SURVEY OF MERCURY CONCENTRATIONS IN AMBIENT AIR INSIDE HEALTHCARE FACILITIES

INTRODUCTION AND OBJECTIVES

One of the goals of the UNDP GEF Project on Healthcare Waste is to protect public health and the global environment from the impacts of mercury releases by demonstrating and promoting proper management of mercury waste and the use of non-mercury alternatives.

The purpose of this survey is to gather data in order to: (1) assess potential mercury exposures of health workers and patients in different parts of healthcare facilities; (2) identify areas where ambient air mercury levels are higher than background levels in healthcare facilities that use mercury devices; and (3) evaluate residual ambient air mercury levels in facilities that have phased out mercury devices.

The compiled data from different project countries could be used to raise awareness among health professionals, prioritize departments or services when developing a phase-out plan for a healthcare facility, and identify departments or services that may require monitoring after a phase-out.

BACKGROUND NOTES

The Scientific Committee on Occupational Exposure Limits for elemental mercury and inorganic divalent mercury compounds (SCOEL/SUM/84, European Commission, May 2007) recommends an occupational exposure limit of 0.02 mg of mercury vapor per m^3 in air. The threshold limit value (daily exposure level above which it is believed a worker could suffer adverse health effects) assigned by the American Conference of Governmental Industrial Hygienists is 0.025 mg per m^3 averaged over a normal 8-hour work day and a 40-hour work week; the National Institute for Occupational Safety and Health has a recommended exposure limit (REL) for mercury vapor of 0.05 mg per m^3 as a time-weighted average (TWA) for up to a 10-hour work day and a 40-hour work week; the permissible exposure limit (PEL) for mercury vapor is a ceiling value of 0.1 mg per m^3 in air according to the U.S. Occupational Safety and Health Administration. For the purpose of this survey, *mercury vapor concentrations in ambient air will be compared to the 0.02 mg per m^3 (20 µg per m^3) limit.*

Many things affect the ambient air mercury levels in a healthcare facility that uses mercury devices or mercury-containing substances. The key factors are:

- The source of mercury (i.e., the amounts of mercury spilled and/or amounts of mercury used during procedures such as the mixing of dental amalgam, as well as the frequency of spills and/or mercury procedures);

- The rate of volatilization which in turn depends on room temperature, velocity of air currents, and the surface areas and number of mercury droplets (Note that the surface area and number of mercury particles are related to the types of surfaces on which mercury was spilled or used; for example, carpets and wood flooring allow mercury droplets to get trapped on fibers or in cracks);
- The rate at which mercury is removed or diluted, which is related to such factors as the size of the room, the type of ventilation, the number of air exchanges per hour in the room, etc.;
- Whether or not the facility practiced effective clean-up procedures after spills or mercury use; and
- The period of time that elapsed since the last mercury spill or mercury procedure.

Since it is difficult to account for all these factors, *the survey will focus on the following general factors: the types of mercury devices, mercury-containing substances, or mercury procedures used in the room; the type of ventilation; and the last time mercury was spilled or used in the room.*

As fluorescent lights and compact fluorescent lamps are in common use throughout healthcare facilities, they will not be considered as a significant mercury sources in this survey. However, measurements could be taken in storage areas where old or broken fluorescent lights are kept.

METHODOLOGY

1.0 Equipment

The Jerome® J405 mercury vapor analyzer (Arizona Instruments LLC, Chandler, Arizona, USA) is used in the study. The Jerome® J405 is an ambient air analyzer with a range of 0.5 to 999 micrograms of mercury vapor per cubic meter (μg/m^3 Hg). It uses gold film sensing technology in which changes in the electrical resistance of a thin gold film, in the presence of mercury vapor, is correlated to the mass of mercury vapor in the sample.

The J405 can be operated for 12 hours using the internal battery or operated with the 120 to 240 volt AC power plug. The J405 was calibrated on 21 January 2011, traceable to NIST, and determined to have an accuracy of 5% (at 25 μg/m^3 Hg) and a relative standard deviation of 0.78%. Specifications are given in Appendix A.

NOTE: The equipment should be returned to the Global Project Team to be recalibrated by 20 January 2012.

2.0 Preparation

a) Obtain the national average heights of adult males and females in the country and calculate an average value. Subtract 15 cm to approximate an average height of the nose from the ground. This represents the breathing zone. The table below provides some values in centimeters.[1]

COUNTRY	Average male height	Average female height	Average nose height
Argentina	174.46	161.03	153 cm
India	165.3	165.3	150 cm
Philippines	163.5	151.8	143 cm
Vietnam	167	156	146 cm

b) Determine the average nose height from the ground in relation to the researcher's own height. When taking samples, the researcher should hold the J405 instrument such that the inlet port is always at approximately the average nose height from the ground.

c) Obtain and record basic information from the healthcare facility.

d) Draw up a list of departments or locations as target sites to test. Develop an efficient routing plan to be able to take measurements in the target site in a short time. If applicable and possible, include the following target sites in your list:

- A site for obtaining background levels: an area outside the healthcare facility away from any potential mercury sources, such as a garden outside the healthcare building, a residential area in the surrounding neighborhood, or at least 10 meters from the entrance of the facility
- Dentistry department especially where amalgam is mixed
- Pediatric ward
- Male and female adult wards
- Nurses' stations
- Biomedical laboratory
- Emergency department
- Outpatient department
- Engineering and maintenance department where mercury sphygmomanometers may be repaired or calibrated
- Healthcare waste storage area
- Storage area for mercury device and fluorescent lamps
- Area around an operating healthcare waste incinerator
- Pharmacy
- Storage area for cleaning solutions and disinfectants

e) Make photocopies of the data sheet in Appendix B.

f) Regenerate the gold sensor of the Jerome® J405 following the manufacturer's instructions on the first day before sampling and at the end of each day of sampling. Regeneration takes about 45 minutes.

[1] "Height Chart of Men and Women in Different Countries," *Disabled World,* October 13, 2008; retrieved in http://www.disabled-world.com/artman/publish/height-chart.shtml

g) Charge the batteries the night before to be able to operate the Jerome® J405 as a portable unit. Complete charging takes about 3 hours and allows the J405 to be used for 12 hours.

2.0 Procedure on the day of sampling

a) Turn on the equipment and follow the initial steps to verify proper instrument operation according to the manufacturer's instructions.

b) Allow the equipment to warm up for five minutes with the Zero Air Filter inserted in the inlet (see manufacturer's instructions) to equilibrate the instrument just before sampling or whenever the equipment automatically shuts down after 20 minutes of non-usage.

c) Take and record three background samples (the three samples could be at the same location or at three different sites outside the healthcare facility).

d) For each target site, fill in the information in the attached data sheet.

e) Select three sampling points to take measurements in each target site. If the staff can identify the locations of recent spills or where mercury is commonly used, select those points for sampling. If locations of past spills are not known, select the following three sampling points per site: (1) the approximate center of the room, (2) a work area far from any windows or heating/air-conditioning vents, and (3) a work area near the windows or vents. If the target site has no windows or vents, select the approximate center of the area and two work areas on opposite sides of the center. If the target site is an outdoor area, select a sampling point closest to where mercury is likely to be found and two other random locations within the site.

f) After selecting the three locations, take one measurement each in the three selected sampling points at the average nose height above ground level and record all three results. Record the readings in the data sheet.

g) Regenerate the sensor at the end of the sampling day.

3.0 Data compilation

a) Compile all the data in the data sheets and tabulate them in an Excel sheet.

b) Submit the data to the Global Project Team.

4.0 Maintenance of the equipment

a) Follow the manufacturer's instructions on preventive maintenance, including changing the small intake filter ("fritware filter") after using for a week, replacing the AG filter after about 500 samples or six months (whichever comes first), and changing internal tubing and filters as needed.

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APPENDIX A
Jerome® J405 Specifications

Range*	0.5 µg/m^3 to 999 µg/m^3 (0.0005 to 0.999 mg/m^3)
Resolution	0.01 µg/m^3 Hg
Response time-sample mode	12 seconds
Response time-survey mode	2 seconds
Flow rate	750 ± 50 cc/min (0.75 ± 0.05 liters/min)
Power requirements	12 VDC for the instrument (provided by the internal battery, AC power supply/charger, external battery pack or car accessory adapter) 100-240VAC, 47-63Hz, 3.2A for the AC power supply/charger
Fuse	Auto-resetting fuse
Internal battery pack	Rechargeable nickel metal hydride (NiMH)
Operating environment	0 °C to 45 °C, non-condensing, non-explosive
Case construction	Aluminum, powder coated
Dimensions	11 in L x 6 in W x 6.5 in H (28 cm L x 16 cm W x 17 cm H)
Weight	5.3 pounds (2.4 kilograms)
Digital meter display	3 ½ inch (9 cm) liquid crystal display (LCD)
Data storage capacity	20,000 samples
Output	Digital: USB serial data to PC, printer or USB flash drive Analog: 4-20mA current loop (requires external power source) Accurate to 0.3% of output
Certifications	TUV 61010, CE

Accuracy and Precision

Calibration	Point Accuracy**	Precision (RSD)
1.0 µg/m^3	± 10%	15%
25 µg/m^3	± 5%	3%
100+ µg/m^3	± 5%	3%

*Sample values below 0.5 µg/m^3 will be recorded and displayed as 0.00 µg/m^3 by the J405. Sample values above 999 µg/m^3 will be recorded, but the display will indicate “High Concentration.”

**After changing the AG filter, accuracy at 1.0 µg/m^3 may change from ±10% to ±20%, and accuracy at 25 µg/m^3 and 100µg/m^3 may change from ±5% to ±7%. RSD is unchanged.

APPENDIX B
Data Sheet

Name of researcher ______________________________________ Date ___________________

Name of healthcare facility ____

Location ____

Number of beds ________________________ Average occupancy rate ____________________

Number of outpatients per day ____

Type of facility (e.g., hospital, clinic, rural health station, etc.) ______________________________

Classification: ☐ Urban facility ☐ Rural facility ☐ Other ______________________________

Level of facility (e.g., primary care, tertiary care, etc.) ____________________________________

Description of services provided (e.g., pediatrics, maternity, etc.) __________________________

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Comments ____

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Background Mercury Readings:

_______________ μg/m³ Description of Location ________________________________

_______________ μg/m³ Description of Location ________________________________

_______________ μg/m³ Description of Location ________________________________

Description of Target Site (e.g., pediatric ward) ________________________________

Were mercury devices ever used at the specific site? □ YES □ NO

If YES, which mercury devices were used (check all that apply):

□ Thermometers □ Sphygmomanometers □ Others (describe) ____________________

If YES, when was the last time mercury devices were used at the site? __________ months

Were procedures that employed mercury ever conducted at the specific site? □ YES □ NO

If YES, describe ____

If YES, when was the last time mercury procedures were done at the site? _______ months

Type of ventilation (check only one):

□ Natural ventilation with windows usually kept open for fresh air

□ Natural ventilation with no windows or windows usually kept close

□ Centralized air-conditioning system and/or centralized heating system

□ Stand-alone room air-conditioner or small window air-conditioning unit

□ Local exhaust ventilation, mechanical exhaust fan, ceiling fan, tabletop fan, or floor fan with or without windows

□ Other (describe) ____

Ambient Air Mercury Readings:

(1) ______________ $\mu g/m^3$ Description of Location ______________________________

(2) ______________ $\mu g/m^3$ Description of Location ______________________________

(3) ______________ $\mu g/m^3$ Description of Location ______________________________

APPENDIX C
Brief Survey of the Literature[2]

DENTAL FACILITIES

Most of the relevant studies found in this literature review relate to mercury levels in dental facilities.

Stonehouse and Newman (2001) investigated the release of mercury vapor from a dental aspirator which vented its waste air through its base directly into the surgery environment. Mercury vapor in air concentrations were measured at the breathing zone of the dentist during continuous operation of the aspirator. At the dentist's breathing zone, mercury vapor concentrations of ten times the occupational exposure limit of 25 $\mu g/m^3$ were recorded after 20 minutes of continuous aspirator operation.

Tezel *et al*. (2001) conducted a study to determine the blood mercury levels in dental students and clinical teaching staff in Ege University, a Turkey dental school using amalgam as a restorative material. There were statistically significant increases in plasma mercury concentration between measurements in all groups at the end of the academic year. Increased mercury levels appeared to be due to background exposure from spillage of mercury and amalgam residues on floors.

A study conducted in 2003 by Ihejiawu *et al.* at an active dental clinic for ten days over a four-week period in the United States revealed elemental mercury concentrations from the breathing zone ranged from non-detectable to 0.0034 mg/m3. The highest mercury concentration detected was 0.199 mg/m^3 at the amalgam well. The highest mercury concentration acquired from the breathing zone of a clinic employee was 0.017 mg/m^3 from the breathing zone of a dental assistant during a tooth restoration process. The dental assistant job category is identified as the “worst case” scenario for elemental mercury exposure due to the increase potential for mercury vapor generation during the amalgam preparation process.

A study of 180 dentists in West Scotland was conducted to determine their exposure to mercury during the course of their work and the effects on their health and cognitive function (Ritchie et al. 2004). Dentists were found to have, on average, urinary mercury levels over four times that of control subjects. One hundred and twenty two (67.8%) of the 180 surgeries visited had environmental mercury measurements in one or more areas above the UK Health and Safety Executive occupational exposure standard (OES) for mercury vapor of 25 µg per cubic meter for 8 hours a day, 40 hours a week. In the majority of these surgeries the high levels of mercury were found at the skirting and around the base of the dental chair. In 45 surgeries (25%) the breathing zone of dental staff was above the OES.

Concentrations of mercury in vapor and in particulate matter (PM10) were measured in the Dental Simulation Laboratory (DSL) and in the Dental Clinic (DC) at the School of Dentistry, University of Puerto Rico. Levels of mercury vapor ranged from 1.1 to 3.3mg/m^3 at the DSL; and from 13.6 to 2.7 $\mu g/m^3$ at the DC. Levels of mercury bound to PM10 were low; however, mercury vapor was several times higher than the suggested OSHA in the DSL (permissible exposure limit - 100 $\mu g/m^3$).

[2] Compiled by Emily Warren

HOSPITAL FACILITIES

The literature review only found three studies related to mercury levels within hospitals. The earliest was conducted in 1979 (Choi-Lao *et al.*, 1979) for airborne mercury in two Ottawa, Canada hospitals. Although the concentrations of mercury vapor were below the TLV, all samples analyzed showed measureable amounts of mercury to be present. Predominant sources of mercury contamination were broken thermometers and sphygmomanometers.

Propkopowicz and Mniszek (2005) carried out a study to measure mercury vapor in seven local hospitals in Poland, as well as in one residence. The results indicated the presence of mercury vaporization sources in the assessed hospital rooms but in the majority of cases mercury levels did not exceed 1 $\mu g/m^3$ (i.e. Polish permissible concentration for residence). However, in some of the hospital rooms, elevated concentrations of mercury vapor were found and airborne levels of up to 13.9 $\mu g/m^3$ were recorded. Higher concentrations of mercury vapor were observed in autumn season when compared to summer.

In a more recent study conducted by Toxics Link (2007) in India, it was found that nearly 70 thermometer breakages take place each month in a 300 to 500 bedded hospital. The study was conducted in two hospitals of Delhi. All the test locations showed presence of mercury vapor at varied levels (1.09 to 3.11 $\mu g/m^3$). The dental wing of both the hospital also had very high level of mercury (3.11 $\mu g/m^3$). The levels were also high in maternity and general wards thus posing substantiation risk to newborn babies and patients.

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