsy research has validated the statistical correlation between the number of dental amalgam fillings and CNS mercury levels. US government risk assessment studies prepared by the Public Heath Service in 1994, established standard minimum risk levels (MRLs) for acute and chronic mercury exposure for the general population. The acute mercury exposure MRL is 0.02 mcg per cubic meter of air, which translates into an intake of 0.4 mcg per day. The chronic mercury exposure MRL is 0.014 mcg per cubic meter of air, which

In 1991, the World Health Organization confirmed that dental amalgam is the greatest source of mercury vapour in the non-industrially exposed population, significantly exceeding that from food or air.

translates into an intake of 0.28 mcg per day. From conservative estimates of the daily intake of amalgam mercury vapour determined by medical and dental experts, the USPHS has concluded that the average daily intake of amalgam mercury vapour exceeds the established MRLs. The USPHS has ruled that chronic exposure to mercury from dental amalgams is not without risk to the general population. Moreover, in 1991, the World Health Organization confirmed that dental amalgam is the greatest source of mercury vapour in the non-industrially exposed population, significantly exceeding that from food or air.

The mercury challenges systemic functions of every individual and of developing foetuses, so it can lead to health problems and fetal malformations. Mercury leakage and its subsequent pathophysiologic effects are most often slow, insidious processes. So health problems caused by dental mercury poisoning are perceived many years after the amalgams are placed

Studies have demonstrated that the removal of dental mercury amalgam fillings can result in definitive and significant improvements in overall health status. The Foundation for Toxic-Free Dentistry compiled data on 1,569 patients from six different sources. Of particular interest in the FTFD analysis report is the fact that 14% of patients experienced some form of allergic symptomology and that 89% reported that their condition had improved or was entirely eliminated after removal of their silver/mercury dental amalgam fillings. Systemic mercury toxicity appears to have a direct causal relationship to the development of allergic sensitivity to foods, chemicals and other environmental factors. Extrapolating the FTFD data to the approximately 150 million individuals with mercury dental amalgams in the India[9], there would be about 21 million people (14%) with mercury amalgam-related allergies.

The Lorschieder-Vimy experiments[10]

The most crucial research in the saga of dental amalgam began in 1983, when a Canadian dentist, Murray Vimy became curious about the stability of the mercury in amalgam fillings. Vimy, also a member of the University of Calgary Medical School faculty, bought some equipment for measuring mercury vapour in the air inside the mouth and set up an initial study, testing a number of patients with amalgams under a variety of circumstances- resting, after chewing or rubbing the fillings, etc. The resulting readings were high enough to be troubling. In the audience at the first presentation of his data, was Fritz Lorscheider, a professor of physiology at the University of Calgary Medical School. Lorscheider's interest was piqued by Vimy's data and he decided to work with Vimy. Vimy and Lorscheider designed a series of experiments that have rarely been equaled in their elegance and their precise results.

In 1985 study Lorscheider and Vimy demonstrated unequivocally that mercury vapour is continuously released from amalgam fillings in measurable quantities. Measurements of air in the mouths of chewing gum, the amount of mercury vapour released from fillings was six times higher than when no chewing had taken place. During thirty minutes of continuous chewing, the mouth air mercury vapour remained high; after chewing stopped the amount of mercury in the mouth air slowly declined to pre-chewing levels over a 90-minute period.

The researchers also observed that brushing the teeth with commercial toothpaste stimulated the release of vapour from amalgam surfaces, at approximately the same higher rate as gum-chewing and for the same time periods.

Next Lorscheider and Vimy decided to try to find out whether the mercury vapour from the fillings was taken into the body, and if it was, to see what happened to it there. For this experiment, their team used dental amalgam made with the normal ingredients and proportions, but with mercury that was radioactively tagged (203Hg).

Six sheep wee each given twelve of these radioactively tagged filling, on the top, biting surfaces of their molar teeth. To ensure that the test was fair, the scientists over-carved the fillings so that the filling was slightly concave and the chewing pressure on these filled teeth was lighter than usual.

Three days after the fillings were inserted, the sheep began excreting mercury in their droppings. After the sheep had had their fillings for 29 days, full body X-ray photographs were taken of the sheep.

The X-ray pictures showed that the radioactively tagged mercury from the fillings was present everywhere in the sheeps' bodies. It was found in the heaviest concentrations in the gastrointestinal tract, and next in the kidneys, liver, and brain. Heavy concentrations were also found in the jawbones, the gum tissues and the lining o the trachea.

In the analyses of the mercury content of different organs and tissues, several things stand out.

First of all, the levels of mercury in the blood and urine are not particularly high. This is useful information because blood and urine tests were once commonly thought to be valid ways of measuring how much mercury the body contains. Judging from the experiments, blood and urine tests bear little relationship to how much mercury is present in body tissue. Samples of whole blood drawn form the sheep contained 9.0ng per gram of mercury, urine 4.7ng per gram. But the kidney contained 7,438ng/mercury per gram – 740 times more than in whole blood, and 1,487 times more than in urine. Feces contained 4,489.3ng/mercury per gram. Other organs which had substantial amounts of mercury were the stomach, the liver, the bone in which the teeth were mounted, the gum tissue and the tracheal lining.

After the publication of the study, the dental establishment reacted with characteristic speed and determination. The "sheep experiment" was criticised for using an experimental animal that ate and chewed very differently from humans, and for not controlling for environmental factors, such as mercury in the diet. Of course, the experiment was not designed to look for mercury, but rather for radioactivity. There is no radioactive 203Hg in nature, so any of it found could only have come from the fillings.

The authors responded to the first criticism by mounting another study. This one was performed with a monkey, which as a primate has a chewing pattern very close to that of humans. This second study showed similar results, and was even more interesting.

As was the case for the sheep, the mercury had migrated throughout its body with in the 28 days of the study. But in the monkey, mercury was present in the jawbone and gums in astonishing quantities. There were also significantly larger quantities of mercury in the monkey's large intestine, colon, bile and tongue. Despite the fact that the critics of the first experiment apparently assumed that the quantities of mercury accumulated would be smaller in monkeys than in sheep, in important respects the studies showed just the opposite. The monkeys absorbed much larger quantities of amalgam in certain areas and also retained far more mercury in their gum tissues and tongue, jawbone large intestine and in their bile. They had smaller, but still enormous, quantities of mercury in the kidneys and gastrointestinal tract.

Humans are primates and thus may be more similar to monkeys in the amounts and locations of mercury accumulation. Not enough animal tests have been done to understand fully the difference. But the results of these experiments are extremely provocative, given the high percentage of humans who have mercury amalgam fillings.

How mercury from dental amalgam can get into environment

Amalgam particles that are rinsed down drains travel through the sewer system to the wastewater treatment plant. From there mercury may enter the environment in one of the three ways:

It may be released directly to a waterway; It may be released to the air if the treatment plant sludge is incinerated and then redeposited to the ground or a waterway; It may be released to soil if treatment plant sludge is land spread.

▲ Placing an item that contains amalgam particles in the bag for incineration allows mercury from the amalgam to be released into the air. The volatilised mercury is then redeposited to the ground or a waterway.

Health impacts of mercury amalgam fillings[11]

▲ **Causes damage to brain in children:** In February 1998, a group of the world's top mercury researchers announced that mercury from amalgam fillings can permanently damage the brain, kidneys, and immune system of children.

▲ **Amalgam fillings linked to neurological problems, gastro-intestinal problems:** The first large-scale epidemiological study of mercury and adverse reactions was recently completed and showed that of the symptoms looked at, there was a link seen to gastrointestinal problems, sleep disturbances, concentration problems, memory disturbances, lack of initiative, restlessness, bleeding gums and other mouth disorders.

▲ **Mercury/alzheimer's disease connection found:** A study related to mercury and Alzheimer's Disease was recently completed by a team of scientists led by well-respected researcher Dr. Boyd Haley. They exposed rats to levels of mercury vapour diluted to account for size differences between humans and rats. The rats developed tissue damage "indistinguishable" from that of Alzheimer's disease. Repeating the experiment showed the same results.

▲ **Amalgam fillings since 1970's unstable:** The type of mercury fillings that began to be used during the last couple of decades, non-gamma-2 (high copper), releases many times more mercury than the older style of amalgam fillings.

▲ **Amalgam fillings release highly toxic elemental mercury:** Mercury is one of the most toxic substances known. The mercury release from fillings is absorbed primarily as highly toxic elemental mercury vapour.

▲ **Amalgam fillings largest source of mercury by far:** Based on a number of studies in Sweden, the WHO review of inorganic mercury in 1991 determined that mer-

Gum chewing, grinding of teeth, computer terminal exposure, presence of gold fillings or gold crowns (even if covering mercury fillings), teeth brushing, braces, and chewing cause the release of significantly increased amounts of mercury from the fillings

cury absorption is estimated to be approximately four times higher from amalgam fillings than from fish consumption. Recent studies have confirmed this estimate. The amount absorbed can vary considerably from person to person.

- ▲ **Gold crowns, gum, bruxism, computer monitors increase release of mercury significantly:** Gum chewing, grinding of teeth/bruxism, computer terminal exposure, presence of gold fillings or gold crowns (even if covering mercury fillings), teeth brushing, braces, and chewing cause the release of significantly increased amounts of mercury from the fillings.
- ▲ **Cumulative poison and builds up in organs:** Mercury released from fillings builds up in the brain, pituitary, adrenals, and other parts of the body.
- ▲ **Mercury amalgam fillings effect porphyrins:** Preliminary results from the first detailed biochemical analysis of patients who removed mercury amalgam fillings showed a significant drop in the excretion of porphyrins (important to heme synthesis – heme carries oxygen to red blood cells), as well as a number of other key biochemical changes.
- ▲ **Potential contributory factor in other diseases:** Mercury from amalgam fillings has been implicated as a possible contributory factor in some cases of Multiple Sclerosis, Parkinson's Disease, IBS, reproductive disorders, allergies, and a variety of other illnesses.
- ▲ **Mercury build up in brain, organs and breast milk of fetuses of mothers with amalgam fillings:** Mercury from fillings in pregnant women has been shown to cause mercury accumulation in brain, kidneys and liver of human foetuses (all of the areas tested). Studies have shown that mercury can be passed to infants from breast milk.
- ▲ **Proper removal of fillings produces eventual health improvement:** A recent study published in the Journal of Ortho-molecular Medicine related to the proper removal of mercury amalgam fillings from 118 subjects showed an elimination or reduction of 80% of the classic mercury poisoning symptoms. In many cases, it took 6 to 12 months after mercury amalgam removal for the symptoms to disappear.

World-renowned experts agree about potential danger

In contrast to statements from dental trade organizations, toxicologists and medical researchers are often quite concerned about the use of mercury. Lars Friberg, the lead toxicologist on the WHO team looking at inorganic mercury and health effects stated that he believes that mercury is unsuitable for dental materials because of safety concerns. Due to the major environmental effects of mercury from amalgam fillings, plus the additional known adverse health effects, Japanese Dental Schools no longer teach the use of mercury amalgam fillings and several other countries have voted to ban amalgam use or issued warnings regarding its use.

Major findings from the case study

- ▲ Amalgam fails at the aesthetic front, because of poor colour matching.
- ▲ Mercury tends to vapourise from the amalgam and get impregnated in the gums. After few years some patients might develop a white silvery line on their gums, which is called amalgam tattoo.
- ▲ In the process of preparing amalgam in the dental sector, generally no protective gear is worn. Dental assistants, who hardly know about problems with mercury, prepare amalgams.
- ▲ Delhi may be generating around 51 kgs of mercury (average of 7.37 and 7.68 plus 9.22) from amalgams each year, which is thrown in the general bins or drained into sewers.

Alternatives to mercury amalgams

Dental restorations can be classified into two types. Inserting filling material directly into the tooth does direct restorations. Indirect restorations are fabricated outside of the mouth.

In recent years, there has been a marked increase in the development of aesthetic materials made of ceramic and plastic. These mimic the appearance of natural teeth and are more aesthetically pleasing where they will be visible.

American Dental Association developed a comparative chart to help dentists explain the relative advantages and disadvantages of the materials used in fillings, crowns, bridges and inlays. They provide a simple overview of the subject based on the current dental literature and are not intended to be comprehensive. The attributes of a particular restorative material can vary from case to case depending on a number of factors.

Amalgam fillings will probably always wear less than composite restorations, however the recent advances in particle formulation and shape have made the newest posterior composites quite competitive for filling back teeth. Composites are even stronger than amalgams in tensile strength, which makes them better for overlaying large biting areas. As the materials con-

Direct restorative dental materials[12]

Factors	Amalgam	Composites (direct and indirect)	Glass- ionomers	Resin- ionomers
General Description	A mixture of mercury and silver alloy powder that forms a hard solid metal filling. Self-hardening at mouth temperature.	A mixture of submicron glass filler and acrylic that forms a solid tooth-coloured restoration. Self- or light-hardening at mouth temperature.	Self-hardening mixture of fluoride containing glass powder and organic acid that forms a solid tooth coloured restoration able to release fluoride.	Self or light-hardening mixture of sub-micron glass filler with fluoride containing glass powder and acrylic resin that forms a solid tooth coloured restoration able to release fluoride.
Principal Uses	Dental fillings and heavily loaded back tooth restorations.	Aesthetic dental fillings and veneers.	Small non-load bearing fillings, cavity liners and cements for crowns and bridges.	Small non-load bearing fillings, cavity liners and cements for crowns and bridges.
Cavity preparation considerat-ions	Requires removal of tooth structure for adequate retention and thickness of the filling.	Adhesive bonding permits removing less tooth structure	Adhesive bonding permits removing less tooth structure	Adhesive bonding permits removing less tooth structure
Clinical considera-tions	Tolerant to a wide range of clinical placement conditions, moderately tolerant to the presence of moisture during placement.	Must be placed in a well-controlled field of operation; very little tolerance to presence of moisture during placement.		
Resistance to wear	Highly resistant to wear.	Moderately resistant, but less so than amalgam.	High wear when placed on chewing surfaces.	
Resistance to fracture	Brittle, subject to chipping on filling edges, but good bulk strength in larger	Moderate resistance to fracture in high-load restorations. load restorations.	Low resistance to fracture.	Low to moderate resistance to fracture.
Bio-compa tibility	Well-tolerated with rare occurrences of allergenic response.			
Post-place ment sensitivity	Early sensitivity to hot and cold possible.	Occurrence of sensitivity highly dependent on ability to adequately bond the restoration to the underlying tooth.	Low	Occurrence of sensitivity highly dependent on ability to adequately bond the restoration to the underlying tooth.
Aesthetics	Silver or grey metallic colour does not mimic tooth colour.	Mimics natural tooth colour and translucency, but can be subject to staining and discolouration over time.	Mimics natural tooth colour, but lacks natural translucency of enamel	Mimics natural tooth colour, but lacks natural translucency of enamel.
Relative Cost to Patient	Generally lower actual cost of fillings depends on their size.	Moderate; actual cost of fillings depends on their size and technique.	Moderate; actual cost of fillings depends on their size and technique.	Moderate; actual cost depends on their size and technique.
Average Number of Visits	One.	One for direct fillings; 2+ for indirect inlays veneers and crowns.	One	One

tinue to improve, they have become tougher and more wear resistant while improvements in placement technique have reduced cold sensitivity. The technology involved in composite formulations has made tremendous strides in improving the wear, strength, appearance, setting characteristics, water miscibility, and numerous other less obvious qualities. They continue to improve yearly. The newest generation of composite filling materials has finally overcome most of the difficulties, which prevented their widespread use in restoring back teeth.

Section 4d: Waste disposal

Hospitals are one of the major contributors of mercury in the waste streams. A number of products that become part of the solid waste stream contain mercury, including certain thermometers, fluorescent lamps, button batteries, thermostats, manometers, switches, relays, and dental supplies. If these wastes are disposed of with our regular trash then the mercury can contaminate our environment.

Breakage, waste disposal, and spills from these products release mercury to the atmosphere or to drains, where it can persist for many years. Wastewater streams emanating from hospitals often show a higher than expected level of mercury.

Incinerators are a significant source of mercury emissions to the atmosphere. This mercury can travel anywhere from a few hundred feet to thousands of miles away from its original source. Once mercury leaves an incinerator, it settles down in the ecosystem and can contaminate millions of pounds of fish. This is in addition to the mercury, which is sent home in thermometers provided to the new patients. Medical care facilities may also emit mercury through accidental spills and releases, that is, through discharges to wastewater and landfills. The amount of mercury in such releases may be quite small. Still, any release is costly and may add to mercury's build-up in the environment. Mercury spills may result in additional fish advisories, and in some circumstances, mercury spill cleanups can be expensive.

Mercury Clean-Up Guidelines

Immediately after a spill keep all people and pets away from the spill area. To minimize the mercury that vaporizes, turn off any heaters and turn up any air conditioners. Ventilate the area by opening windows and, when possible, keep open for at least two days.

Never use a vacuum to clean up a mercury spill. Not only will the mercury contaminate your vacuum; the heat from the vacuum will evaporate the mercury, further distributing it throughout the house. Similarly, never use a broom to clean up mercury. It will only distribute the mercury into smaller beads, and will contaminate the broom.

Assemble the necessary supplies before attempting a clean up. These include gloves, eye protection, an eyedropper or a syringe, and two stiff pieces of paper or cardboard, two plastic bags, a large tray or box, duct tape or packing tape, a flashlight and a wide mouth container. Remember that any tools used for clean up should be considered contaminated and disposed of with the mercury.

Major findings from the case study

- Delhi may be generating around 51 kgs of mercury from amalgams each year, which is thrown in the general bins or drained into sewers.
- An average sized hospital in Delhi with dental wing might be generating 2.8 kgs of mercury waste.
- Some of the dentists interviewed, do collect the residual amalgam or mercury separately. But as there are no regulations regarding this waste disposal, it eventually gets thrown in municipal waste.

Do not touch the mercury. Remove all jewelry and watches from your hands, as mercury will bond with the metal. Put on gloves, preferably rubber gloves to minimize contact with mercury. Use the flashlight to locate the mercury. The light will reflect off the mercury beads and make them easier to find.

On a hard surface or tightly woven fabric, use stiff paper to push beads of mercury together. Use the eyedropper to suction the beads of mercury, or working over the tray to catch any spills, lift the beads of mercury with the stiff paper. Carefully place the mercury in a wide mouth container. Pick up any remaining beads of mercury with sticky tape and place contaminated tape in a plastic bag along with the eyedropper, stiff paper, and gloves. Label the bag as mercury waste. Place this bag and sealed container in the second bag. Label it as mercury waste.

Footnotes

[1] http://www.chem.unep.ch/mercury/2003-gov-sub/India-submission.pdf

[2] http://www. Middlecities.org/PDF/mercury_bulletin.pdf

[3] http://www.ciwmb.ca.gov/WPIE/HealthCare/EPAHgInHosp.pdf

[4] The curved surface of a liquid at the liquid-air interface in a narrow tube

[5] http://www.amalgam.org/

[6] Cation- Ion with positive charge

[7] Van der Waals forces: The physical forces of attraction and repulsion existing between molecules and which are responsible for the cohesion of molecular crystals and liquids.

[8] Galvanic action: An electrical process by which corrosive elements are leached from one metal substance and attracted to another.

[9] Indian population is 1 billion; 250million people stay in urban areas and are above 6 years of age. Assuming that 60%of this population has dental amalgam filling in their mouth.

5 Section 5: Health impacts of mercury

Mercury is very toxic and it may be fatal if inhaled and harmful if absorbed through the skin. It may cause harmful effects on the nervous, digestive and respiratory systems, and the kidneys. Mercury may also cause lung injury – effects may be delayed. Mercury is corrosive to some metals. It is a skin sensitiser – it may cause allergic skin reaction, and it is a reproductive hazard.

Exposure to mercury can happen through

- Eating fish or shellfish contaminated with methyl mercury;
- Breathing vapours in air from spills, incinerators, and industries that burn mercury-containing fuels;
- Release of mercury from dental and medical treatments;
- Breathing contaminated workplace air or skin contact during use in the workplace (dental, health services, chemical, and other industries that use mercury).

Short-term exposure to high concentrations of mercury vapour can cause harmful effects on the nervous, digestive and respiratory systems, and the kidneys. This type of exposure may occur when mercury is heated.

Initial exposure to high concentrations of mercury vapour produces symptoms similar to "metal fume fever" including fatigue, fever, and chills. Respiratory system effects include cough, shortness of breath, tightness and burning pains in the chest and inflammation of the lungs. Occupational exposure to 1 to 44 mg/m^3 of mercury vapour for 4 to 8 hours causes chest pain, cough, coughing up blood, impaired lung function and inflammation of the lungs. In some cases, a potentially life-threatening accumulation of fluid in the lungs (pulmonary edema) has occurred. Exposure to high, but unspecified, concentrations of mercury vapour has caused death due to respiratory failure. All of the reported deaths resulted from inhaling mercury vapours formed upon heating mercury.

Several case reports have described harmful nervous system effects following inhalation of high concentrations of mercury vapour. The most prominent symptoms include tremors (initially affecting the hands and sometimes spreading to other parts of the body), emotional instability (including irritability, excessive shyness, a loss of confidence and nervousness), sleeplessness, memory loss, muscle weakness, headaches, slow reflexes and a loss of feeling or numbness.

A classic sign of exposure to high concentrations of mercury is inflammation of inside of the mouth (stomatitis), sometimes with a metallic taste, excessive salivation and difficulty swallowing. Other digestive system effects include abdominal pains, nausea, vomiting and diarrhoea.

Kidney injury is common following exposure to high concentrations of mercury. Reported effects range from increased protein in the urine to kidney failure. Exposure to high concentrations of mercury has also caused increased blood pressure and heart rate.

Long-term health effects of exposure to mercury

The harmful effects of long-term exposure to elemental mercury are generally thought to be caused by inhalation exposure. However, mercury liquid and vapour are absorbed through the skin in small amounts and this route of exposure can contribute to the overall exposure. Effects following absorption through the skin are expected to be similar to those reported for long-term inhalation exposure.

Effects on the nervous system: Effects on muscle coordination, mood, behaviour, memory, feeling and nerve conduction have been reported following long-term occupational exposure to mercury. These effects are often observed in employees with moderately high or high exposure to mercury. At lower exposures, the results are inconclusive with no effects being reported in some studies and mild effects reported in other studies. Although improvement has been observed upon removal of the person from the source of exposure, it is possible that some of the changes may be irreversible. The nervous system effects of mercury toxicity are sometimes referred to as "Mad Hatter's Disease" since mercurous nitrate was used in making felt hats.

A classic sign of mercury toxicity is a fine tremor, usually of the fingers, hands or arms and occasionally the eyelids, lips, tongue, and whole body. Many occupational studies indicate that tremors become more pronounced with longer exposures to mercury. Tremors are thought to be a sensitive indicator for long-term low-level exposure to mercury vapour. One report described tremors in employees with average exposures as low as 0.026 mg/m^3 for an average of 15 years.

Behaviour and personality changes such as irritability, excitation and shyness, psychotic reactions such as delirium and hallucinations, loss of appetite, tiredness, sleeplessness, short-term memory loss and impaired nerve conduction have also been reported following long-term exposure. In one study, subtle behavioural effects were detected in dentists with moderate mercury exposure.

Damage to the nerves of the arms and legs (poly-neuropathy) has been reported in employees with high exposures. Reduced sensation and strength in the arms and legs, muscle cramps and decreased nerve conduction has been observed. Employees with episodes of very high exposure appear to be more at

In men, organic forms of mercury were found to cause hypospermia, and impotence. Evidence of minor genetic damage (aneuploidy) was found, thought to be caused by interference with thiol groups in the spindle apparatus of dividing cells

risk of developing these effects.

Effects on kidneys: Many occupational studies indicate that moderate to high exposure to mercury can cause harmful effects on the kidneys. Early indicators of kidney injury include increased levels of protein in the urine (proteinuria) and increased levels of certain enzymes in the blood and urine.

Skin sensitisation: Allergic skin sensitization has been reported in people with occupational exposure to mercury liquid or vapour. Once a person is sensitized to a chemical, contact with even a small amount causes outbreaks of dermatitis with symptoms such as skin redness, itching, rash and swelling. This can spread from the hands or arms to other parts of the body. Occupational skin sensitization to mercury has been observed in people exposed to mercury in dental amalgams, tattoos or breakage of medical instruments. Positive patch tests were obtained in a dentist, five doctors, a nurse's aid, a mercury recycling employee and a pipeline repairman who had developed red, dry, itchy skin (contact dermatitis) following occupational exposure. Previous history of allergies was not discussed for any of these cases. Skin sensitization to mercury has also been reported in the general public.

Limited information suggests that long-term exposure to mercury vapour can cause inflammation and ulceration of the inside of the mouth, sore gums, drooling, diarrhea and other effects on the digestive system. It may affect the heart, resulting in increased blood pressure and/or heart rate. In most studies, effects on the immune and endocrine systems were not observed in employees exposed to mercury. However, altered immune response has been suggested in a few studies.

Mercury and reproductive health

Chronic mercury exposure can seriously impair fertility and outcome of pregnancy. In one study 45 women dentists and 31 dental nurses were questioned about their reproductive history and hair samples were taken to estimate mercury exposure. A positive association was found between elevated mercury levels and incidence of malformations and aborted pregnancies. Mercury exposure also resulted in menstrual cycle disorders, arising from interference with the part of the brain, which controls reproduction (hypothalamo-pituitary-gonadal axis).[1]

During pregnancy, mercury passes readily through the placenta; the concentration in cord blood is elevated above the level of the maternal blood. There is therefore a risk to the foetus in chronically exposed pregnant women. In the most recent report, a Swedish dentist was exposed to mercury vapour during her pregnancy through a leaking amalgamator; the foetus showed mild kidney inflammation but was born clinically healthy. The World Health Organisation stated in 1991 that 'the exposure of women in child-bearing age should be as low as possible'.

In men, organic forms of mercury were found to cause hypospermia, a reduction in libido and impotence in some subjects. Evidence of minor genetic damage (aneuploidy) was found, thought to be caused by interference of the metal with thiol groups in the spindle apparatus of dividing cells. More recently, an adverse effect of mercury on sperm motility was reported and another report describes an increased rate of spontaneous abortion in women whose partners were occupationally exposed to mercury vapour.

Signs and symptoms of mercury poisoning

Central Nervous System

- Decrease in the size of the brain
- Headache
- Dizziness
- Ataxia
- Hyperreflexia
- Short-term memory loss
- Poor concentration
- Paresthesia: numbness and tingling in the fingers and/or toes
- Tingling sensation around mouth or lips
- Shaking or tremor of the hands
- Trembling eyelids
- Incoherent speech
- Difficulty in speaking
- Fatigue
- Degeneration and atrophy of cortical structures and white matter

Gastrointestinal system

- Anorexia
- Weight loss
- Gingivitis
- Loose teeth
- Gastroenteritis
- Nausea and vomiting
- Intermittent stomach pain
- Enzymatic inactivity causing interference with metabolic processes

Urinary system

- **Nephritis:** bloody urine, decrease in urine output, fluid retention with edema of hands or feet (believed to have an autoimmune effect that produces antibodies that attack and damage kidney cells)

Sensory systems

- Blurred vision
- Changes in vision
- Blindness
- Deafness
- Changes in hearing
- Constriction of visual fields leading to tunnel vision

Personality disturbances

- Uncontrolled mood swings
- Depression
- Shyness
- Nervousness
- Irritability
- Irrational temper outbreaks (Mad Hatter Syndrome)

Pediatrics

- Delayed development
- Mental retardation
- Cerebral palsy syndrome
- Failure to thrive
- Acrodynia —A condition resulting in extreme irritability; insomnia; constant itching with excruciating pain in hands, feet, and joints; photophobia; salivation; and profuse perspiration (also known as "pink disease," because hands and feet become bluish pink followed by desquamation of soles and palms)

Workplace exposure limits

The Environmental Protection Agency (EPA) estimates that for an adult of average weight, exposure to 0.021 milligrams of inorganic or organic mercury per day in food or water will probably not result in any harm to health.

Elemental mercury (mercury zero) is a liquid and gives off mercury vapour at room temperature. Its vapour pressure is sufficiently high to yield hazardous concentrations of vapour at temperatures normally encountered both indoors and outdoors under most climatic conditions. For example, at 24°C, a saturated atmosphere of mercury vapour would contain approximately 18 mg/m^3 — a level of mercury 360 times greater than the average permissible concentration of 0.05 mg/m^3 recommended for occupational exposure by the National Institutes of Safety and Health, USA (NIOSH, 1973).

These exposure limits are for air levels only. When skin contact also occurs, a worker may be overexposed even if air levels are less than the limits listed above.

Workers working around mercury should wear protective clothing and gloves along with mercury respirators that prevent them

from breathing in mercury vapour. If you have people who are constantly exposed to mercury, they should be regularly be tested to make sure they are not suffering any health effects due to the exposure.

Mercury thermometers are an issue because when these or any other product containing mercury breaks, the mercury can evapourate, creating a risk of dangerous exposures to mercury vapour in indoor air. This volatilised and liquid mercury enters the environment through air, water effluent or solid waste system, and can be deposited in lakes and rivers, where it can be transformed into highly toxic methyl mercury. Very small amounts of mercury can do significant damage. One gram of mercury per year is enough to contaminate all the fish in a lake with surface area of 20 acres.

Combustion of various mercury-containing products in municipal solid waste is the second largest source of mercury to the environment in the United States; the fourth largest source of mercury to the environment is combustion of medical wastes. These two categories together account for nearly one-third of the mercury released to the atmosphere.

If one fails to clean up a mercury spill, then the mercury will eventually volatilize and might reach dangerous levels in indoor air. The risks increase if one attempts to clean up a mercury spill with a vacuum cleaner, or if the mercury is heated for some reason. The danger of significant mercury exposure is greatest in a small, poorly ventilated room.

The medical literature contains some cases of serious illness and even death resulting from exposure to mercury from fever thermometers. Most, but not all, of these cases involve young children, who are known to be most susceptible to the effects of mercury.

It is also common for children to break fever thermometers in their mouths. Mercury that is swallowed in such cases poses low risk in comparison with the risk of breathing mercury vapour. The mercury passes through the body without being absorbed, but then it enters the waste water system and can reach the environment.

Mercury build-up or accumulation in the body

Elemental mercury is a heavy liquid. The vapour evapourates from the liquid and evapouration occurs more rapidly when the liquid is heated. The vapour is well absorbed following inhalation. Elemental mercury is excreted from the body slowly. It has an elimination half-life of 40-60 days. Most elemental mercury is excreted in exhaled air, and small amounts in the feces and urine. Very small amounts can be eliminated in sweat, saliva and milk. Following ingestion, elemental mercury is poorly absorbed and most of it is excreted in the feces. Elemental mercury liquid and vapour can be absorbed through the skin in small amounts. Elemental mercury is transferred to the developing child in pregnant women.

Measurement of mercury in the body

Mercury and other toxic heavy metals are primarily measured in hair, blood cells and urine samples. Simply put, hair analysis is a useful screening tool but does not provide information about the actual amount of mercury in the body. Red blood cell analysis gives somewhat more information about tissue levels, but misses mercury bound in brain, bone and fatty tissues. By far, the most accurate, practical, clinical measurement of the relative total body burden of mercury is obtained through a provocative, 24-hour elemental urine analysis. In this procedure, a dose of DMSA and glycine is taken the evening before beginning the urine test, thereby extracting mercury and other toxic heavy metals from their hiding places deep in the tissues, which is then collected in the urine, thus giving a more accurate measure of total body burden.

Minimising exposure to mercury

People dealing with this chemical should be properly trained regarding its hazards and its safe use. Maintenance and emergency personnel should be advised of potential hazards.

Unprotected persons should avoid all contact with this chemical including contaminated equipment. Immediately report leaks, spills or ventilation failures. Avoid generating vapours or mists. Avoid using mercury equipment wherever possible. When handling large quantities, closed handling systems should be used. Do not heat mercury in other than a closed system.

Do not use with incompatible materials such as strong oxidizing agents (e.g. chlorine dioxide). Never return contaminated material to its original container.

Use the type of container recommended by the manufacturer. Metals that have good or excellent resistance to corrosion by amalgamation include, iron, steel, stainless steel, nickel and molybdenum. Inspect containers for leaks before handling. Secondary protective containers must be used when this material is being carried. Label containers. Avoid damaging containers. Keep containers tightly closed when not in use. Assume that empty containers contain residues, which are hazardous. Use corrosion-resistant transfer equipment when dispensing. Whenever possible use self-closing, portable containers for dispensing small amounts of this material. Never transfer liquid by pressurizing original container with air or inert gas. Good housekeeping is very important. Immediate and complete cleanup of spills is necessary. Do not use on porous work surfaces (e.g. wood). Use work surfaces that can be easily decontaminated.

Mercury Poisoning around the world

Evidence of mercury's neurotoxicity has been available for some time, although early on it was anecdotal. The term "mad hatter" is thought to have come from the designation given to hat makers during the 19th century. The name describes the neurological effects of elemental mercury poisoning in hat makers who used mercury to construct felt hats. Another anecdotal incident refers to a dark year (1693) in Sir Isaac Newton's life when he withdrew from family and friends because he thought they were plotting against him. He was purported to be using elemental mercury in laboratory experiments during this time.

There have been several instances of mercury poisoning reported worldwide. In **1965 in Niigata, Japan**, 330 people were affected by eating contaminated fish. Thirteen of these people died. In **Iraq in 1961**, in **Pakistan in 1963**, and in **Guatemala in 1966**, over 30 people were affected in each case by eating flour made from seeds treated with mercury containing fungicides. In the U.S., in New Mexico, a farmer and his family were poisoned from eating a hog, which had been fed contaminated garbage.

The most infamous large-scale mercury poisoning occurred at **Minamata Bay, Japan, in 1952**. **Minamata Bay**: In 1952, in Minamata Bay, Japan, the most well known instance of mercury poisoning occurred. The Chisson Chemical Company dumped mercury in Minamata harbor. The population of Minamata Bay ate contaminated fish from this harbor. As a result, 397 people were affected. Of these, 68 people died, including 22 unborn children. Minamata was the first known instance of widespread mercury poisoning. Mercury poisoning is sometimes referred to as "Minamata disease."

Mercury and wildlife

Human beings are not the only species affected by the accumulation of methyl-mercury in the environment. While fish advisories can persuade people to adjust their diets accordingly, many species, including alligators, eagles, herons, ospreys, otters, and raccoons, are consuming fish, which is hazardous to them. It is likely that reproductive damage from mercury toxicosis is contributing to the decline of breeding wading bird populations in southern Florida. According to one study, methyl-mercury concentrations in Florida's bald eagles are below levels that cause mortality, but they remain in the range of concentrations that can cause behavioral changes and reproductive failure. Mercury toxicosis may have also been responsible for at least one Florida panther death in the Everglades

National Park and is strongly implicated in two other panther deaths since 1989. This is particularly significant in Florida because the endangered panther population is dwindling and it is feared they might not be saved from extinction.

Footnotes

[1] http://www.mercurysafety.co.uk/index.htm

6 Section 6: Mercury trade

Mercury is a rare element and is found in the United States and Mexico, Southern Europe (Spain, Italy, the Balkans) and several states of the former Soviet Union and Central Asia. Not surprisingly, the natural mercury content in soil and water is relatively high in these areas. The most important ore for production is cinnabar (HgS). These days, due to environmental concerns and subsequent reduction in its use, it is only mined in Almaden, in Spain.

The annual primary world demand for mercury is uncertain but approximates 5,000 tonnes. The value of the total world mercury market was estimated at $75 million in 1982, but this came down to just one-third of that figure, $25 million, 10 years later in 1992. It is difficult to get a detailed picture of global mercury flows. By far the largest consumers are the industrialized countries of the OECD family, but an 'eastward' shift is observed. This trend is due to the phasing out of industries using mercury or mercury-based compounds in the developed world.

Trade in India

Mercury is not extracted in India; it is totally imported. Mercury and mercury containing wastes are included in the waste streams of the Basel Convention on trans-boundary movements of hazardous waste and their disposal.

Mercury bearing wastes has been banned under Schedule 8 of the Hazardous Waste (Management and Handling) Amendment Rules 2003.

India is importing as well as exporting several mercury as well as digital (non- mercury based) equipment.

Import policy and duty[1]

Articles/Items/ goods	Policy	Duty
Mercury	Free	56.832
Clinical thermometer	Free	50.8
BP instrument	Free	50.8

Export-import of digital thermometers

Year	Export	Import
1998-99	90.19	109.08
1999-2000	65.64	50.17
2000-01	261.93	86.19
2001-02	77.22	104.97
2002-03	54.12	127.31
Apr-Sep 2003-04	267.47	40.82

Supply of mercury and mercury compounds to India (in MT/year)

Year	Export
1996-97	257
1997-98	245
1998-99	305
1999-2000	457
2000-01	522
2001-02	738
2002-03	1,385

7 Section 7: Rules regarding mercury usage

Indian laws and guidelines on mercury

The two rules that deal with hazardous substances are- The Hazardous Waste Management and Handling Rules (1989), which list mercury and mercury containing waste as hazardous waste. Another rule is the Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989, which covers a few mercury compounds.

By the definition and categories mentioned in the Hazardous Waste Rules, mercury release from products or instruments of mercury (used in healthcare) would be covered under this rule.

Considering Chlor-alkali industry as the major polluter of mercury a policy has been laid down for mercury usage in it. However, the authorities admit that mercury used in healthcare was not considered significant enough to draft any individual policy for this sector

Why was the health-care sector never accountable?

Waste category No.4 of Schedule in Hazardous Waste Rules covers mercury bearing waste, and the regulatory quantities are 5 kgms per year (the sum of the specified substance calculated as pure metal).

Going with a very conservative estimate (considering only mercury fever thermometers, BP apparatus and amalgams and ignoring all other uses of mercury in a hospital), an average sized hospital, with a dental wing would generate around 2.8 kg/annually of elemental mercury as hazardous waste, which is disposed into drains, or yellow bags or the general waste bins indiscriminately[22]

Bigger hospitals may fall under the regulatory quantities, but even hospitals that do not fall under this category are not absolved of their duty to manage hazardous waste as per the maintenance of health, preservation of the sanitation and environment.

Thus all generators come under the purview of the rules though some may not need to seek authorization.

Waste category no. 18 of the Hazardous Waste Management & Handling Rules, includes discarded containers and container liners of hazardous and toxic chemicals and wastes, irrespective of any quantity.

Hospitals buy elemental mercury to refill their BP apparatus and even for their dental use and there is no mechanism of disposal of these containers.

Thus the hospitals have enough mercury and should be made accountable for the hazardous waste they generate.

Some other existing guidelines on mercury include the Indian Standards published by Indian Standards Institute.

The Indian standard for code of safety for mercury published by the Indian Standards Institute (ISI)

- Section 0.2.1 of this standard says that mercury and its compounds are toxic. A code of safety for mercury will be helpful in taking preventive measures for protection of health of persons exposed to this material in industry
- Section 0.5 – Mercury poisoning is included in the schedule of Notifiable diseases under the Factories Act, 1948. It is a compensable disease under the Workmen's Compensation Act, 1923
- Section 4.1.4 gives the threshold limit value in air for mercury as 0.05mg/m^3 of air for repeated exposure for 8 hours workday and 40 hours work week
- Section 5 deals with storage and handling and states that since spillage of mercury is practically unavoidable, the spilled material should be washed away to drains and collected in water sealed traps. Lime sulphur may be sprinkled over the surface to get rid of finer particles, which may be left behind
- Section 7 talks about the preventive measures- protective gear mentioned include overalls, respirator with a desired filter; emphasises on training of staff and monitoring of ventilation and working conditions, mercury vapour concentration (to be measured with electrically operated mercury vapour meters or chemical based methods)

The standard code for mercury should apply to any place, which uses mercury including the hospitals. Their implementation in the hospital setting would mean that the hospital would need to have a mercury policy and training on aspects of mercury exposure and spill management. It would also entail occupational safety through the use of protective gear; monitoring exposure limits; and ensuring water-sealed traps for mercury collection in drains.

This code needs to suggest better ways for spill handling rather than suggesting washing of mercury in drains.

In the Supreme Court of India, Civil original jurisdiction, Writ petition no. 657 of 1995 Order, Dated October 14, 2003, reads- HPC is of the view that there are enough tasks for the MOEF to perform at the highest level, in terms of ensuring that the rest of the structure concerned with the area of environment (particularly hazardous wastes, their import, generation and disposal) functions in a manner where there is waste minimization in production, reduced used of toxics, maximum environmentally sound recycling, alternative uses of so-called wastes, reduced end of the pipe solutions and ' finally, where unavoidable, environmentally safe disposal facilities. It is the foremost responsibility of the MOEF that the, national institutional framework operates in a manner that can ensure this, and that there is a phased targetted programme of actions. It should not be satisfied with just issuing rules/guidelines that are not implemented.

Indian standard of specification for dental mercury

Section 5 on marking says that each container used to store mercury shall be marked with the words 'Poison' and 'For Dental Purposes Only'.

In the Indian standard for thermometer for mercury barometer there is no requirement of labelling the thermometer as hazardous substance. Fever thermometers, which are present in each household and are used by common man, who have little or no information about its content are also not labelled. Thermometers of any kind should have a mandatory marking, labelling it as hazardous substance and should have instruction on the methods to control and manage any spill during the course of use.

There is no training imparted for safe use of mercury products to the healthcare staff. Several people get exposed unknowingly of the dangers. In the Supreme Court of India, Civil original jurisdiction, Writ petition no. 657 of 1995- Order, Dated October 14, 2003 reads- "We have considered the suggestion of HPC under term of reference no. 4 relating to impact of Hazardous Waste on Worker's Health. Having regard to the recommendations and submissions made by the learned counsel we direct the Ministry of Labour and Ministry of Industry to constitute a special committee to examine the matter and enumerate medical benefits which may be provided to the workers having regard to the occupational hazard as also keeping in view the question of health of the workers and the compensation which may have to be paid to them.

In the Supreme Court of India, Civil original jurisdiction, Writ petition no. 657 of 1995 Order, Dated October 14, 2003, reads- HPC is of the view that there are enough tasks for the MOEF to perform at the highest level, in terms of ensuring that the rest of the structure concerned with the area of environment (particularly hazardous wastes, their import, generation and disposal) functions in a manner where there is waste minimization in production, reduced used of toxics, maximum environmentally sound recycling, alternative uses of so-called wastes, reduced end of the pipe solutions and ' finally, where unavoidable, environmentally safe disposal facilities. It is the foremost responsibility of the MOEF that the, national institutional framework operates in a manner that can ensure this, and that there is a phased targetted programme of actions. It should not be satisfied with just issuing rules/guidelines that are not implemented.

Assuming all these provisions and clauses given in the Indian laws and standards, it is apparent that mercury toxicity has been acknowledged by the government bodies but adequate measures have not been adopted for safe use and disposal of this metal. Even after the availability of much safer alternatives for all mercury uses in medical sector, the government policies are silent on eliminating use of toxic products. Considering the order of Supreme Court on Hazardous waste, the government needs to look into minimising use of toxic material and ensuring proper disposal etc.

Laws and legislations against mercury worldwide

Common features of existing national initiatives

A number of countries have implemented national initiatives and actions, including legislation, to manage and control releases and limit use and exposures of mercury within their territories.

It may take the form of laws, decrees, orders, regulations, rules, standards, norms and similar written statements of national policy and requirements for behaviour. Countries rarely have a single law to cover chemicals, including mercury, instead separate pieces of legislation and separate ministries are commonly involved, highlighting the need for cooperation between government ministries in the development, implementation and enforcement of legislation on chemicals.

Although legislation is the key components of most initiatives, safe management of mercury may also include efforts to reduce the volume of mercury in use by developing and introducing safer alternatives and cleaner technology. It may also include other national measures, such as the use of subsidies to support substitution efforts and voluntary agreements with industry or users of mercury.

Such initiatives have stimulated significant reductions in mercury consumption in a number of countries, and corresponding reductions of releases have been attained.

The initiatives can generally be grouped as follows:

- Environmental quality standards, specifying maximum acceptable mercury concentrations for different media such as drinking water, surface waters, air, soil and for foodstuffs such as fish;

- Environmental source actions and regulations that control mercury releases into the environment, including limits on air and water point sources and promoting use of best available technologies and waste treatment and waste disposal restrictions;
- Product control actions and regulations for mercury-containing products, such as batteries, cosmetics, dental amalgams, lighting, paints/pigments, pesticides, pharmaceuticals, etc.;
- Other standards, actions and programmes, such as regulations on exposures to mercury in the workplace, requirements for information and reporting on use and releases of mercury in industry, fish consumption advisories and consumer safety measures.

Product control regulations for mercury containing products

Dental amalgam: A number of countries have put in place measures to reduce or even phase out the use of mercury in the dental sector. In addition to the use of amalgam separators to substantially reduce the amount of mercury discharges through wastewater from dental clinics (combined with appropriate service to maintain the effectiveness of these systems), some countries are also promoting the substitution of mercury-containing amalgam fillings, especially among sensitive populations including pregnant women, children and those with impaired kidney functions.

Denmark and Sweden are perhaps among those countries that have gone the farthest in attempting to eliminate the use of mercury-containing amalgam. The Swedish Government's overall goal to phase-out mercury also includes dental amalgam. In Sweden the consumption of mercury for dental use has decreased significantly after a policy decision by the Parliament in 1994 to phase out the use of dental amalgam. Up till now dental amalgam has been subject primarily by voluntary phasing out measures. In Denmark, dental amalgam is allowed only in molar teeth, where the filling is worn, but the Government is ready to ban the remaining use of dental amalgam, whenever the Danish National Board of Health is satisfied that the non-mercury alternatives have full substitution capabilities. Currently, Norway is developing a directive on the use of dental filling materials, which will encourage dentists to reduce the use of amalgam as much as possible.

In New Zealand, a 'Practice guideline – controlling dental amalgam waste and wastewater discharges' has been adopted, describing a code of practice on the use, storage, collection and disposal of mercury in New Zealand dental surgeries. It recommends that amalgam scrap should be collected, stored and sent for recycling or for disposal at an approved landfill when collection for recycling is not available. Amalgam scrap should be stored under water in an airtight container to reduce mercury vapour levels. Also, amalgam scrap and contaminated particulate amalgam waste should not be disposed of in any medical waste to be incinerated. Dental surgeries should use systems to reduce amalgam discharge to wastewater - in regions where reductions in total mercury discharge to wastewater are required by territorial local authorities, amalgam separators should be installed and serviced appropriately to maintain the effectiveness of these systems.

In the interest of protecting their citizens, Sweden, Norway, Germany, Denmark, Austria, Japan, Finland and Canada have taken steps to limit and phase out the use of amalgam restorations.

Stands on dental amalgam in select countries

- **Sweden:** In 1994, Sweden announced a phased-in ban on the use of amalgam. Presently there is a ban on the use of amalgam in anyone under the age of 19.
- **Denmark:** Dental Amalgam is only allowed in molar teeth.
- **New Zealand:** In New Zealand, a "Practice guideline - controlling dental amalgam waste and wastewater discharges" has been adopted, describing a code of practice

Material used instead of amalgam, collection and treatment method in countries[11]

Country	Method used	Collection and treatment method
Denmark	Plastic	Amalgam seperator prior discharge.
Estonia	Glass-ionomers, composites	Collected as waste or hazardous waste if possible, disposal
Finland	Composites, glass-ionomers	Seperators prior discharge, collection in licensed depots
Germany	Plastic, ceramic, gold-alloys	Amalgam collectors
Latvia	Light curing, filling materials	Collected by licensed company
Poland	Composites	Waste containing amalgam is collected separately
Russia	Glass-ionomers, composites	Amalgam not used
Sweden	All kinds of substitutes	Collected as hazardous waste, disposal and recovery

on the use, storage, collection and disposal of mercury in New Zealand dental surgeries.

- **Germany:** Germany has banned a certain type of amalgam (gamma 2 phase) and issued advisories against the used of amalgam in children, pregnant women and people with Kidney problems.
- **Austria/Japan/Canada:** Initiated process to phase out amalgam restorations. Restrictions or warnings on use of mercury fillings such as for children, pregnant women, women of childbearing age, people with damaged kidneys or immune systems, and in the mouth adjacent to other metals.
- **Norway:** Use of amalgam has been limited as much as possible in consideration to the environment and possible adverse health effects since July 2003.

Thermometers: Mercury-containing thermometers is a product consumers all over the world are familiar with. In Sweden, the import, professional manufacture and sale of clinical mercury thermometers were prohibited from 1 January 1992. In addition, in order to promote collection of mercury thermometers, economic incentives have been used to persuade households to turn in their mercury thermometers. In Denmark, there is a general ban on sale of mercury containing thermometers. Exemptions from this ban are primary EU approved thermometers.

Other standards and programmes

Occupational health and safety: A number of countries have also implemented measures to ensure occupational safety and health of workers and regulate exposures to mercury in the workplace, often by establishing so-called Permissible Exposure Limits (PELs). **Information and reporting requirements –** Several countries have developed systems to collect and disseminate data on environmental releases and transfers of toxic chemicals from industrial facilities, often known as Pollutant Release and Transfer Registers (PRTRs). PRTRs have proven valuable, not only to track the environmental performance of industrial facilities and the effectiveness of government programmes and policies that apply to them, but also to stimulate voluntary initiatives by companies to reduce their releases and transfers of toxic chemicals.

An example of such a system is the United State's Toxics Release Inventory (TRI). Starting with the 2000 reporting year, the reporting threshold for mercury and its compounds has been lowered to 5 kilograms per year (the previous threshold was 4500 kilograms).

A third example is Australia's National Pollutant Inventory (NPI), which reports information, based on estimation techniques, on the types and amounts of certain chemicals being emitted to the environment. From 2000-2001 onwards reporting will be compulsory. Enforcement is the responsibility of the relevant Australian State or Territory.

International and regional agreements – A number of countries also participate in international and regional conventions and agreements, which might set supplementary reduction goals with regard to mercury releases.

The European Commission is currently investigating further potential regulatory actions on products containing mercury, in preparation of potential amendments to the marketing and use directive. Among others, the following mercury-containing products are reported to be under consideration: Button cell batteries, industrial and control instruments, lighting and thermometers (OSPAR, 2000c). Within these considerations, it is also under discussion whether a full substitution is justified, taking into account the ongoing reduction of mercury use within the European Community

Major international initiatives

Sweden

- **Waste products:** As far as waste disposal is concerned, there are separate collection systems and already existing efforts for the collection of batteries, fluorescent lamps, amalgam waste etc.
- **Laboratory chemicals:** Mercury-containing chemicals for analysis and reagents are mainly used in the environmental control, by its use of mercury sulphate in COD (chemical oxygen consumption) analyses. Information activities have not been effective to phase-out this particular use. The Swedish government is therefore considering an amendment of Ordinance 1998:944, by which the use of mercury in chemicals for analysis and reagents were proposed to be banned from January 1, 2004.
- **Final disposal of mercury:** Mercury is a substance that remains a threat to human health and the environment in perpetuity, and for this reason it should not be recycled. Instead, mercury-containing waste must be dealt with permanently in a safe and environmentally acceptable way. In a report to the Government, the Swedish Environmental Protection Agency in 1997 proposed terminal storage of waste containing mercury in a deep rock facility. A governmental committee has recently submitted its final report on how to dispose waste containing more than 0.1 percent (by weight) of mercury. It is proposed that a mandatory requirement for permanent storage deep down in rock should be in force within five years.

USA

- **Dental amalgam:** The Food and Drug Administration (FDA) also regulates dental amalgam under FFDCA. Dental mercury is classified as a Class I medical device, with extensive safety regulations on its use. Dental amalgam alloy is classified as a Class II device, subject to additional special controls.
- **Thermometers:** Voluntary efforts are underway jointly with appropriate industry and associations to reduce mercury in thermometers through mercury free substitutes. Several USA States have banned the use of mercury fever thermometers, and most major retailers no longer sell them.
- **Occupational safety and health:** The Occupational

Overview of international agreements/ instruments containing provisions relating to mercury

Section	International agreement instrument	Geographic coverage of agreement or instrument	Agreement or instrument relevance to mercury	Types of measures addressing mercury
9.3.1	LRTAP Convention and its 1998 Aarhus Protocol on Heavy Metals	Central and Eastern Europe, Canada and USA	Addresses mercury and mercury compounds in releases, products, wastes, etc.	Goal definition, binding commitments on release reductions and recommendations, monitoring
9.3.2	OSPAR Convention	North-east Atlantic including the North Sea (including internal waters and territorial sea of Parties)	Addresses mercury and mercury compounds in releases, products, wastes, etc.	Goal definition, binding commitments on release reductions, recommendations, monitoring, informa-tion
9.3.3	HelsinkiConvention	Baltic Sea (including entrance of the Baltic Sea and drainage areas to these waters)	Addresses mercury and mercury compounds in releases, products, wastes, etc.	Goal definition, binding commitments on release reductions, recommendations, monitoring, informa-tion
9.3.4	Basel Convention	Global	Any waste containing or contaminated by mercury or its compounds is considered a hazardous waste and covered by specific provisions	Binding commitments regarding international transport of hazardous waste, procedure for information and approvals on import/ export of hazardous waste
9.3.5	RotterdamConvention	Global	Addresses inorganic mercury compounds, alkyl mercury compounds, alkyl-oxyalkyl compounds and aryl mercury compounds used as pesticides	Binding commitment regarding import/ esport of those mercury compounds covered, procedures for information exchange and export notification
9.3.6	StockholmConvention	Global	Mercury compounds are NOT addressed by the Convention	–

Safety and Health Administration has responsibility for maintaining safe workplace conditions. OSHA sets permissible exposure levels for elemental mercury in workplace settings. Mercury is listed as a neurotoxin capable of causing behavioral changes, decreased motor function and other effects on the nervous system. OSHA mercury standards also recommend that skin contact should be avoided.

▲ **Workplace standards** may influence the types of processes used at a facility. For example, when OSHA tightens its standards for a particular substance, it may force users of that substance to modify their processes or eliminate use of that substance entirely in order to meet these new standards. Workplace air concentration levels for exposure to elemental mercury: Section 29 CFR 1910.1000 sets the permissible exposure limit (PEL) for an 8-hour time weighted average (TWA) of 0.1 mg/m^3.

▲ **Medical waste incinerators** (62 FR 48348) in September 1997. The guidelines establish standards that limit emissions from new and existing incinerators. The emission guidelines are expected to reduce emissions from exist-

Overview of **international organisations** and programmes with activities addressing the adverse impacts of mercury on health and the environment

Section	International organisation or programme	Geographic coverage of agreement or instrument	Organisation's relevance to mercury	Types of activities addressing mercury
9.3.1	LRTAP Convention and its 1998 Aarhus Protocol on Heavy Metals	Central and Eastern Europe, Canada and USA	Addresses mercury and mercury compounds in releases, products, wastes, etc.	Goal definition, binding commitments on release reductions and recommendations, monitoring
9.4.1	IARC	Global	Addresses the evaluation of carcinogenic risk of chemicals, including mercury to humans	Evaluations on individual chemicals, information, guidelines
9.4.2	ILO	Global	Addresses occupational health and safety issues linked with use of chemicals, including small-scale mining activities and mercury	Information, guidelines capacity building
9.4.3	IPCS	Global	Addresses health and environmental aspects of mercury (including inorganic mercury and methylmercury)	Information risk evaluations, scientific data and precautionary information
9.4.4	OECD	OECD member States	Addresses mercury and mercury compounds in releases, products, wastes, etc.	Information, recommendations
9.4.5	UNEP GPA	Global	Addresses heavy metals, including mercury	Goal definition, guidelines
9.4.6	UNIDO	Global	Addresses environmentally sustainable industrial activities, including artisanal mining	Information, guidelines capacity building
9.4.7	World Bank	Global	Addresses environmentally sustainable industrial activities, including artisanal mining	Information, guide lines, capacity building

UNEP Mercury Assessment Report 2000

ing incinerators by 93 to 95 percent.

- Several states, including New York, California and Texas have adopted relatively stringent regulations in the past few years limiting emissions from medical waste incinerators. The implementation of these regulations has brought about very large reductions in emissions of mercury in those states.
- **Information and reporting requirements** have been put under the USA Toxics Release Inventory (TRI).

Mercury discharges from the dental sector: Several PARCOM Recommendations relating to the reduction of mercury discharges from dental sources are applicable under OSPAR. In 1981, the Paris Commission recommended the installation of special filters in dental surgeries and clinics to collect the residues of mercury amalgams. PARCOM Recommendation 89/3 on Programmes and Measures for Reducing Mercury Discharges from Various Sources urges that alternative materials to dental amalgams should be used where appropriate and where excessive cost can be avoided. Surplus or old amalgam should be trapped and separated efficiently, then sent for recovery of the mercury content. PARCOM Recommendation 93/2 on Further Restrictions on the Discharge of Mercury from Dentistry states that equipment should be installed to separate water and amalgam to enable collection of the amalgam as from January 1, 1997.

Another international programme is 'The international Programme on Chemical Safety (IPCS)' established in 1980, a joint venture of the United Nations Environment (UNEP), the International Labour Organization and the World Health Organization(WHO).The overall objective of the IPCS are to establish the scientific basis for assessment of the risk to human health and the environment from exposure to chemical safety, and to provide technical assistance in strengthening national capacities for sound management of chemicals.

Inspite of this program, there has been no initiatives from The WHO and there is no clear policy from them for the management of mercury in the hospitals.

The WHO does not provide any literature or information for management of the use of the toxic chemical nor does it lay any emphasis on the reduction of its usage.

Even though the organisation realises that medical waste incinerators are the fourth largest source of mercury emission in the environment, there have been clear indications of the organization pushing for these obsolete technologies in the country.

In India the regulations and safeguards for handling mercury are virtually non-existent. Mercury pollution compromises the most basic human rights- life, clean food and water, work in safe environments, environmental health. The US EPA ranks health care sector as the forth- largest source of mercury air emission due to their contribution to the medical waste incinerator. However in India there are no mercury emission standards specified in the Bio-medical waste Rules 1998. Besides incineration, mercury also enters the environment directly as a result of improper disposal of broken thermometers and other mercury containing instruments. On an average India produces 10 to 12 million instruments a year including clinical and laboratory thermometers as well as blood pressure measuring instruments, consuming about 15 tonnes of mercury annually. Most of the mercury from these broken equipment either goes down the drain or is collected and put in black bags. As far as the hospitals are concerned, none of them check for mercury release, either in the incinerators or in the effluent released. The healthcare sector has not started looking at issues of emissions from waste incinerators or the effluents discharged into sewers seriously. Some policy or guideline needs to be worked out for phased elimination of mercury use and safe use and disposal of mercury products as an interim measure.

8 Section 8: Recommendations

Recommendations for policy makers

- ▲ Imports of mercury to be placed on restriced list, and to be phased out as alternatives come in.
- ▲ Open sale of mercury to be banned.
- ▲ Promote manufacture of digital thermometers and blood pressure instruments, non-mercury dental amalgams, through fiscal and non fiscal measures as well as awareness programs.
- ▲ Manufactures of mercury devices to be asked to take back used/collected mercury.
- ▲ Strict norms to be made for the collection and containment of mercury in health care institutions..To ensure that mercury wastes are not disposed off randomly.
- ▲ Ban incineration of medical waste to ensure no merury emissions.
- ▲ Promoting curricula development with special emphasis on hazardous substance and pollution prevention. The curricula of medical, nursing, dental, para medical, schools etc should be considered for adding this information on. Training programmes for waste management and occupational safety should include details on mercury toxicity and handling.
- ▲ Establishing a clearing-house for information relevant to mercury, for example, information on risk management strategies, appropriate alternatives and related costs, and ensuring easy access to this information.
- ▲ Given the human health concern, it is important that awareness programmes are launched to educate the populations to the risk and impact of mercury exposure in humans especially potentially vulnerable population viz pregnant women, breast feeding women, the fetus new born and young childern residing in the hot spot area's of the country and also consequences of MeHg exposure through fish consumption. There is a strong cultural pattern of fish consumption among coastal people

Recommendations for institutions/hospitals

- ▲ Phasing out mercury containing instruments or chemicals with the safer alternatives.
- ▲ Mercury inventorisation in the hospital to assess the mercury usage and plan a phase out strategy
- ▲ Clear Policy on Mercury usage- handling procedures, safeguards, spill clean up etc.
- ▲ Introduce reporting formats to report and register any mercury spills/ leaks
- ▲ Complete Safety precautions against any possible mercury disasters.
- ▲ Post hazard and warning information in the work area. In addition, as part of an ongoing education and training effort, communicate all information on the health and safety hazards of mercury to all health care workers.
- ▲ It is essential to handle mercury and mercury containing devices carefully. Small droplets of spilled mercury may lodge in cracks and sinks, mix with dust, accumulate on work- benches, and adhere to clothing, shoes, and jewelry. This allows for transportation of the mercury to other parts of the work place or home, thus potentially spreading the contamination.
- ▲ Thermometer container (with antiseptic) should be of plastic, glass bottles cause breakage.
- ▲ Establish mercury waste management in hospitals to ensure that no mercury enters the sewage system/ incinerator/ municipal bins. All the waste should be contained and dealt with as hazardous waste.

Recommendations for dentists

- ▲ Separators in dental clinics to be made mandatory
- ▲ Mercury fillings to be discouraged in young children, pregnanat women and nursing mothers.
- ▲ Tie up with a hazardous waste facility to dispose off amalgam waste/ Bio medical waste facilites can collect it from dentists and redirect it to the suitable disposal site.
- ▲ Make sure that your staff and assisstants are educated about the hazards of mercury andre trained in mercury usage.
- ▲ Switch to non-mercury fillings such as composite fillings as they are safer – for you and your patients
- ▲ Test yourself and your staff regularly for mercury levels

Suggested tips for handling mercury safely

- ▲ Use mercury in uncarpeted and well ventilated areas. Provide troughs on smooth surfaced tables and benches to collect mercury spills. Reserve a room for mercury use only.
- ▲ Ask workers to remove all jewelry and watches, especially gold. Mercury readily combines with gold. Workers who handle mercury are to wear mercury vapor respirators and protective clothing: gloves, disposable gowns, and shoe coverings.
- ▲ Prohibit smoking and eating in or near mercury exposed areas.
- ▲ Train employees to understand the dangers and precautions with handling mercury. Also train employees on the properties and hazards of mercury. Proper training on how to dispose of mercury will contribute to the prevention of environmental exposure. Staff training is a key element in the proper prevention and management of mercury spills.
- ▲ Clean and calibrate all mercury-containing equipment to the specifications of the manufacturer.
- ▲ Properly document and lable all containers contain mercury.
- ▲ Have an emergency spill and containment plan in case a spill does occur.
- ▲ Avoid having chemicals such as chlorine dioxide, nitric acid, nitrates, ethylene oxide, chlorine and methylazide in the same area as mercury since they will react violently with mercury.
- ▲ Be sure to keep mercury away from biological waste or anything else that will be incinerated since incineration puts mercury vapor into the air.

Recommendations for individuals/occupational safety

- ▲ Avoid skin contact with Mercury. Wear protective gloves and clothing.
- ▲ Wear chemical goggles and face shield.
- ▲ A person whose clothing has been contaminated by Hg should change into clean clothing promptly.
- ▲ Do not take contaminated clothes home. Family members could get exposed.
- ▲ On skin contact with Mercury, immediately wash or shower to remove the chemical.
- ▲ Do not eat, smoke, or drink where Mercury is handled, processed, or stored, since the chemical can be swallowed. Wash hands carefully before eating or smoking.

Mercury reference websites

- http://www.epa.gov/seahome/mercury/src/outmerc.htm
- http://www.healthbenchmarks.org/Mercury/
- http://www.noharm.org/mercury/issue
- http://www.sustainablehospitals.org/HTMLSrc/IP_factsheet_contents.html - mercury
- http://www.h2e-online.org/tools/mercury.htm
- http://www.mercurypoisoned.com/
- http://www.toxicteeth.net/about_Us.cfm
- www.informinc.org
- http://www.nih.gov/od/ors/ds/nomercury/
- www.ewg.org
- http://www.findarticles.com/cf_dls/m0ISW/2001_May/73959332/p1/article.jhtml?term=
- http://www.mercurypoisoningfyi.com/
- http://www.testfoundation.org/

Other sources referenced

- UNEP Mercury Assesment Report 2002
- Dentist the Menace
- Mercury In India, Toxic Pathways
- Health Impacts of Mercury: The International Programme on Chemical Safety
- Mercury Menace: *Down to Earth* Supplement
- http://www.chem.unep.ch/mercury/default.htm
- http://europa.eu.int/comm/environment/chemicals/mercury/
- http://www.toxicteeth.com

Appendices

Appendix 1: Skin Whitening Creams

Everyday, around the world, the media bombards women of colour with the idea that light skin is attractive. And to attain this "Westernized" ideal of beauty, women throughout Africa and Asia are using dangerous chemicals to bleach their skin.

Believing whiter skin will make them more attractive, millions of women throughout Africa are using skin whitening creams containing hydro-quinone, a chemical used to develop black and white film, and mercury to lighten the colour of their skin.

Use of skin-lightening soap and creams can give rise to substantial mercury exposure. Prolonged use of these creams destroys the skin's protective outer layer and can cause nerve damage, kidney failure and skin cancer, according to the American Academy of Dermatology.

Appendix 2: One gram of mercury in a twenty acre lake: origin of the phrase

What is the basis for the commonly-used phrase, "one gram of mercury can contaminate a twenty acre lake"? Variations of this analogy have been used to illustrate the concept that relatively small quantities of mercury can result in contamination of lakes and streams. The origin of this analogy was a 1995 brochure produced by a joint program of three Great Lakes states, Minnesota, Michigan, and Wisconsin[1]. The pertinent section of the brochure states: "About a gram of mercury enters a 20-acre lake each year. A gram of mercury is only a small drop. A teaspoonful of mercury weighs about 70 grams. Even these small amounts of mercury in lake water can contaminate the fish, making them unfit to eat on a regular basis."

The figure of one gram per 20-acre lake is based on a 1992 study by the Minnesota Pollution Control Agency (MPCA) that found that virtually all of the mercury in lakes is the result of atmospheric deposition, at the rate of mercury of 12.5 micrograms per square meter per year.[2] This deposition rate corresponds to about one gram (the average amount of mercury in a fever thermometer) deposited in a twenty acre lake every year. As evidenced by fish consumption advisories due to mercury in over 40 states, over time, this seemingly small annual atmospheric deposition often results in mercury-contaminated fish that are unsafe to consume on a regular basis. Ongoing monitoring of mercury in precipitation reveals deposition rates that are often lower than 12.5 micrograms per square meter (for example, see http://nadp.sws.uiuc.edu/mdn/maps/2001/01MDNdepo.pdf), but this monitoring does not include mercury that is deposited directly from the atmosphere when it is not raining, so called "dry" deposition. Dry deposition of mercury is thought to be as much as 50% of "wet" deposition, a factor that brings total deposition in many areas close to the 12.5 found by the MPCA study. Regardless, many studies have found a deposition rate approximately equal to one gram of mercury per twenty acres.

The point of the "one gram per twenty acre lake per year" message is that for lakes that do not receive point-source pollution such as a wastewater discharge, all of the mercury in the fish is delivered by the atmosphere at a seemingly small rate. The exact level of fish contamination varies because of variation in watershed size, lake depth, primary productivity, food chain characteristics, wetland areas, methylation rates, and probably other factors.

It is literally true that the fish contamination found in most lakes is the result of atmospheric mercury deposition at the rate of about one gram per 20 acres, a rate that increased by over a factor of three from the industrial revolution to the 1990s. However, some people have erroneously interpreted this information to mean that spilling a gram of liquid mercury, say from a fever thermometer, into a lake could result in the same degree of fish contamination. Although a spilled gram of liquid mercury may volatilize and return to earth dissolved in rain, liquid mercury directly poured into a lake would not contaminate fish as efficiently as the same amount of mercury in rain. Atmospheric mercury does not dissolve in rainwater until it has become ionized by atmospheric processes. Ionic mercury is probably more available than liquid mercury for conversion to methyl mercury, the form that accumulates in fish. However, it is important to keep all forms of mercury out of the environment. All forms of mercury have the potential to move through the atmosphere, be ionized, and become methyl mercury. Mercury never degrades and goes away.

A more exact summary of this information would be: "Approximately one gram of mercury, the amount in a single fever thermometer, is deposited to a 20-acre lake each year from the atmosphere. This small amount, over time, can contaminate the fish in that lake, making them unfit to eat on a regular basis."

Edward B. Swain, Minnesota Pollution Control Agency,
edward.swain@pca.state.mn.us, March 2004

1. Mercury in the Environment: The Waste Connection. 1995. Brochure produced by a joint program of the Minnesota Pollution Control Agency, Michigan Department of Natural Resources, and the Wisconsin Department of Natural Resources, developed with a grant from the U.S. Environmental Protection Agency.

2. Swain, E.B., et. al., 1992, "Increasing Rates of Atmospheric Mercury Deposition in Midcontinental North America", *Science*, 257: 784-787.

Appendix 3: Thimerosal

Thimerosal is an additive that has been used in biologics and vaccines to kill bacteria used in certain vaccines and prevent bacterial contamination in certain containers. Thimerosal contains four main ingredients, ethyl mercuric chloride, thiosalicylic acid, sodium hydroxide and ethanol. Ethyl mercuric chloride is essentially organic mercury. The inorganic mercurial thimerosal (merthiolate) has been used as an effective preservative in numerous medical and non-medical products since the early 1930s. Some of the vaccines that contain thimerosal include Hepatitis B, diphtheria, pertussis, acellular pertussis, tetanus and HIB vaccines. Both the potential toxicity of thimerosal and sensitisation to it in relation to the application of thimerosal-containing vaccines and immunoglobulins, especially in children, have been debated. The very low thimerosal concentrations in pharmacological and biological products are relatively non-toxic, but probably not in utero and during the first 6 months of life. The developing brain of the foetus is most susceptible to thimerosal and, therefore, women of childbearing age, in particular, should not receive thimerosal-containing products. Definitive data of doses at which developmental effects occur are not available. Moreover, revelation of subtle effects of toxicity needs long-term observation of children. The ethylmercury radical of the thimerosal molecule appears to be the prominent sensitiser. The prevalence of thimerosal hypersensitivity in mostly selected populations varies up to 18%, but higher figures have been reported. With regard to the debate on primary sensitisation during childhood and renewed attention for a reduction of children's exposure to mercury from all sources, the use of thimerosal should preferably be eliminated or at least be reduced. In 1999 the manufacturers of vaccines and immunoglobulins in the US and Europe were approached with this in mind. The potential toxicity in children seems to be of much more concern to them than the hidden sensitising properties of thimerosal. In The Netherlands, unlike many other countries, the exposure to thimerosal from pharmaceutical sources has already been reduced. Replacement of thimerosal in all products should have a high priority in all countries.

Appendix 4: Instruments, products, and laboratory chemicals used in hospitals that may contain mercury

Thermometers

- ▲ Body temperature thermometers
- ▲ Clerget sugar test thermometers
- ▲ Heating and cooling system thermometers
- ▲ Incubator/water bath thermometers
- ▲ Minimum/maximum thermometers
- ▲ National Institute of Standards and Technology calibration thermometers
- ▲ Tapered bulb (armored) thermometers

Sphygmomanometers

Gastrointestinal tubes

- ▲ Cantor tubes
- ▲ Esophageal dilators (bougie tubes)
- ▲ Feeding tubes
- ▲ Miller Abbott tubes

Dental amalgam

Pharmaceutical supplies

- ▲ Contact lens solutions and other ophthalmic products containing thimerosal or phenylmercuric nitrate
- ▲ Diuretics with mersalyl and mercury salts
- ▲ Early pregnancy test kits with mercury containing preservative
- ▲ Merbromin/water solution
- ▲ Nasal spray with thimerosal, phenylmercuric acetate or phenylmercuric nitrate
- ▲ Vaccines with thimerosal (primarily in hemophilus, hepatitis, rabies, tetanus, influenza, diphtheria and pertussis vaccines)
- ▲ Cleaners and degreasers with mercury contaminated caustic soda or chlorine

Batteries (medical use)

- ▲ Alarms
- ▲ Blood analyzers
- ▲ Defibrillators
- ▲ Hearing aids
- ▲ Meters
- ▲ Monitors
- ▲ Pacemakers
- ▲ Pumps
- ▲ Scales
- ▲ Telemetry transmitters
- ▲ Ultrasound
- ▲ Ventilators

Batteries (non-medical uses)

Lamps

- ▲ Fluorescent
- ▲ Germicidal
- ▲ High-intensity discharge (high pressure sodium, mercury vapour, metal halide)
- ▲ Ultraviolet

Electrical equipment

- ▲ Tilt switches
- ▲ Air flow/fan limit control
- ▲ Building security systems
- ▲ Chest freezer lids
- ▲ Fire alarm box switches
- ▲ Lap-top computer screen shut-off
- ▲ Pressure control (mounted on bourdon tube or diaphragm)
- ▲ Silent light switches (single-pole and three-way)
- ▲ Temperature control (mounted on bimetal coil or attached

to bulb device)
- ▲ Washing machine (power shut off)

Float control
- ▲ Septic tanks
- ▲ Sump pumps

Thermostats (non-digital)

Thermostat probes in electrical Equipment

Reed relays (low voltage, high precision analytical equipment)

Plunger or displacement relays (high current/high voltage applications)

Thermostat probes in gas appliances (flame sensors, gas safety valves)

Pressure gauges
- ▲ Barometers
- ▲ Manometers
- ▲ Vacuum gauges

Other devices, such as personal computers, that utilize a printed wire board
- ▲ Blood gas analyzer reference electrode (Radiometer brand)
- ▲ Cathode-ray oscilloscope
- ▲ DC watt hour meters (Duncan)
- ▲ Electron microscope (mercury may be used as a damper)
- ▲ Flow meters
- ▲ Generators
- ▲ Hitachi Chem Analyzer reagent
- ▲ Lead analyzer electrode (ESA model 3010B)
- ▲ Sequential Multi-Channel Autoanalyzer (SMCA) AU 2000
- ▲ Vibration meters

Laboratory chemicals that may contain mercury (compiled in 1997)

This list is intended to demonstrate the wide variety of laboratory chemicals that may contain mercury. It was derived from examining the Massachusetts Water Resources

Authority Mercury Source Identification Program Database. Some of the chemicals may contain added mercury and others may contain mercury as a contaminant in a feedstock.

If the mercury is a contaminant, its presence or absence may vary from lot to lot. In the case of kits, it is necessary to consider separately each of the reagents that make up the kit. This list should not be assumed to be complete. Request that vendors disclose mercury concentration on a Certificate of Analysis for all chemicals ordered.

- ▲ Acetic acid
- ▲ Ammonium reagent/Stone analysis kit
- ▲ Antibody test kits
- ▲ Antigens
- ▲ Antiserums
- ▲ Buffers
- ▲ Calibration kits
- ▲ Calibrators
- ▲ Chloride
- ▲ Diluents
- ▲ Enzyme Immunoassay test kits
- ▲ Enzyme tracers
- ▲ Ethanol
- ▲ Extraction enzymes
- ▲ Fixatives (B5, Zenkers)
- ▲ Hematology reagents
- ▲ Hormones
- ▲ Immunoelectrophoresis reagents
- ▲ Immunofixationphoresis reagents
- ▲ Immusal
- ▲ Liquid substrate con
- ▲ Negative control kits
- ▲ Phenobarbital reagent
- ▲ Phenytoin reagent
- ▲ Positive control kits
- ▲ Potassium hydroxide
- ▲ Pregnancy test kits
- ▲ Rabbit serum
- ▲ Shigella bacteria
- ▲ Sodium hypochlorite
- ▲ Stains
- ▲ Standards
- ▲ Sulphuric acid
- ▲ Thimerosal
- ▲ Tracer kits
- ▲ Urine analysis reagents
- ▲ Wash solutions

Source: www. noharm. org

Appendix 5: Questionnaires used in the study

Hospitals

A. Name
B. Years in operation
C. Bed Strength
D. Occupancy
E. Number of doctors
F. Number of nurses
G. Number of trainees they have at one time
H. Total staff count
I. Instruments containing mercury used in Hospital
J. Number of total thermometers in the hospital (any area wise break up)
K. Frequency/patterns of temperature maintenance
L. Total replacements of thermometer in a month
M. Have they ever used digital thermometer, if yes, kind of difficulty
N. Number of Sphygmomanometers (area wise)

O. Total replacements of BP app. in a month
P. Any policy on use of these instruments/ collection and disposal of hg
Q. Any training to staff on these lines
R. Cost of a single unit of thermometer/ sphygmomanometer
S. How often are these bought and the quantity of each of these purchased
T. Manufacturer and supplier (contact details)
U. Cost of alternate equipment
V. Is the hospital connected to a sewage treatment plant
W. How often is the liquid effluent tested
X. Is the effluent ever tested for hg
Y. Any other comment or suggestion

Hospital personnel

A. Name
B. Profession
C. Years in this profession
D. Any mercury containing instruments/ product that they use in the hospital
E. What do they know about Hg
F. What is the source of this information
G. Any training sessions on use and disposal of mercury
H. How many thermometers break in a month
I. Most obvious reason of breakage
J. Who handles hg when it spills
K. What do they do in case of a spill
L. Do they report the incident of breakage/ spill of Hg instrument
M. Have they ever experienced any problem after handling Hg
N. Are any protective gear used while cleaning mercury
O. Have they ever used any alternate equipment
P. Any difficulty they faced while using them (accuracy, ease, functioning)
Q. Any problem in handling BP Apparatus
R. Any problem during its spillage or breakage
S. Any other comment

Dental clinics/colleges

A. Name
B. Years of practice
C. Number of fillings done in a day
D. What kind of filling is being used by you/ substitutes available for dental amalgams
E. Have you ever worked with alternate fillings, if yes, any complains
F. Which is considered better and why
G. Longevity of the amalgam/alternates
H. How is amalgam bought
I. What is the usage pattern of amalgam/ substitute
J. What do you know about hg and source of that information/awareness reg. hazards of Hg
K. Do you inform your patients about the amalgam contents or mercury toxicity
L. What is the cost difference between amalgam and substitutes
M. Does the temporary filling have hg
N. Any apparent problems felt after long exposure to amalgams
O. What precautions taken while handling amalgams
P. Any other procedure/ instrument in dentistry that is known to have Hg
Q. Are you member of the Indian dental association or any other dental association
R. Use of separators in dental clinics

Suppliers/manufacturers

A. Major players/ name of the companies manufacturing Hg instruments
B. Any local players involved
C. Annual sales, Industry turnover
D. Source of raw material
E. Type of facility (process of manufacture)
F. Is this process standard/ anyother processes involved
G. Disposal process
H. Provision for worker safety
I. Any take back policy, If yes, are the customers aware of it
J. Is there any legislation that they are supposed to follow
K. Are they supposed to attach any note/ or word of caution about the product being hazardous

Alternative products

A. Major players/ name of the companies manufacturing Hg instruments
B. Any local players involved
C. Annual sales, Industry turnover
D. Cost/unit
E. Mechanism behind working of the instrument
F. Any hazardous component involved
G. Reasons for the high cost
H. Life of the battery
I. Type of the battery
J. Maintenance involved, if any
K. Breakage possibility with respect hg thermometer
L. Growth of the market
M. Effect to the cost if market rises
N. Years in market

Appendix 6: Export-import figues

Department of Commerce, Export Import Data Bank;
Export: Commodity-wise all countries; Dated: 29/5/2004

Commodity: 280540
Mercury, Unit: NOS

Country	Values in Rs. Lacs		Quantity in thousands	
	2002-2003	2003-2004 (Apr-Sep)	2002-2003	2003-2004 (Apr-Sep)
Nepal	–	0.06	–	0.01
Tanzania Rep	0.04	–	0.16	–
UAE	0.36	–	0.03	–
Djibouti	0.09	–	0.03	–
Kenya	0.17	–	0.01	–
Total	**0.67**	**0.06**	**0.23**	**0.01**

Commodity: 90251110
Clinical thermometer, Unit: NOS

Country	Values in Rs. Lacs		Quantity in thousands	
	2002-2003	2003-2004 (Apr-Sep)	2002-2003	2003-2004 (Apr-Sep)
Singapore	1.40	95.19	2.50	138.56
USA	107.91	55.38	272.41	195.53
Mexico	4.08	16.61	15.00	60.00
Malaysia	–	6.29	–	17.05
France	2.30	3.39	8.20	3.00
UAE	9.79	1.62	41.00	3.30
Kenya	1.26	0.92	4.09	1.94
Kuwait	–	0.76	–	1.80
Zambia	0.18	0.59	1.90	0.50
Oman	0.26	0.37	0.90	2.00
Nepal	0.17	0.11	0.38	0.20
Saudi Arabia	–	0.05	–	0.10
Hong Kong	0.77	–	5.00	–
Indonesia	2.04	–	10.00	–
Iraq	80.29	–	143.00	–
South Africa	1.08	–	5.98	–
Sri Lanka	5.08	–	20.00	–
Switzerland	0.78	–	2.00	–
Thailand	0.94	–	2.70	–
UK	11.54	–	33.05	–
Total	**229.88**	**181.27**	**568.11**	**423.98**

Commodity: 90189011
Blood Pressure instruments (Sphygmomanometers)
Unit: NOS

Country	Values in Rs. Lacs		Quantity in thousands	
	2002-2003	2003-2004 (Apr-Sep)	2002-2003	2003-2004 (Apr-Sep)
Singapore	–	101.50	–	10.00
Sri Lanka	–	67.13	–	7.18
Afghanistan	–	6.41	–	0.56
Bangladesh	–	3.57	–	0.16
Yemen Republic	–	2.21	–	0.10
Malawi	–	2.01	–	0.14
France	2.79	1.61	3.85	0.10
Kenya	–	1.00	–	0.12
Australia	0.31	0.57	0.03	0.06
Zambia	0.78	0.45	0.10	0.10
Zimbabwe	1.22	–	0.70	–
South Africa	2.44	–	1.01	–
Latvia	0.34	–	6.00	–
Lithuania	0.89	–	0.45	–
Iran	0.42	–	0.10	–
El Salvador	0.50	–	0.77	–
Albania	0.26	–	0.10	–
Malaysia	–	2.72	–	0.02
Maldives	–	0.12	–	0.03
Mongolia	0.46	–	0.16	–
Nepal	0.98	–	0.27	–
Nicaragua	2.02	–	45.00	–
Rwanda	0.37	–	0.03	–
Sweden	1.81	–	0.05	–
Trinidad	0.77	–	0.31	–
UK	1.65	–	0.23	–
USA	0.77	–	0.08	–
Total	**21.62**	**186.45**	**59.30**	**18.52**

Commodity: 90251910
Digital thermometers
Unit: NOS

Country	Values in Rs. Lacs 2002-2003	Values in Rs. Lacs 2003-2004 (Apr-Sep)	Quantity in thousands 2002-2003	Quantity in thousands 2003-2004 (Apr-Sep)
USA	29.62	162.18	37.69	108.24
Singapore		156.95		151.34
Oman	0.12	4.78	0.01	4.00
Bangladesh	0.91	3.28	0.40	2.55
UAE	6.89	3.20	2.60	1.18
Germany		0.52		0.10
Panama Republic		0.30		0.01
Thailand	1.68	0.29	0.07	0.02
Kenya	0.94	0.25	0.06	0.01
Myanmar		0.02		0.00
Australia	0.02			
Bahrain	0.44		0.01	
Burundi	0.03			
China	2.58		1.69	
Denmark	0.05			
Ethiopia	0.27		0.01	
Iraq	11.00		10.00	
Malaysia	1.65		0.71	
Nepal	0.02			
Pakistan	0.49		0.04	
Peru	0.35		0.07	
Saudi Arabia	0.07		0.01	
South Africa	0.12		0.07	
Sri Lanka	6.90		0.17	
Sudan	1.11		0.01	
Turkey	0.50		0.20	
UK	1.95		0.20	
Zambia	0.16		0.10	
Total	**67.88**	**331.79**	**54.12**	**267.45**

Department of Commerce, Export Import Data Bank;
Export: Commodity-wise all countries; Dated: 29/5/2004

Commodity: 280540
Mercury
Unit:

Country	Values in Rs. Lacs 2002-2003	Values in Rs. Lacs 2003-2004 (Apr-Sep)	Quantity in thousands 2002-2003	Quantity in thousands 2003-2004 (Apr-Sep)
UK	3.94	72.31	2.02	35.50
Netherland	49.77	41.02	26.35	3.84
Algeria	188.82	28.59	134.62	23.78
Spain	330.72	16.63	180.65	4.29
USA		8.56		0.10
Germany	12.13	3.22	6.87	0.98
Japan	0.13	0.13	0.01	0.00
Italy	209.32		134.31	
China	19.70		6.18	
UAE	30.37		25.50	
Russia	20.89		14.69	
Total	**865.78**	**170.46**	**531.20**	**362.78**

Commodity: 90251910
Clinical thermometers
Unit: NOS

Country	Values in Rs. Lacs 2002-2003	Values in Rs. Lacs 2003-2004 (Apr-Sep)	Quantity in thousands 2002-2003	Quantity in thousands 2003-2004 (Apr-Sep)
China	58.60	3.86	359.99	11.10
Germany	5.20	0.88	2.76	0.31
USA		0.06		0.00
Belgium	1.51		0.50	
Chinese Taipei	1.47		5.77	
Hong Kong	3.12		9.60	
Italy	1.17		1.00	
Malaysia	0.03		0.14	
UK	9.61		5.99	
Total	80.71	4.80	387.64	11.41

Commodity: 90189011
Blood Pressure instruments (Sphygmomanometers)
Unit: NOS

Country	Values in Rs. Lacs 2002-2003	Values in Rs. Lacs 2003-2004 (Apr-Sep)	Quantity in thousands 2002-2003	Quantity in thousands 2003-2004 (Apr-Sep)
USA	59.74	372.74	0.37	5.53
Germany	242.76	314.43	1.52	3.86
Singapore	15.52	114.24	0.12	4.76
UK	0.36	76.40	0.30	2.71
Japan	19.79	57.37	1.20	2.19
Switzerland	11.71	51.67	0.14	0.50
China	33.54	50.55	0.56	1.85
Italy	30.69	35.64	0.08	0.48
France	16.44	24.49	0.35	0.43
Sweden	4.16	18.95	0.00	0.08
Malaysia		13.39		0.37
Chinese Taipei	6.85	13.11	0.40	0.31
Korea	7.56	11.89	0.04	0.37
Hong Kong	12.46	11.63	0.02	0.28
Netherland	4.11	8.40	0.00	0.45
Spain		8.03		0.06
Finland	10.83	4.73	0.01	0.05
Israel		4.00		0.01
Ireland		3.63		0.08
Australia	10.96	2.05	0.06	0.00
Belgium		1.76		0.01
Denmark	1.84	1.68	0.05	0.03
Pakistan		1.24		0.00
Unspecified		0.63		0.08
Sri Lanka		0.06		0.00
Brazil	4.11		0.01	
Austria	25.06		0.03	
Norway	6.97		0.02	
Total	**525.45**	**1,202.71**	**5.28**	**387.27**

Commodity: 90251910
Digital Thermometers
Unit: NOS

Country	Values in Rs. Lacs 2002-2003	Values in Rs. Lacs 2003-2004 (Apr-Sep)	Quantity in thousands 2002-2003	Quantity in thousands 2003-2004 (Apr-Sep)
USA	99.25	45.38		0.97
UK	31.89	19.88		0.23
Germany	69.84	19.51		0.68
China	27.00	15.33		35.75
Unspecified	0.51	11.43		0.80
Japan	108.43	9.15		0.41
Singapore	7.33	3.99		0.31
Switzerland	0.60	3.27		0.04
Hong Kong	4.10	1.43		1.50
Finland	1.97	1.05		0.02
Chinese Taipei	16.94	0.31		0.04
Korea	0.39	0.28		0.06
Brazil		0.11		0.00
Netherland	0.43	0.09		0.00
Sweden	6.46	0.06		0.00
Denmark	1.95	0.04		0.00
Philippines		0.04		0.00
Italy	6.44	0.03		0.00
Belgium	1.98		0.11	
Canada	0.93		0.01	
France	0.62		0.02	
Malaysia	0.23		0.03	
Austria	0.21		0.00	
Australia	0.14		0.00	
Total	**387.64**	**131.40**	**127.31**	**40.81**

Appendix 7: US State Bills

Date	State	Bill
June 10, 2003	Illinois	State law (Public Act 93-0165) that bans the manufacture, sale and distribution of mercury fever thermometers and mercury-added novelty items after July 1, 2004.
May 20, 2003	Maine	State law (LD 1159) (pdf) that prohibits the sale of mercury in switches, measuring devices (including sphygmomanometers), instruments and thermostats with an effective date of July 1, 2006.
May 19, 2003	Washington	State law (House Bill 1002) that requires the labeling of florescent lamps that contain mercury. Prohibits the sale of mercury-containing items in products such as thermometers, motor vehicles, and thermostats after January 2006. Directs the Department of Ecology to develop and implement a state plan for a permanent mercury repository. Orders the Department of Health to develop an education plan for mercury disposal. Charges schools to find a way to get rid of existing mercury. Sphygmomanometers may not be sold with the exception of a hospital of healthcare facility with a mercury reduction plan in place.
October 3, 2002	Michigan	State law (House Bill 4599) (pdf) that bans the sale of mercury thermometers.
June 3, 2002	Connecticut	State law (House Bill 5539) that bans the sale and distribution of mercury fever thermometers after January 1, 2003 and places restrictions on the sale of other mercury-containing equipment.
February 25, 2002	Massachusetts	State law (House Bill 3772) that bans the sale of mercury fever thermometers.
October 10, 2001	California	State law (SB 633) that restricts the use and distribution of mercury fever thermom eters; places controls on the disposal of appliances and vehicle components containing mercury; and bans the addition of mercury to novelties and clothing articles, the sale of a car that contains a mercury vehicle switch and the use of mercury-containing items from use in schools, except for measuring devices.
August 8, 2001	Oregon	State law (HB 3007) that phases out mercury thermostats and prohibits the sale of fever thermometers, novelty products and automotive light switches with mercury
July 13, 2001	Rhode Island	State law (S 0153) that prohibits the sale or distribution of mercury fever thermometers in the state
June 8, 2001	Maine	State law (LD 1665) that requires manufacturers of formulated products to disclose mercury content, prohibits hospitals from supplying mercury fever thermometers, bans retail sales of mercury fever thermometers and bans sales of mercury dairy manometers and mercury to schools
May 18, 2001	Maryland	State law (HB 75) that prohibits the sale of mercury fever thermometers in the state and prohibits primary or secondary schools from using elemental or chemical mercury
May 10, 2001	Indiana	State law (HB 1901) that limits the circumstances under which a mercury fever thermometers may be sold, prohibits the sale and distribution of most mercury-added novelties and restricts schools from using mercury
April 26, 2001	Minnesota	State law (SF 70, HF 274) that prohibits the sale or distribution of mercury thermometers
June 20, 2000	New Hampshire	State law (HB 1418) that prohibits the sale of certain mercury-added products; establishes notification and disclosure requirements for permissible mercury-containing products; establishes limitations on the use of elemental mercury; etc.

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