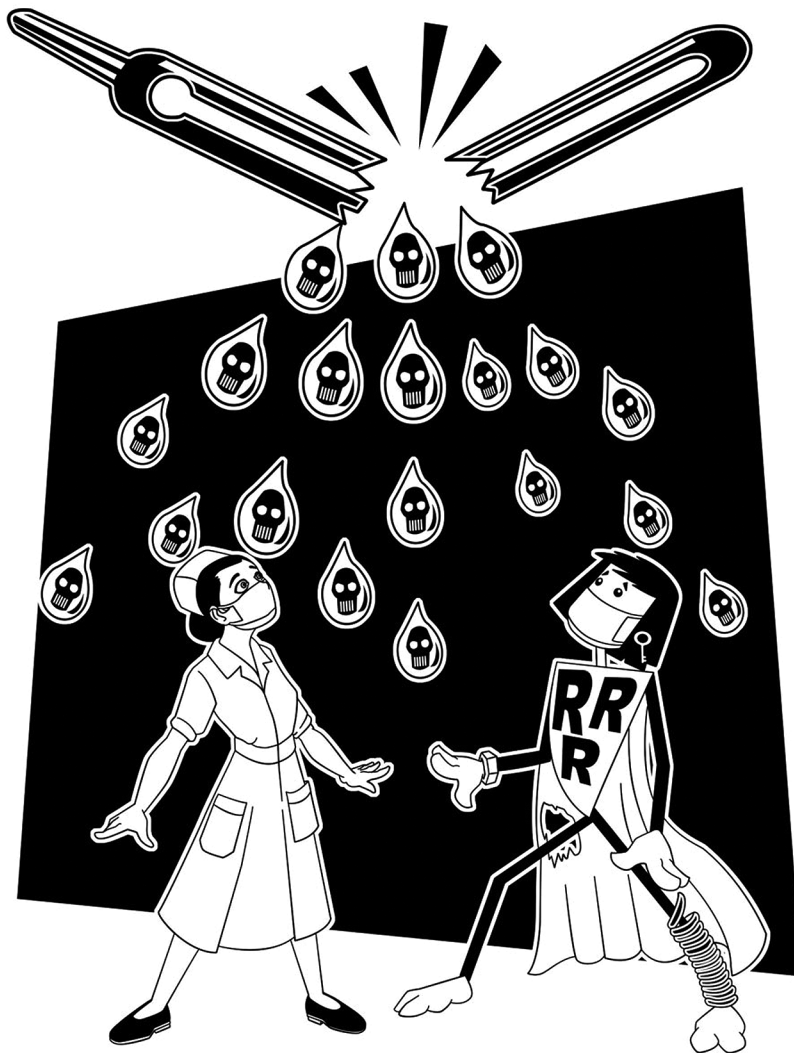




Toxics Link  
for a toxics-free world

# Mercury in Hospital Indoor Air



Mercury spills in hospitals, clinics and labs expose doctors, nurses, other health care workers and patients to elemental mercury, a very dangerous substance. Considering that a single broken thermometer is enough to contaminate a 20-acre lake, the magnitude of the problem is evidenced by this study, which shows that a 300- to 500-bed hospital in Delhi sees 70 thermometer breakages a month, on the average.

# MERCURY IN HOSPITAL INDOOR AIR: STAFF AND PATIENTS AT RISK



**JANUARY 2007**

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# MERCURY IN HOSPITAL INDOOR AIR: STAFF AND PATIENTS AT RISK

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## Acknowledgment

The Idea of this study emerged from an earlier study titled: *Lurking Menace: Mercury in Healthcare Facilities*, conducted by us in 2004. It was a first of its kind research on the challenges and risks posed by breakage of mercury-based thermometer and minimal awareness on mercury toxicity among the healthcare staff.

We wish to deeply acknowledge the support we received from the two hospitals for providing their premises and making necessary arrangements for conducting tests.

Valuable inputs were provided by Dr. Abhay Kumar, Senior Programme Officer, in interpretation of data.

Satish Sinha, Chief Programme Coordinator and Ravi Agarwal, Director, as always, were key in shaping the direction and accuracy of the study.

Finally, to all the members of Toxics Link for their continuous support and timely advice.

**Prashant Pastore**

**Senior Programme Coordinator**

**Toxics Free Healthcare Programme**

## Foreword

Never before in the history of humankind has there been such a vast exposure to multiplicity of chemicals and environmental contaminants. Mercury is one such, and totally replaceable. However, despite years of the issue being raised, there has been no policy action. This study further underlines the ongoing risk which healthcare workers face owing to the use of mercury production.

In this context, the study report aims to advocate for mercury-free healthcare settings in the country and across regions, which would significantly reduce the risks posed by the use and disposal of mercury and urges that policy action to be taken urgently.

**Ravi Agarwal**

Director, Toxics Link

January, 2007

## TABLE OF CONTENTS

- EXECUTIVE SUMMARY.....06
- INTRODUCTION.....08
- ENVIRONMENTAL IMPACT OF MERCURY.....08
- HEALTH IMPACTS OF MERCURY.....10
- MERCURY IN HEALTHCARE.....12
- POPULATION AT RISK.....13
- STANDARDS VERSUS PREVENTION.....16
- RATIONALE OF STUDY.....19
- OBJECTIVES.....20
- METHODOLOGY.....21
- RESULTS.....26
- DISCUSSION.....29
- CONCLUSION & RECOMMENDATIONS.....32

## EXECUTIVE SUMMARY

One of the most significant environmental offenders, mercury is widely associated with healthcare institutions and industry. It is used in its elemental form as liquid metal in a number of healthcare products like thermometers, blood pressure cuffs and esophageal dilators.

Mercury can easily migrate across various environmental mediums in air, soil and water. Through anthropogenic release, it is transported to long distances and re-deposited away from the sources of origin. Given the nature of its persistent presence over a long period of time, mercury concentration marine and other biological species tends to multiply with age.

Mercury exists in various physical and chemical forms. The most important one -- from a toxicological point of view -- is methyl mercury. Vapour from this form is rapidly absorbed through lungs and in humans over 75-85 per cent of what is inhaled ends up being absorbed.

Mercury is toxic by ingestion, inhalation and skin absorption. Exposure to it can cause nausea, blurred vision, painful breathing, excessive salivation and pneumonitis, while chronic exposure leads to memory problems, hypertension, vision impairment, hallucinations and personality disorders.

Elemental mercury has liquid form at room temperature and when released, such as a broken thermometer, it vapourises and disperses into the surrounding air. When mercury spillage happens indoors it can lead to exposure through inhalation. The severity of the exposure depends on air temperature, amount of mercury released, air flow and the the body-type of the individual being exposed.

Mercury spills in hospitals, clinics and labs expose doctors, nurses, other health care workers and patients to elemental mercury. As at room temperature significant amounts of liquid elemental mercury transforms into a gas, exposing workers and patients in the area. In a study conducted by Toxics Link in Delhi it was found that nearly 70 thermometer breakages take place each month in a 300 to 500

bedded hospital. Data also shows that an average-sized hospital annually releases 3 kg of mercury in the environment.

At present there are no standards for mercury in the indoor ambient air. Though the Government had placed a limit for occupational exposure of mercury at the level at which it crosses the skin-barrier for alkali compounds. The above standard under the Factories Act of 1948, amended in 1987, do not apply to healthcare facilities.

#### **Findings:**

1. The study was conducted in two hospitals of Delhi.
2. These hospitals have phased out mercury thermometers and have in place a mercury management policy.
3. All the test locations showed presence of mercury vapour at varied levels.
4. The nursing station and maintenance room in the hospital B showed a higher concentration of mercury.
5. The highest concentration was found in storage and calibration areas of the hospital-A
6. The dental wing of both the hospital also had very high level of mercury ( $3.11 \mu\text{g}/\text{m}^3$ )
7. The levels were also high in maternity and general wards thus posing substantiation risk to newborn babies and patients.
8. Findings indicate that there is an urgent need for regulatory intervention to minimise mercury emissions in indoor air of health care facility.
9. Agency for Toxic Substances and Disease Registry (ATSDR) had suggested and  $1.0 \mu\text{g}/\text{m}^3$  is action level for remediation.
10. The study recommends that the all the hospitals must substitute mercury-based products.
11. Finally, the study recommends large-scale investigations of this nature for a more comprehensive policy intervention.



## INTRODUCTION

Hospitals and healthcare institutions are popularly perceived to be safer and healthier than any other usual place. But what would you say, when told that the medical health staff that works in these settings or the people who visit them are risking their health due to a poison that is slowly saturating the indoor air of these establishments.

Mercury is one of the most significant environmental offenders widely used and associated with the healthcare. It is mostly found in healthcare products in its elemental form as liquid metal. It is used in thermometers, blood pressure cuffs, and esophageal dilators.<sup>1</sup> It is also found in cleaning agents and fixatives for laboratory work. In a database comprising 5,000 medical products, compiled by a technical assistance organization, more than 15 per cent contained mercury.<sup>2</sup>

## ENVIRONMENTAL EFFECTS OF MERCURY

Mercury can migrate across various environmental mediums in air, soil and water. Mercury deposited from anthropogenic releases can be re-emitted from land and water, undergo long-range transport<sup>3</sup> in the atmosphere, and be re-deposited elsewhere, and so on. This process of emission and re-emission is the reason why animals and people in remote areas with no local mercury releases, such as in the Arctic, may have elevated mercury levels.

A significant problem is that mercury is used in so many different facets of modern life. Mercury is found in devices commonly used in hospitals, our homes and schools. Most of these devices are safe

<sup>1</sup> Shaner H. 1997. *Becoming a Mercury Free Facility: A Priority to Be Achieved by the Year 2000*. Chicago: American Society for Healthcare Environmental Services.

<sup>2</sup> Shapiro K, Stoughton M, Graff R, Feng L. 2000. *Healthy Hospitals: Environmental Improvements Through Environmental Accounting*. Boston, MA: Tellus Institute.

<sup>3</sup> The volatility of elemental mercury (Hg<sup>0</sup>), which allows mercury to travel in a multi-step sequence of emission to the atmosphere, transportation, deposition and re-emission. As a result, mercury from point source emissions may remain localized in the environment, or may be transported regionally and even globally. Atmospheric transport is likely the primary mechanism by which Hg<sup>0</sup> is distributed throughout the environment, unlike many pollutants that follow erosion or leaching pathways. Mercury can enter the atmosphere as a gas or bound to other airborne particles and circulates until removal. Removal occurs primarily through the "wet" deposition of Hg<sup>2+</sup> in rainfall, however it can also occur in the presence of snow, fog, or through direct, or "dry", deposition.

to users (though, its product manufacturing can be very toxic), as long as the mercury is sealed, but if a device is broken or disposed of improperly, toxic mercury will eventually be released into the environment.<sup>4</sup> A study in India also showed 70 thermometers broke in a month on an average 300-500 bedded health facility.<sup>5</sup>

Probably, the most commonly found mercury hazard is the mercury thermometer, frequently used in hospitals and at homes. Although small, a broken thermometer can leak enough released mercury to harm a child or to contaminate a 20-acre lake. Even unbroken, once a mercury thermometer enters a landfill, that mercury still poses an environmental hazard. The survey by Toxics Link estimated that on an average nearly 29 percent of the middle class families have experienced breakage of thermometer and its disposal in general waste.

A very important factor in the impacts of mercury to the environment is its ability to build up in organisms and move up along the food chain. Although all forms of mercury can accumulate to some degree, methylmercury<sup>6</sup> is absorbed and accumulates to a greater extent than other forms. Inorganic mercury can also be absorbed, but is generally taken up at a slower rate and with lower efficiency than methylmercury. The biomagnification<sup>7</sup> of methylmercury has most significant impact on animals and humans. Fish appear to bind methylmercury strongly; nearly 100 percent of mercury that bioaccumulates<sup>8</sup> in predator fish is methylmercury. Most of the methylmercury in fish tissue is covalently bound to protein sulfhydryl groups. This binding results in a long half-life for elimination

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<sup>4</sup> Bynum Sandra, Prevent Mercury Poisoning, [www.charityguide.org/volunteer/fewhours/mercury-poisoning.htm](http://www.charityguide.org/volunteer/fewhours/mercury-poisoning.htm) accessed on November 2006

<sup>5</sup> Lurking Menace: Mercury in the health Care Setting, Toxics Link, June 2004

<sup>6</sup> The term 'methylmercury' is commonly used as a generic term to describe (mono) methylmercury compounds. In fact, methylmercury is not a compound in itself but a cation, CH<sub>3</sub>Hg<sup>+</sup>, which forms one part of methylmercury compounds; usually methylmercury salts. Dimethylmercury is one methylmercury compound that is not a salt. The methylmercury cation is normally associated with either a simple anion, like chloride (Cl<sup>-</sup>), or a large molecule (e.g. a protein) with negative and positive charges. The methylmercury cation is the most toxic form of mercury, able to inhibit fetal brain development, which results in the behavioural changes and reduced cognitive and motor ability.

<sup>7</sup> The term biomagnification refers to the progressive build up of some heavy metals (and some other persistent substances) by successive trophic levels – meaning that it relates to the concentration ratio in a tissue of a predator organism as compared to that in its prey (AMAP, 1998).

<sup>8</sup> The process by which a contaminant accumulates in the tissues of an individual organism. For example, certain chemicals in food eaten by a fish tend to accumulate in its liver and other tissues.

(about two years). As a consequence, there is a selective enrichment of methylmercury (relative to inorganic mercury) as one moves from one trophic level to the next higher trophic level.<sup>9</sup>

Given steady environmental concentrations, mercury concentrations in a given fish species tend to increase with age due to the slow elimination of methylmercury and increased intake due to changes in trophic position that often occur as fish grow to larger sizes (i.e., the increased fish-eating and the consumption of larger prey items). Therefore, older fish typically have higher mercury concentrations in the tissues than younger fish of the same species.<sup>10</sup>

This has posed serious danger to fish eating community as it enters in their diet and subsequently to human body. Preliminary estimates of mercury levels in hair and blood samples from the 1999 National Health and Nutrition Examination Survey suggests that approximately 10 percent of women have mercury levels within one tenth of potentially hazardous levels indicating a narrow margin of safety for some women.<sup>11</sup>

## HEALTH IMPACTS OF MERCURY

Mercury exists in various physical and chemical forms. The most important from a toxicological point of view are the metallic form, also called the elemental form and methyl mercury. Vapour of elemental mercury is rapidly absorbed through the lungs. In humans 75-85 per cent of an inhaled dose is absorbed.<sup>12</sup> Elemental mercury in liquid or vapour form is not well absorbed from the gastro-intestinal tract (possibly less than 0.01 percent).<sup>13</sup>

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

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<sup>9</sup> [www.greenfacts.org/mercury/1-3/mercury-3.htm](http://www.greenfacts.org/mercury/1-3/mercury-3.htm)

<sup>10</sup> UNEP Global Mercury Assessment report, Summary of the Report, paragraph 68

<sup>11</sup> <http://www.epa.gov/waterscience/fish>

<sup>12</sup> WHO. Environmental health criteria 118: Inorganic mercury. World Health Organisation Geneva, International Programme on Chemical Safety 1991.

<sup>13</sup> Bornmann, G., Henke, G., Alfes, H., Mollmann, H. Intestinal absorption of metallic mercury (in German) Arch Toxicol. 1970;26:203-209

breath, tightness and burning pains in the chest and inflammation of the lungs. Occupational exposure to 1 to 44 mg/m<sup>3</sup> 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 vapour formed upon heating mercury.<sup>14</sup>

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 diarrhea.

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.<sup>15</sup>

In a review conducted by the USEPA (1997), the reports from accidental exposures to high concentrations of mercury vapours (Aronow et al. 1990; Fagala and Wigg 1992; Taueg et al.1992), as well as studies of populations chronically exposed to potentially high concentrations (Ehrenberg et al. 1991; Roels et al. 1982; Sexton et al.1978) have shown effects on a wide variety of cognitive, sensory, personality and motor functions. In general, symptoms have been observed to subside after removal from exposure. However, persistent effects (tremor, cognitive deficits) have been observed in occupationally exposed subjects 10-30 years after cessation of exposure (Albers et al. 1988, Kishi et al. 1993, Mathiesen et al. 1999, Letz et al. 2000). Studies of workers exposed to elemental mercury

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<sup>14</sup> Opcit no 12

<sup>15</sup> Opcit no. 12

vapour have reported a clear increase in symptoms from the Central Nervous System (CNS) at exposure levels greater than 0.1 mg/m<sup>3</sup> (Smith et al. 1970) and clear symptoms of mercury poisoning at levels resulting in urinary mercury greater than 300 µg in a 24-hour urine sample.<sup>16</sup>

The above literature establishes the fact that mercury is toxic by ingestion, inhalation and skin absorption with acute and chronic exposure effects including central nervous system and kidney damage. Acute exposure includes nausea, blurred vision, painful breathing, excessive salivation and pneumonitis, while chronic or longer-term exposure includes memory disturbance, hypertension, vision problems, hallucinations, tremors and personality changes. Because mercury can cross the blood-brain barrier, and because it can affect brain development, its effects are of special concern to pregnant or lactating women and young children.

## **MERCURY IN HEALTHCARE**

Mercury is liquid at room temperature and pressure. Spilled elemental mercury, such as, from a broken thermometer, can vapourise and disperse into the surrounding air. This situation, when it takes place indoors, can lead to exposure to mercury vapours through inhalation. The severity of the exposure depends on air temperature, amount of mercury spilled, air flow in the room, and the size of the person being exposed.<sup>17</sup> Mercury is especially hazardous because of its volatility. Accidental spills can deposit mercury in locations such as cracks in the floor.

Studies show that just one broken thermometer, if not properly cleaned up, can lead to indoor air mercury pollution which may cause adverse health effects. In a typical health care setting, mercury may be released from thermometers, blood pressure devices, gastrointestinal and other mercury containing medical products. Fixatives, preservatives, lab chemicals, cleaners and other products may also contain intentionally added mercury which, when discarded to the waste stream, result in environmental contamination. Furthermore, many building products such as thermostats, pressure gauges and switches also contain mercury.

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<sup>16</sup> Ibid

<sup>17</sup> [http://www.nihe.org/hcept\\_tool/mercury.html](http://www.nihe.org/hcept_tool/mercury.html)

Mercury spills in hospitals; clinics and labs expose doctors, nurses, other health care workers and patients to elemental mercury. At room temperature significant amounts of liquid elemental mercury transform to a gas, exposing workers or patients in the area to potentially highly toxic levels. As mentioned earlier, in a study by Toxics Link, it was found that nearly 70 thermometers break every month in a 300-500 bedded hospital.<sup>18</sup> Data also showed that an average-sized hospital releases 3 kg of mercury into the environment every year. On the usage of thermometers showed that broken and defective thermometers are discarded and thrown into normal waste. Thus spills are not just causing occupational hazard, they are also contributing to environment pollution. If discarded as a waste, mercury will eventually make its way into the environment where organisms living in rivers, lakes, or moist earth transform it into highly toxic organic mercury. This type of mercury which affects nerves and brains at extraordinary low levels persists and accumulates in animals, fish and the global environment. Another important source of mercury exposure at household levels are caused by breakage of thermometers. All this is adding to normal waste stream and also causing serious indoor air pollution at household levels.

## **POPULATION AT RISK**

### ***Occupational hazard to nurses***

Nurses' work with or near mercury containing products daily. They are in danger of breathing in its toxic vapour when one of these products breaks. Many nurses could be pregnant, or be of the childbearing age. Developing nervous systems in fetuses and children are particularly susceptible to the harmful effect of mercury.

Largely, exposure to mercury in a hospital to the healthcare worker is through mercury spills which are a common occurrence. The most common route of exposure of humans to elemental mercury is through the lungs because the metal volatilises at room temperature. This vapour irritates the lungs affects the kidneys easily penetrates the blood brain barrier and is neurotoxin. In addition exposure can cause spontaneous abortion and other pregnancy complications. Mercury exposure for the developing fetus and nursing infants comes both from mercury stored in the woman's body prior to

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<sup>18</sup> Opcit no 4.

pregnancy, and from mercury to which the woman is exposed to during pregnancy and breast feeding. This is because mercury readily crosses the placenta and can be found in breast milk.

### ***Occupational hazard to dentists***

Dentists and their assistants may be exposed to metallic mercury from breathing in mercury vapour released from amalgam fillings and to a much lesser extent from skin contact with amalgam restorations. Family members of workers who have been exposed to mercury may also be exposed to mercury if the worker's clothes are contaminated with mercury particles or liquid.

The WHO<sup>19</sup> (, Switzerland, 1991) confirms that dental amalgam—an inexpensive alloy of silver, copper, tin and 50 percent mercury—is the largest source of human exposure to elemental mercury for those who have dental amalgam.

The lungs rapidly absorb 75-85 per cent of elemental mercury vapours coming from dental amalgam.<sup>20</sup> Recent research confirms that mercury escapes from dental amalgam and is converted to methyl mercury after combining with bacteria in the mouth.<sup>21</sup> Laboratory tests have shown that the average person with dental amalgam receives 10 times as much daily mercury exposure as the average person without amalgam fillings.

Eighty-one women (45 dentists and 36 dental assistants) occupationally exposed to metallic mercury underwent a toxico-clinical examination.<sup>22</sup> Total Mercury Levels (TMLs) were determined in scalp and pubic hair. Furthermore a detailed questionnaire study was made concerning adverse reproductive events. TMLs in the hair of the exposed women examined exceeded significantly those determined in the hair of 34 controls not exposed to mercury. All exposed women had continued working during

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<sup>19</sup> Opcit no. 12

<sup>20</sup> NAS/NRC report, 2000

<sup>21</sup> Leisteuvo J. Et al, Dental amalgam fillings and the amount of organic mercury in human saliva, *Caries Res* May-Jun:35(3):163-166, 2001; Sellars, WA, Sellars, R., University of Texas Southwestern Medical School, "Methyl mercury in dental fillings in the human mouth," *Journal of Nutritional & Environmental Medicine*, 6(1):33-37, 1996.

<sup>22</sup> Radzislav Sikorski et.al. Women in dental surgeries: reproductive hazards in occupational exposure to metallic mercury 'International Archives of Occupational and Environmental Health', vol.59, No.6, 1987.

pregnancy. There was a significant, positive association between TMLs in the hair of exposed women and the occurrence of reproductive failures in their history. The relation between TMLs in the scalp hair and the prevalence of menstrual cycle disorders was statistically significant. These findings indicate that dental work could be another occupational hazard with respect to reproductive processes.

### ***Effect of mercury on patients/communities***

A review published in British Medical Journal described a 9-year-old boy who had neurological and renal complications after mercury spillage from a sphygmomanometer three months after it had been provided by the hospital for monitoring blood pressure at home. The boy's constant restlessness was considered strange, but his mother described him as hyperactive and regarded this behaviour as normal. It was noted, however, that his handwriting and schoolwork had deteriorated over the preceding month. Inquiry revealed that the patient's sibling had undergone renal transplantation as a result of nephrotic syndrome, and the family had been provided with a mercury sphygmomanometer for home blood pressure monitoring. Three months before presentation, the patient had dismantled the sphygmomanometer in his bedroom—spilling mercury on his bed and carpet—and had played with it for a day or two before informing his mother.<sup>23</sup>

A potential source of exposure to metallic mercury for the general population is mercury released from dental amalgam fillings. An amalgam is a mixture of metals. The amalgam used in silver colored dental fillings contains approximately 50percent metallic mercury, 35percent silver, 9percent tin, 6percent copper, and trace amounts of zinc. When the amalgam is first mixed, it is a soft paste which is inserted into the tooth surface. It hardens within 30 minutes. Once the amalgam is hard, the mercury is bound within the amalgam, but very small amounts are slowly released from the surface of the filling due to corrosion or chewing or grinding motions. Part of the mercury at the surface of the filling may enter the air as mercury vapour or be dissolved in the saliva.<sup>24</sup>

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<sup>23</sup> <http://www.bmj.com/cgi/reprint/319/7206/366.pdf> accessed on December 2006

<sup>24</sup> <http://www.dentalwatch.org/hg/atsdr.html> accessed on January 2007



## STANDARDS VERSUS PREVENTION

At present, India has no standards for mercury in indoor ambient air. The Government of India has established levels for occupational exposure of mercury at workplace under The Factories Act of 1948 amended in 1987 for mercury skin alkali compounds. The permissible exposure limit of  $0.01 \text{ mg/m}^3$  for time weighted concentration for 8 hrs and  $0.03 \text{ mg/m}^3$  for short-term exposure of 15 minutes.<sup>25</sup>

The code of safety published by Indian Standards Institutes mentioned that mercury and its compounds are toxics. Section 0.5 mentions that mercury poisoning is included in the schedule of notifiable diseases under the factories act, 1948. It is compensable disease under the Workmen's Compensation Act, 1923. The threshold limit value in air for mercury is  $0.05 \text{ mg/m}^3$  of air for repeated exposure for 8 hours work day and 40 hours weekday.

The above standards deals with the industrial levels and these rules are not applicable to common people and health care facilities. These standards are generally based on preventing adverse health effects from exposure over a 40-hour workweek or 8 hour/day and tend to be higher than environmental exposure which might be applicable to residents and health care facilities.

The standards in India are set as on the policy of available technology and economic well-being but the standards should also be subject to revision based on the current research and development across the world. As these standards are set for the larger well being of communities. Internationally there various standards available for different places and level for mercury in ambient air: These standards are mentioned in the table below.<sup>26</sup>

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<sup>25</sup> The Factories Act of 1948 amended on 1987

<sup>26</sup> [www.newmoa.org/prevention/mercury/MercuryIndoor.doc](http://www.newmoa.org/prevention/mercury/MercuryIndoor.doc) accessed on December 2006

**Table 1: Environmental and Occupational Health Standards for Inhalation Exposure to Mercury Vapour**

Agency	Mercury Concentration ( $\mu\text{g}/\text{m}^3$ ) <sup>1</sup>
OSHA Ceiling limit <sup>2</sup>	100
NIOSH REL <sup>3</sup>	50
ACGIH TLV <sup>4</sup>	25
ATSDR MRL <sup>5</sup>	0.2
ATSDR Action Level, for indoor exposures	1.0
EPA Rfc <sup>6</sup>	0.3

<sup>1</sup> micrograms per cubic meter  
<sup>2</sup> Ceiling limit = the concentration of mercury vapour cannot exceed this value at any time  
<sup>3</sup> REL = Recommended Exposure Limit, a time weighted average for an 8-hour day.  
<sup>4</sup> TLV = Threshold Limit Value, a time weighted average for an 8-hour day  
<sup>5</sup> MRL = minimal risk level  
<sup>6</sup> Reference concentration

The Environmental Protection Agency (EPA) sets a reference concentration of  $0.3 \mu\text{g}/\text{m}^3$  for inhalation exposure to mercury. The reference concentration is a screening tool used to help risk assessors determine where to focus their investigations into hazardous exposures; adverse health effects do not necessarily result from exposure at the reference concentration. For example, if  $0.3 \mu\text{g}/\text{m}^3$  mercury were measured in air inside a building, EPA would further investigate the exposure.

Similarly, the Agency for Toxic Substances and Disease Registry has set a minimal risk level (MRL) for inhalation exposure at  $0.2 \mu\text{g}/\text{m}^3$ . The MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse health effects over a specified period of time. ATSDR also recommends an action level of  $1.0 \mu\text{g}/\text{m}^3$ , which triggers remediation if exceeded in indoor air.

The Occupational Safety and Health Administration (OSHA) sets a legally enforceable ceiling limit for workplace exposure at 100 micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ). Mercury concentration cannot exceed this level at any time during the workday. The National Institute for Occupational Safety and Health (NIOSH) sets its recommended exposure limit (REL) for mercury vapour at  $50 \mu\text{g}/\text{m}^3$  as a time weighted average (TWA). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a threshold limit value (TLV) of  $25 \mu\text{g}/\text{m}^3$  mercury vapour as an average exposure for a normal 8-hour workday.

The Canadian standards are adopted by the Ministry of Labour, based on the United States Occupational Safety and Health Administrations recommendations in setting and enforcing workplace standards. The administration receives guidance from the National Institute for Occupational Safety and Health and the American Conference of Government Industrial Hygienists. These organizations do not differentiate between pregnant and non-pregnant women in their recommendations. Recommended TLV (Threshold limit value )-TWA (time-weighted average ) for mercury vapour and for inorganic and non alkylne organic mercurials are shown in table below:

**Table2.** Recommended airborne concentration of mercury <sup>27</sup>

Values	Mercury Vapour, Inorganic And Nonalkyline Organic Mercurials	Ethyl And Methyl Mercury
Threshold limit value (time-weighted average)	$0.05 \mu\text{g}/\text{m}^3$	$0.01 \mu\text{g}/\text{m}^3$
Threshold limit value (ceiling)	$0.1 \mu\text{g}/\text{m}^3$	$0.04 \mu\text{g}/\text{m}^3$
Short-term exposure limit	$0.03 \mu\text{g}/\text{m}^3$	$0.03 \mu\text{g}/\text{m}^3$
Immediately dangerous to life and health	No data	$10 \text{mg}/\text{m}^3$

## Rationale and purpose of study

Taking these facts in to consideration, Toxics Link in a study conducted at hospitals in Delhi, has found that on an average 70 thermometer breaks in a typical 300-500 bedded health facility, thus putting

<sup>27</sup> Canadian Family Physician 1999;45:43-5 From the web: [www.motherisk.org/prof/updatesDetail.jsp?content\\_id=312](http://www.motherisk.org/prof/updatesDetail.jsp?content_id=312)

persons at severe risk of exposure to mercury vapour. Elemental mercury evaporates at a rate of 7  $\mu\text{g}/\text{cm}^2/\text{hr}$  at 20°C.<sup>28</sup> And nearly 80percent of inhaled mercury is absorbed and at once crosses the blood–brain barrier.<sup>29</sup>

Once spilled, sprinkled, or left in an open container, elemental mercury may release vapour for prolonged periods. Significant levels of mercury vapour have been found in buildings decades after spillage, resulting in the significant exposure of subsequent building occupants without their knowledge.<sup>30</sup>

Broken clinical thermometers typically contain only 0.6 to 0.67 gram of elemental mercury but can generate mercury vapour concentrations an order of magnitude above both the U.S. EPA Reference Concentration and the Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Level (MRL).<sup>31</sup>

This release of mercury in hospitals may pose health risk for those who are exposed and may also include persons working or seeking treatment in these facilities, it is this risk that needs to be further investigated and established.

Given the lack of documentation and scientific data in the country on mercury vapour in hospital buildings, Toxics Link conducted this investigative study in two hospitals in Delhi , where elemental mercury spill have occurred in past and continued to use of various mercury containing devices.

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<sup>28</sup> Andren AW, Nriagu JO. 1979. The global cycle of mercury. In: The Biogeochemistry of Mercury in the Environment (Nriagu JO, ed). New York:Elsevier-North Holland Biomedical Press, 1–15.

<sup>29</sup> Cherian MG, Hursh JG, Clarkson TW. Radioactive mercury distribution in biological fluids and excretion in human subjects after inhalation of mercury vapour. Arch Environ Health. 1978;33: 190–214

<sup>30</sup> Centers for Disease Control and Prevention. Mercury exposure among residents of a building formerly used for industrial purposes—New Jersey, 1995. MMWR Morb Mortal Wkly Rep. 1996;45:422–424.

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The study is an attempt to investigate the presence of mercury in hospital indoor air. The findings from the study will be used to inform decisions about appropriate public health strategies and directions for further investigations.

## **OBJECTIVES**

The study has following objectives:

1. To test whether there is a presence of mercury in the ambient air of the hospital
2. Analyse and compare the findings with various standards available nationally and internationally
3. To suggest recommendations for further action

## METHODOLOGY

1. **Secondary Literature review** : The health and environmental effects of mercury will be studied through secondary literature and available in print as well as on web. The secondary search has largely helped in finding out the different studies and researches, which establishes hazardous and toxic effect of mercury on human health. The literature survey has also helped in finding out the current position at international level on mercury in health care.
2. **Testing of Mercury in Hospitals:**
  - a. **Sample Collection:** The ambient air test was carried out in different locations in two hospitals of Delhi. The hospitals were selected on random basis. These hospitals are in private sector. For the sake of convenience of analysis these hospitals are named as Hospital A and Hospital B. The places within the hospitals selected for the ambient air testing are:

Hospital A	Hospital B
<ul style="list-style-type: none"> <li>• Dental Wing</li> <li>• Mercury Storage Room</li> <li>• Calibration Room</li> <li>• Single bedded room</li> </ul>	<ul style="list-style-type: none"> <li>• General Ward</li> <li>• Maternity ward</li> <li>• Pediatric ward</li> <li>• Nursing Station</li> <li>• Medicine ward</li> <li>• Maintenance ward</li> </ul>

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**description of Hospitals:** Both the hospitals are of two different types. Toxics Link has been working with these hospitals for the past some time on the issue of mercury. These facilities have stopped using mercury-based thermometers from their facilities. The purpose of the study is to identify the problem of mercury pollution in the health care sector and not to focus on one or two facilities. Thus the anonymity of these

hospitals is maintained. And for the purpose of analysis they are named as Hospital A and Hospital B.

- c. The sample locations are carefully selected so as to cover places where exposure can happen to all type of persons viz. Nurses, Patients doctors etc. The description of various locations are given below:

### **Hospital A**

**Dental wing :** The dental wing is situated on the 1st floor. It is a small room with no ventilation. It is one seated AC room with one door for outlet. The length, breath and height are 4.5m, 3.5m and 5 m respectively. All the waste mercury fillings (collected and stored in a bottle) are also kept there.

**Mercury Storage Rom:** This room is a very small, almost square in shape. The length, breath and height are 3m, 3m and 5m respectively. It has no windows for ventilation and is situated at the basement.

**Calibration room-** The calibration room is also situated at the basement with no windows. The laundry and calibration room are attached. Calibration is done in a very small space provided in front of laundry. Two exhaust fans are also there in the room so as to ensure the steam outlet.

**Normal Room:** The normal room is rectangular in shape. It is situated on the 2nd floor. It is one bedded and has 2 windows and one washroom.

### **Hospital B**

Hospital B is a 400-bedded multi specialty private hospital. This hospital is presently using Digital thermometers but other mercury containing products are also used. The

ambient air mercury level was measured at six different locations. The details of the locations are mentioned below:

1. **General Ward:** This ward is 10 bedded and is situated on the first floor. This ward is rectangular in shape. It has 20 windows. The length, breadth and height are 9m, 5m & 4 m respectively.

2. **Maternity ward:** This ward is 4 bedded and is situated on the second floor. This ward is rectangular in shape. It has 2 windows and 3 ventilators.

3. **Pediatric Ward:** This ward is 8 bedded and is situated on the third floor. It has 5 windows and 4 ventilators. The length, breadth and height are 10m, 5m, and 4 m respectively.

4. **Nursing Station:** The nursing station is situated on the second floor. It is a small room with one door outlet in open area. It is a small room and the length, breadth and height are 2.5m, 3m & 4m respectively.

5. **Medicine ward:** This ward is situated on the fourth floor. It is 8 bedded and has 4 windows and 6 ventilators and one door for the outlet. Its length, breadth and height are 10m, 8m, and 4.5m respectively.

6. **Maintenance Room:** This room is on the ground floor. B.P.Appratus Calibration is done here. This is a small room with one small window. The length, Breadth and height are 3.5m, 3.5m and 5m respectively.



#### (d) Lab Methodology

The sample collection and testing was conducted by Delhi Test House (DTH). This is a NABL/ISO-9001 accredited Lab. The method applied is used for the estimation of mercury in air by cold atomic absorption measurement. The sample was collected for the duration of approximately two hours.

**Sampling:** The air samples from above mentioned locations were collected by using High Volume Sampler. The trap is filled with 25 ml of acid permanganate solution. Then the air is passed through this trap at a rate of 2.0 LPM for two hour. After this the trap was disconnected and reagent was transferred in to 50 ml volumetric flask and made up to volume with distilled water which were then brought back to the laboratory for further investigations

**Preparation of standards:** 0.1micro gram standard solution was prepared by serial dilution of the stock solution (1000 ppm), while maintaining 5 percent nitric acid and 0.01 percent  $K_2CR_2O_7$  concentration. One blank standard was also prepared by using distilled water.

**Analysis** of Hg in trap collected by High Volume sampler was done by cold vapour technique in Atomic absorption spectrophotometer (AAS) coupled with hydride genrator. The instrument used was AAS of GBC 632 plus.

**Estimation** is done by transferring aliquot of standard, sample and blank solution in to the reaction vessel R2. In this, hydroxylamine and hydrochloride solution was added drop wise. The volume was adjusted to 20 ml with 10 percent  $HNO_3$  solution. 2percent  $SnCl_2$  was added and stopper was replaced immediately. 0percent absorption was adjusted on display and the absorbance of standard and sample solution was noted. The mercury content reading of aliquot was taken from the calibration curve.

**Calculation:**

The mercury in air was calculated by using following formula.

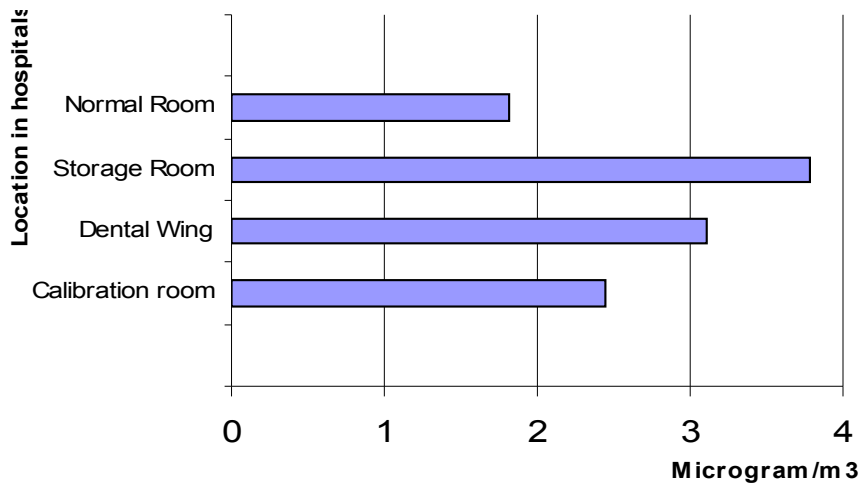
$$\text{Mercury content in Air (Pbb)} = \frac{\text{Mercury content in aliquot (}\mu\text{g)}}{\text{Volume of air (in litres)}}$$

## Results

The results of Hg in ambient air in hospitals A and B are given in table 3 below. And fig. 1 and 2 show the graphical representation of the same.

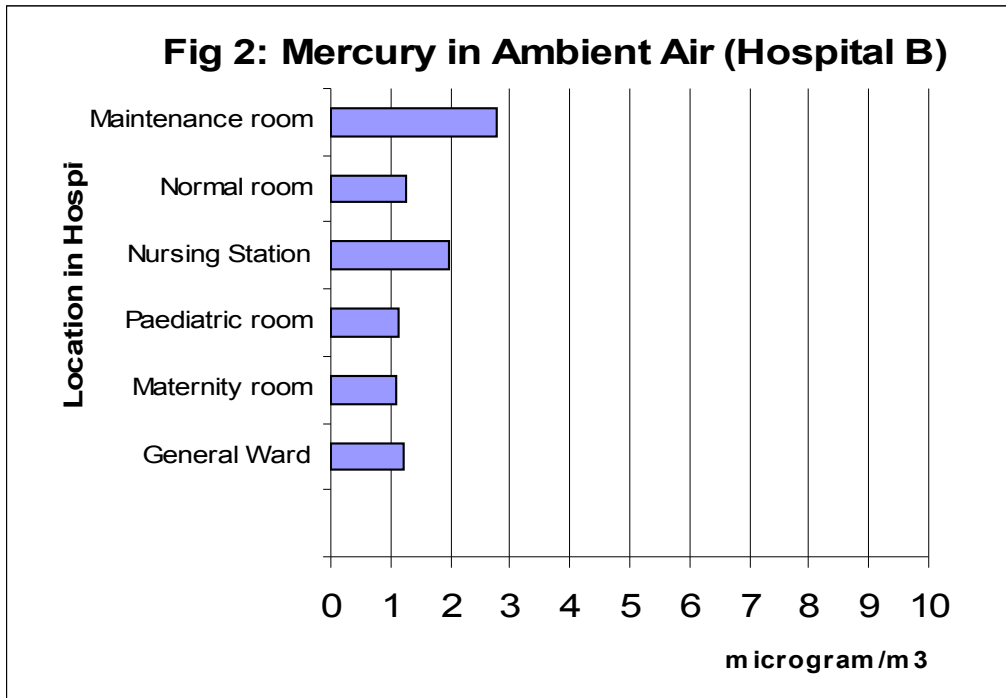
Sno.	Sample Location	Date of Sampling	Duration of sampling in minutes	Avg. flow of rate of vapours/gases, lpm	Ambient air Temp degree centigrade	Time of monitoring	Result in $\mu\text{g}/\text{m}^3$
<b>Hospital A</b>							
1	Calibration room	22.09.06	150.6	2.0	32	12.00	2.44
2	Dental Wing	22.09.06	55.8	2.0	32	12.10	3.11
3	Storage Room	22.09.06	116.4	2.0	32	12.20	3.78
4	Normal Room	22.09.06	150	2.0	30	14.30	1.82
<b>Hospital B</b>							
1	General Ward	08.11.06	124.2	2.0	26	11.00	1.23
2	Maternity room	08.11.06	121.2	2.0	26	11.30	1.09
3	Pediatric room	08.11.06	136.8	2.0	27	11.10	1.12
4	Nursing Station	08.11.06	123.6	2.0	27	13.50	1.98
5	Normal room	08.11.06	120	2.0	27	15.25	1.27
6	Maintenance room	08.11.06	120	2.0	27	16.10	2.77

**Table 3: Mercury level at different location in Hospital A and Hospital B**

**Fig 1: Mercury In Ambient Air (Hospital A)**

### Hospital A

The level of mercury is highest in store room (3.78 Microgram/m<sup>3</sup>) and is found to be lowest in Normal single bedded ward (1.82 Microgram/m<sup>3</sup>). The duration of sampling in storage room and normal room were 116.4 minutes and 150 minutes, having the ambient air temperature of 32C and 30C respectively. The high level of mercury in storeroom is mainly because this place is also used for storage of spilled mercury. The other two locations viz. Calibration room (2.44 Microgram/m<sup>3</sup>) and Dental wing (3.11 Microgram/m<sup>3</sup>) having the sampling duration of 150.6 minutes and 55.8 respectively, has also shown high concentration of mercury in ambient air. Both calibration room and dental wing had same ambient air temperature i.e. 32C.



### Hospital B

The mercury level was found to be highest in the Maintenance room (2.77 Microgram /m<sup>3</sup>) and lowest in maternity room, having the duration of sampling of 120 minutes and 121.2 minutes respectively. The difference in ambient air temperature in maintenance room (27C) and maternity room (26C) was only of 1C. The highest level of mercury in the maintenance room was due to the fact that apart from storage of spilled mercury, this room is also used for calibration of BP apparatus. The second highest level of mercury was found in the nursing station (1.98 Microgram/m<sup>3</sup>) followed by Medicine ward (1.27 Microgram/m<sup>3</sup>) having the duration of sampling of 123.6 minutes and 120 minutes respectively. The ambient air temperature in these locations was the same i.e. 27 C. The other two remaining locations viz. General ward (1.23 Microgram/m<sup>3</sup>) and pediatric room (1.12 Microgram/m<sup>3</sup>) have also shown high concentration of mercury in the ambient air, having the ambient air temperature of 26C and 27 C respectively. The duration of sampling in the respective wards were 124.2 minutes and 136.8 minutes.

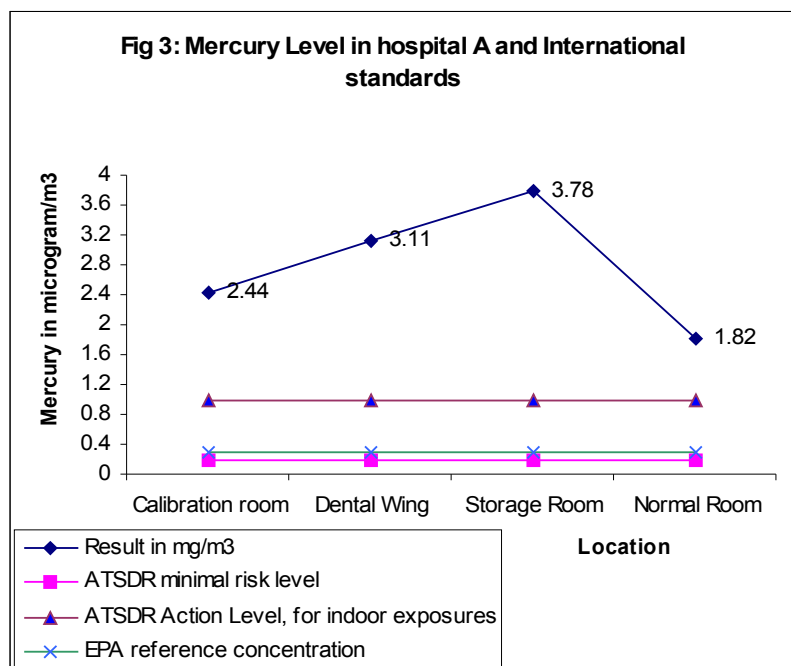
## DISCUSSION

The measurements of metallic mercury vapour were carried out in two medium sized hospitals. All the locations specified had shown the presence of metallic mercury at varied levels. The results clearly show that there is higher concentration mercury present in the ambient air of Hospitals. The possible source for mercury in ambient air is because of many reasons and due to the presence of both medical and non-medical mercury based products inside the hospital. The common medical devices are thermometers, sphygmomanometers (blood pressure monitors), esophageal dilators (also called bougie tubes), Cantor tubes and Miller Abbott tubes (used to clear intestinal obstructions), dental amalgam, laboratory chemicals (fixatives, stains, reagents, preservatives) and medical batteries. Though there is small risk of mercury exposure during normal use of these instruments and products. However, problems may occur if the mercury in a product is exposed to air. The elevated levels of mercury in the ambient air of the hospital suggestive of release of mercury in hospital air despite of having mercury containment systems i.e. spill management and use of digital thermometers in these hospitals.

Overall, all places have detectable higher levels of mercury, but mercury in ambient air of Hospital A is found to be higher than Hospital B. This could be because of various reasons such as ventilation system, air conditioning, and scale of operation. Hospital A is larger facility than Hospital B. But no conclusive reason can be provided for this difference.

### Hospital A

In Hospital A, the ambient level of mercury is highest in store room (3.78  $\mu\text{g}/\text{m}^3$ ), This could be because of the fact that the store room is used for the



storage of mercury which has collected after spills occur due to breakage and leakage of blood pressure equipments.<sup>32</sup> The lowest level of air level mercury is found in single bedded ward (1.82  $\mu\text{g}/\text{m}^3$ ). This ward is located at second floor of the hospital and is linked to centralized cooling system. The mercury level in this ward can be attributed to either past history of breakage or through the centralized AC duct.

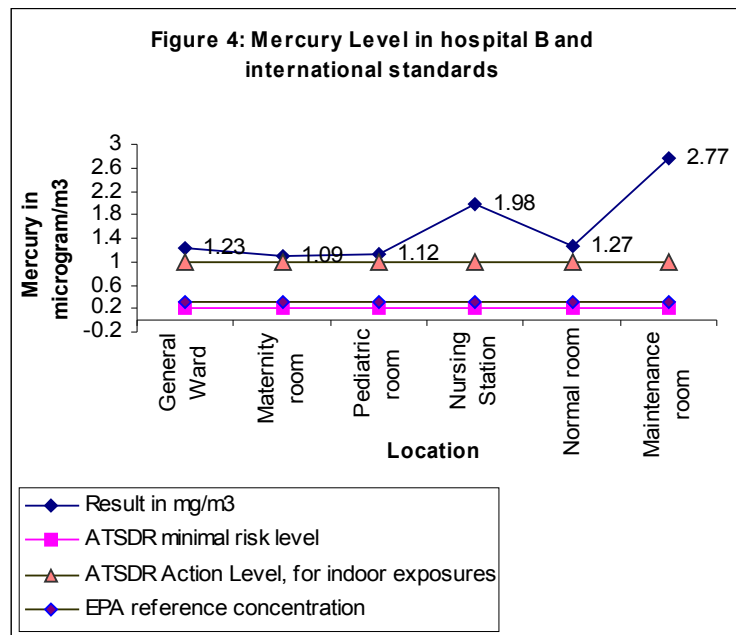
The Dental wing of the Hospital has also very high level of mercury (3.11  $\mu\text{g}/\text{m}^3$ ). The higher level of mercury in dental department may be because of use of mercury in preparation of dental amalgams.

The mercury level in calibration place lower than Dental and store room. Though this place is used for the calibration of mercury blood pressure equipments. This can be due to the fact that this place is located with the centralized steaming system of the hospital and has two large size exhausts to vent out the steam and most of the vapourized mercury escapes from these exhaust.

### Hospital B

The air level concentration is comparatively lower than the levels found in Hospital A, but all the levels are higher than the standards proposed by various agencies internationally. Like hospital A this hospital has also phased out mercury-based thermometer but they still use mercury based Blood pressure apparatus.

The highest ambient air level of mercury is found in maintenance room (2.77  $\mu\text{g}/\text{m}^3$ ).



<sup>32</sup> These hospitals are among few hospitals in Delhi, which has mercury spill management and mercury policy in place. Because of absence of any guidelines and policy the hospital is storing mercury in safe manner.

This could be because of use of this room is for the calibration of blood pressure instruments. And subsequent release of mercury in the air. The ambient air concentration of mercury is also found to be higher than other places. This can be because of past breakages (before the facility shifted to non mercury thermometer) and also because of possible leakage from blood pressure instruments. In all other places the levels are between 1.09 to 1.27  $\mu\text{g}/\text{m}^3$ . Though the levels in the Hospital B are comparatively low but are above the safe levels provided internationally (Fig 4).

The pattern of ambient air concentration of mercury is same in both the hospitals. The ambient air level in calibration room in hospital A and of maintenance room in hospital B are higher then the other locations. Both these places are used for the calibration of blood pressure equipments.

The findings revealed that the mercury level in the hospitals are lower than the limits set under Indian factories act and Occupational Safety and health Administration (OSHA) (USA) and National Institute for Occupational Safety and Health (NIOSH (USA)) levels. But these acts are applicable to factories and workplace. All three agencies include a skin notation in their standards, indicating intact skin, mucous membranes and eyes can absorb the mercury.

But on the other hand the Environmental Protection Agency (EPA), which has, sets a reference concentration of 0.3  $\mu\text{g}/\text{m}^3$  for inhalation exposure to mercury. The air concentrations of mercury in both the hospitals are very high. These are even higher than the recommendations by the Agency for Toxic Substances and Disease Registry (ATSDR), which suggest and 1.0  $\mu\text{g}/\text{m}^3$  is action level for remediation (Fig 3 and 4).

The findings provide a first look into the fact that there are dangerous levels of mercury is present in the hospitals ambient air. These levels of mercury in both the hospitals are found even after the one-year of phasing out of mercury thermometers. The high levels of mercury may be attributed to other sources i.e. BP apparatus, florescent tube lights and other products.



## CONCLUSION AND RECOMMENDATIONS

The findings from the study show substantial presence of mercury in ambient air of both the hospitals and at different locations the level higher than the standards stipulated across the world. The concentration varies across the locations, depending on the use of mercury in routine activities.

Whether exposure to mercury vapour happens from breakage and spillage of mercury-containing equipment or from through any other means, this poses health threat and should be addressed. This will require a large-scale outreach and intervention strategy. For this future investigations should classify all sources of mercury that are present at a healthcare facility.

Though, the current study is restricted to the two hospitals. The results indicate that if the levels of mercury in ambient air of hospitals that have been phasing out of mercury based thermometers is so high what would be status in facilities that do not have mercury management policy in place.

The study recommends that all hospitals must substitute mercury-containing products. The government should prepare a roadmap for this and it also suggests prevention of spillage and breakage through proper maintenance.

Finally, the findings provide an urgent ground for an effective regulatory intervention. Though the hazards of mercury exposure related to healthcare have has been globally documented, yet this is going unnoticed in India. Absence of scientific information, low awareness and absence of a regulatory mechanism on mercury exposure will continue if health facilities and health systems fails to implement alternative technologies to reduce the use of this poison.



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for a toxics-free world

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