MERCURY VAPOR LEVELS IN DENTAL INSTITUTIONS

(SCHOOLS and SUPPLY STORES)

BAN TOXICS!

Asian Center Environmental Health

International Association of IAOMT Oral Medicine & Toxicology PHILIPPINES

World Alliance for Mercury-Free Dentistry
Alliance Mondiale pour une dentisterie sans mercure
Всемирный альянс за стоматологию без ртути
Alianza Mundial por una Odontologia Sin Mercurio
التحالف العالمي لطب أسنان خال من الزئبق
世界无汞牙科联盟

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Disclaimer

ABSTRACT

Objective. The Philippine Department of Health is preparing a planned phase-out of dental amalgam in 3 years. If successful this move will make the Philippines compliant with the requirements of the Minamata Convention on Mercury (Convention) and places it among the leaders in the field of mercury elimination in the world. This study was undertaken to determine mercury (Hg) vapor levels in ambient air in institutions such as dental schools and supply stores to provide a picture of the extent of the Hg pollution in the sector. Moreover, the study aims to pave the way for concerned agencies to better address the Hg problem, specifically acknowledging the urgency on how the dental amalgam instruction would proceed in dentistry learning institutions.

Methodology. Hg vapor concentrations from identified emission sources (such as equipment or facilities used in amalgam procedures, storage and immediate disposal sites, among others) in dental schools were measured utilizing the Lumex RA-915+ Mercury Vapor Analyzer. Measurements over a 10 second sampling period are taken and the mean and relative deviation is reported by the instrument. Climatic conditions such as temperature and humidity were determined using Kestrel® 4500.

For dental supply stores, ambient Hg levels were determined in a 5-minute period, as well as spot-check values for dental amalgam Hg storage areas, when available.

Results. Hg concentration values vary from 967ng/m^3 to a high of 35,617ng/m^3—the majority of which are beyond recommended reference standards such as the ATSDR Action level of >1,000 ng/m^3. Some areas posted Hg concentration of >10,000 ng/m^3, which is considered as the evacuation alert level by the US EPA.

Enclosed rooms with minimal entrance/exit points for air flow and limited air circulation have shown high Hg levels for both dental schools and supply stores. The addition of windows and exhaust systems may decrease Hg levels, as depicted in 2 stores where maximum Hg level is 44.2 ng/m^3. However, these interventions are insufficient if the goal is the virtual elimination of Hg, since literature provides that chronic, long-term exposure to Hg can still threaten human health.

Conclusion. The determination of Hg levels in dental institutions provided evidence that Hg emissions from dental amalgam can be substantial and can exceed human exposure limits. The continued use of dental amalgam, especially in schools were this type of restoration is required to be undertaken by dental students, increases the risk of Hg hazard not only for the students, their instructors, school staff, but also for the general population.

Key words. Mercury vapor, dental schools, dental supply stores

INTRODUCTION and RATIONALE

Hg and Hg compounds are highly toxic substances with adverse effects on humans, ecosystem and wildlife [1]. While initially seen as an acute, localized hazard, Hg pollution is now also established to pose chronic toxicity exposure diffused to the greater population in the global scale. It is one of the hazardous substances listed by the United States Environmental Protection Agency (US EPA) for "virtual elimination." [2]

Hg is unique among metals in possessing a high vapor pressure of 0.001201 Torr at 20OC [3]. This means that the saturation concentration of Hg in air increases dramatically with increasing temperature (Table 1). About 80% of inhaled Hg vapor is retained in the body, and dissolved Hg vapor concentrates in circulating red blood cells [4]. It is carried throughout the body, crossing the blood-brain and placental barriers [5]. It is also well absorbed from the lung, and exposure to high concentrations of this toxic substance may result to pneumonia, bronchitis, chest pain, dyspnea, cough, stomatitis, gingivitis, excessive salivation and diarrhoea [6]. On the other hand, chronic exposure to low dose Hg vapor can impact the central nervous system, causing tremors, behaviour changes and abnormal reflexes [6]. Severe injury to organ systems, including the kidneys, liver, brain, heart and colon can be caused by exposure to very high concentrations of Hg [6].

These health impacts prompted the World Health Organization (WHO) to recommend the phase-out of Hg use, stating that "there is no safe level of Hg in which there is no adverse effect." [7] Furthermore, the International Association for Research on Cancer (IARC) has confirmed that Hg (methylmercury) is a possible human carcinogen [8].

Table 1. Vapor pressure and saturation concentrations of Hg in air at selected temperatures: Hg concentrations in air increase rapidly with increasing temperature

Temperature (°C)	Temperature (°F)	Vapor pressure (Torr)	Vapor pressure (mg/m^3)
0	32	0.000185	2.2
10	50	0.000490	5.9
20	68	0.001201	13.2
30	86	0.00277	29.5
40	104	0.006079	62.6

At 20°C, the saturation concentration of Hg in air is 132 times the Occupational Safety and Health Agency (OSHA) exposure limit.

Hg is persistent in the environment and can be transformed into methylmercury, its most toxic form, which can bioaccumulate in living organisms and biomagnify through the food chain [9]. Hg can drift long distances through the atmosphere and has contaminated global food supplies at levels which may represent major risks to human health [9].

In 2002, the United Nations Environment Programme (UNEP) concluded that Hg poses great risks to human health and the environment after conducting a global study on the impacts of Hg [10]. In 2005, the UNEP estimated that 362 tons of dental mercury is consumed worldwide annually [1,9]. The EU Strategy Concerning Mercury, adopted in the same year, estimated that 90 metric tons of Hg is used for dental amalgam in the region, the second biggest use after mercury-cell chlor-alkali plants [1,9]. In the Philippines, the dental industry remains to be one of the main sources of anthropogenic application of Hg, as it is used as a base substance in the creation of dental amalgams or fillings.

Mistakenly referred to as "silver filling", a dental amalgam is a silver-colored material used to fill (restore) teeth that have cavities. It is made up of mercury (50%), silver (~22% to 32%), tin (~14%), copper (~8%) and other trace minerals [11]. Depending on tooth characteristics and cavity size, the average mouth filling can contain 3 to 4 grams of Hg [1].

Dental amalgams serve as the leading source of mercury intoxication for people who have them [12]. Hg comes out from the filling in vapor form and its amount depends upon a number of factors [13]:

- Cavity size;
- Tooth characteristics;
- Composition
- Age of amalgam;
- Time taken for filling;
- Number of fillings, and;
- Temperature of ingested food/drinking liquids and activities like chewing & grinding of teeth.

Dental amalgam fillings interact in a complex way with the environment in the oral cavity as they are subjected to chemical, biological, mechanical, and thermal forces. These forces change the restoration's appearance and properties, while metal ions, amalgam debris, non-metallic corrosion products, and mercury vapor are released into the oral cavity.

The phenomena and conditions that affect the amalgam/ environment interaction include the chemistry and biochemistry of the environment, formation of biofilms on the amalgam surfaces, existence of localized corrosion cells, galvanic contacts with other metallic restorations, abrasion during mastication, and synergistic effects of the different forces [14].

Practitioners in the dental industry—dentists, dental hygienist, dental auxiliaries, dental clinical instructors, dental students and dental supply traders are prone to Hg intoxication through inhalation of Hg vapors during the storage of dental amalgam, the preparation of amalgam and amalgam-related procedures (restoration, polishing and drilling amalgam). Particularly alarming is the huge number of dental amalgam restoration installed to typodonts and even actual human patients in dental schools—serving as a training ground for the students to practice their skills in preparation for the counterpart Philippine licensure examination of the Dental Professional Regulations Commissions (PRC). Students perform around two to eleven dental amalgam cases per semester, in which the responsibility of purchase, preparation and storage of amalgam components are left to the hands of these budding dental professionals. Aside from direct mercury vapor emission sources, dental practitioners and the common public are exposed to the elemental and organic forms of Hg during transport, storage and disposal of Hg and Hg wastes. Improper management of Hg wastes leads to Hg being released to the environment.

Because Hg is considered as a major environmental pollutant, the Minamata Convention of Mercury, signed by the Philippine government in 2013, calls for its phasing down in use, as does the WHO, which calls for a "switch" to alternatives. With alternatives to amalgam now available, Secretary Ona of the Department of Health has announced a plan for a three-year phase-out of devices containing Hg, including amalgam [15].

Unresolved to date, however, is the critical question of whether dental amalgam placement will continue in Philippine dental schools, thus perpetuating dental students' and patients' exposure to mercury.

In 2012 the New York University (NYU) dental school, responding to the worldwide controversy over the use of mercury in dentistry, shifted its teaching and dental clinics to safer alternatives for several reasons: promoting superior minimally-invasive dentistry, ending environmental pollution, and growing patient aversion to Hg [16]. In October 2013, the government of Singapore followed suit, announcing that it will phase out teaching amalgam at its dental schools [17]. With the large number of dental students now being young women, and Hg being a reproductive toxicant, this information may have particular urgency in terms of the creation and implementation of policies relating to dental amalgam restoration instructions.

Given the current situation of Hg in the dental sector, this study was conducted to determine Hg levels in ambient air in selected dental schools in the Philippines (NCR, CAR, Region VII and XI), and dental supply stores within Metro Manila. The results will signify whether dental school students and practitioners are exposed to Hg levels beyond recommended standards or limits. This will help provide a picture of the extent of the Hg pollution in the sector, paving the way for concerned agencies and dental institutions to better address the problem.

MATERIALS and METHODS

This study evaluated vapor emissions from five dental schools from different regions in the Philippines and 3 dental supply stores located within Metro Manila (Table 2.1 and 2.2). Hg vapor levels are measured using the Lumex RA-915+ Hg vapor analyzer which uses differential Zeeman atomic absorption spectrometry with high frequency modulation of polarized light (253.7 nm) in a multi-path optical cell (10 m) to measure Hg vapor with a vendor-claimed detection limit of 2 ng/m^3.

Table 2.1. Site information including number of dental chairs and type of dental vacuum systems used (dental schools)

Dental School	Region	Area (m^2)	Dental Vacuum System
A	NCR	---	(1- door)
B	NCR	58.68	(2-doors)
C	CAR	461.77	Turbine and rotary vane (>10-windows, 1-door)
D	VII	58.13	(1-door, >5-windows)
E	IX	280.5	Turbine and rotary vane (2-doors)

When no dental vacuum system is present, number of air flow points is cited.

Dental schools. A calibrated Lumex RA-915+ analyzer was used to measure ambient Hg vapor levels from (1) dental equipment or facilities used during amalgam-related procedures, and (2) disposal sites within the general vicinity of the restorative department. The "protocol mode" of the Lumex RA-915+ analyzer was used to measure Hg concentrations. In this mode, three measurements over a 10 second sampling period are taken and the mean and relative deviation is reported by the instrument.

Table 2.2. Site information including type of vacuum systems used (dental supply stores)

Supply Store	Region	Area (m^2)	Dental Vacuum System
A	NCR	55	(open frontage)
B	NCR	55	(open frontage)
C	NCR	64	(door)

When no dental vacuum system is present, number of air flow points is cited.

Dental supply stores. Measurement procedures in dental supply stores include the determination of a central point within the store area where the machine will be located. Average, minimum and maximum Hg levels were measured within a 5-minute range. Hg emissions of dental amalgam components being sold were also determined over a 10 s sampling period.

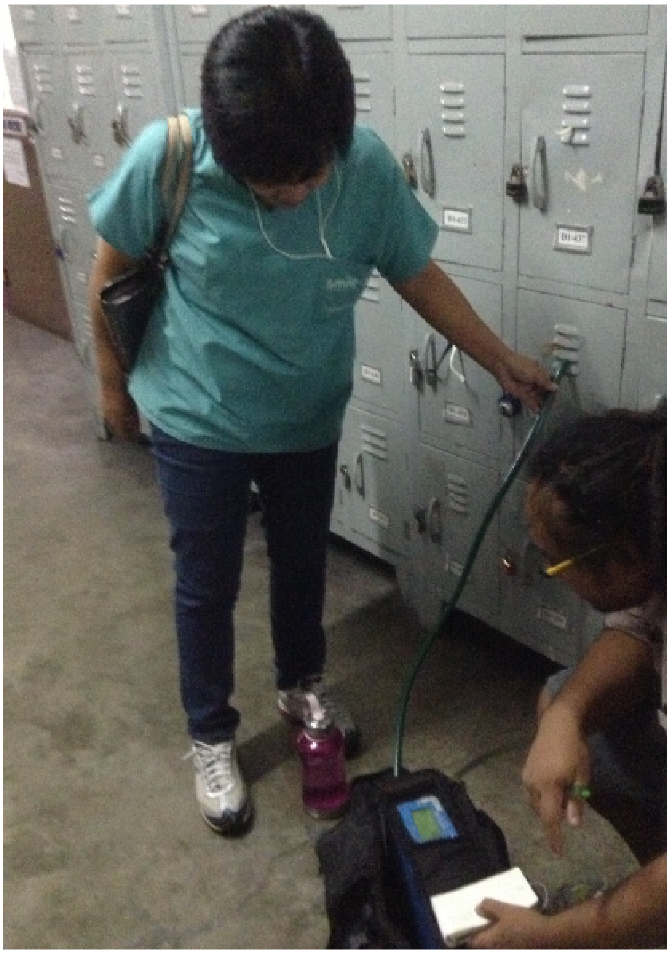
Data on ongoing temperature and humidity were taken using Kestrel® 4500, whereas geographical coordinates were taken with Garmin-eTrex GPS.

RESULTS and DISCUSSION

Dental schools. The succeeding tables (Table 3.1 to 3.5) show actual Hg level readings for all 5 dental institutions. Type I Hg emission sources include all equipment/ facilities used in amalgam-related procedures, including those conducted on a patient or on a phantom head. On the other hand, type II emissions sources refer to storage and disposal sites within the immediate vicinity of the clinic or laboratory. This includes sinks and regular- and Hg-waste intended waste bins. Climatic conditions during sampling recorded temperature and humidity values beyond 20°C, which are advantageous to the highly volatile nature of Hg. Hg concentration values vary from 967ng/m^3 to a high of 35,617ng/m^3—the majority of which are beyond recommended reference standards such as the ATSDR Action level of >1,000 ng/m^3 (Table 5). Some areas posted Hg concentration of >10,000 ng/m^3, which is considered to be the evacuation alert level by the US EPA.

Hg values for both closed and open amalgamators (Type I) show that Hg emissions still continue regardless of the condition of the equipment. An opened amalgamator in School A had an average Hg reading of 5,793.33 ng/m^3, while it posted a concentration of 3,307.33 ng/m^3 when closed. Both values exceed the limit for exposure.

Since students are responsible for acquiring and purchasing their amalgam materials, they tend to store these in their steel lockers located along the building corridors. A spot-check in School B showed that the improper storage of dental amalgam can lead to Hg values of 1,718 ng/m^3, in which the student can be directly exposed to whenever he/she opens the unit. The emission can also seep through the vents of locker units and diffuse into the air circulating within the vicinity.



Significant values were also recorded for Type II emission sources, such as sinks (997 ng/m^3 to 24,480 ng/m^3) and waste bins (2020 ng/m^3 to 19,520 ng/m^3). Oral fluids (saliva) from patients are normally deposited in sinks, as well as on Hg-contaminated dental instruments used in restoration or removal. A majority of the schools allocate a waste container for amalgam wastes such as scrap amalgam, old teeth with fillings, and syringes and personal protective equipment or PPEs (gloves) used during amalgam procedures. Again, the volatile nature of Hg allows for subsequent emissions to still take place regardless of whether a separate waste container is allocated or not. Furthermore, lack of knowledge regarding proper storage and/or disposal of this type of hazardous waste leads to Hg eventually ending up in the municipal waste stream.

The absence of entrance/exit points for air flow and a vacuum system inhibits the diffusion of Hg emissions in the dental school laboratories, thus concentrating its vapors within the room. Schools (A, B and D) with enclosed, air-conditioned restorative sections recorded higher Hg levels due to the recycling of Hg-contaminated air within the room. Of the 5 schools, School E recorded the lowest Hg values, since this is a provisional area built by the college prior to their transfer to a new building. Additionally, consistently high Hg values in different points within the same area/room illustrate that individual amalgam procedures contribute to the ambient Hg concentration in which dental students and practitioners are exposed to during clinic hours (around 8 to 9 hours).

Table 3.1. Selected* Hg level readings in Dental School A

	Area	Hg concentration, ng/m^3			Average (ng/m^3)
		1	2	3	
Type 1	Phantom head	4,112	4,103	4,243	4,152.67
	Seat #10	4,097	3,869	3,659	3,895
	Closed amalgamator	3,306	3,309	3,307	3,307.33
	Open amalgamator	5,989	5,648	5,743	5,793.33
Type 2	Sink #1	10,350	9,581	9,781	9,904
	Sink #2	29,180	22,540	17,620	23,113.33
	Scrap amalgam container	3,689	3,837	3,883	3,803
	Waste bin #1	3,221	3,589	3,581	3,463.67
	Waste bin #2	3,534	3,564	3,560	3,552.67

Temperature (°C): 23.6
Humidity (%): 39.5

Table 3.2. Hg level readings in Dental School B

Area		Hg concentration, ng/m³ 1	2	3	Average (ng/m³)
Type 1	Seat #3	20,030	20,030	20,030	20,030
	Locker #48	1,575	1,693	1,885	1,718
Type 2	Sink #1	24,150	24,980	24,300	24,480
	Waste bin #1	19,300	19,630	19,630	19,520
	Waste bin #2	18,870	19,250	19,250	19,120

Temperature (°C): 25.2
Humidity (%): 53.86

Table 3.3. Selected* Hg level readings in Dental School C

Area		Hg concentration, ng/m³ 1	2	3	Average (ng/m³)
Type 1	Cuspidor	2,548	1,423	2,699	2,223.33
	Plate	1,751	1,148	1,246	1,381.67
Type 2	Seat #5	775	1,217	1,369	1,120.33
	Phantom desk	2,301	2,456	1,254	2,003.67
	Sink #1	1,258	2,076	1,254	1,529
	Waste bin #1	4,875	4,358	6,752	53,28.33
	Waste bin #2	19,852	37,741	49,259	35,617.33

Temperature (°C): 27.2
Humidity (%): 82.56

Table 3.4. Selected* Hg level readings in Dental School D

Area		Hg concentration, ng/m³ 1	2	3	Average (ng/m³)
Type 1	Cuspidor	6,599	6,602	6,443	6,548
	Phantom desk	6,563	5,901	5,851	6,105
	Seat #1	6,734	7,187	6,747	6,889
	Amalgamator	13,340	12,920	13,000	13,086.67
Type 2	Sink #1	7,106	7,378	7,165	7,216.33
	Waste bin #1	12,390	11,360	13,750	12,500
	Waste bin #2	17,320	16,810	16,220	16,783.33

Temperature (°C): 24.1
Humidity (%): 49

Table 3.5. Selected* Hg level readings in Dental School E

Area		Hg concentration, ng/m³ 1	2	3	Average (ng/m³)
Type 1	Cuspidor	1,077	1,076	1,054	1,069
	Tray	1,037	1,019	998	1,018
	Seat #1	991	967	943	967
Type 2	Sink	902	1,029	1,061	997.33
	Waste bin #1	2,369	1,835	1,856	2,020
	Waste bin #2	3,824	4,387	3,553	3,921.33

Temperature (°C): 25.6
Humidity (%): 62.4

Dental supply stores. Ambient Hg levels in dental supply stores were measured in a 5-minute period. Spot-checks of dental amalgam mercury storage areas, when available, were also determined. Dental supply stores A and B recorded low Hg levels, since these stores have open frontages where surrounding air can diffuse Hg emissions from elemental mercury or encapsulated amalgam. Furthermore, low Hg levels are recorded in store A because of the unavailability of stock amalgam during field visit. Similar with the observations for dental schools, dental supply store C posted high Hg levels due to it being an enclosed space with limited entry/exit points for air flow.

Table 4.1. Ambient Hg levels (ng/m3) in Dental Supply	
Minimum	24.3
Maximum	36.5
Average	29.7
Inside storage cabinet	*no Hg*
Near (closed) storage cabinet	*no Hg*

Table 4.2. Ambient Hg levels (ng/m3) in Dental Supply	
Minimum	29.1
Maximum	44.2
Average	37.4
Inside storage cabinet	326

Table 4.3. Ambient Hg levels (ng/m3) in Dental Supply	
Minimum	5657.8
Maximum	5948.5
Average	5797.4
Near storage shelf	5314

In August 2008, the Department of Environment and Natural Resources (DENR) conducted a Hg inventory assessment using a toolkit provided by UNEP. An estimated total of 234,031 kg Hg/year was recorded, with main emissions coming from primary virgin metal production (31.95%), extraction and use of fuel and energy sources (20.45%) and other intentional uses such as those in the dental industry [18]. The over-all Hg emissions in the country are distributed mainly to air (45%), land (19%) and water (18%), with the rest going to general waste [18].

Too, the total Hg load to the atmosphere from the dental sector cannot be ignored. A report commissioned by the European Environmental Bureau (EEB) on May 2007 showed the main pathways of dental Hg through the economy and society include [9]:

- Hg supply sources;
- Hg brokers and traders;
- Suppliers of amalgam products to the dental trade;
- Application of Hg in dental practices;
- Dental Hg in waste streams;
- Recycling or storage of Hg, and
- The eventual disposition of dead bodies with Hg fillings, whether by burial or by cremation.

All of these routes inevitably contribute to Hg pollution, especially when sound and proper management procedures are neglected or non-existent.

Figure 1. Pathway of Hg and Hg waste [1]

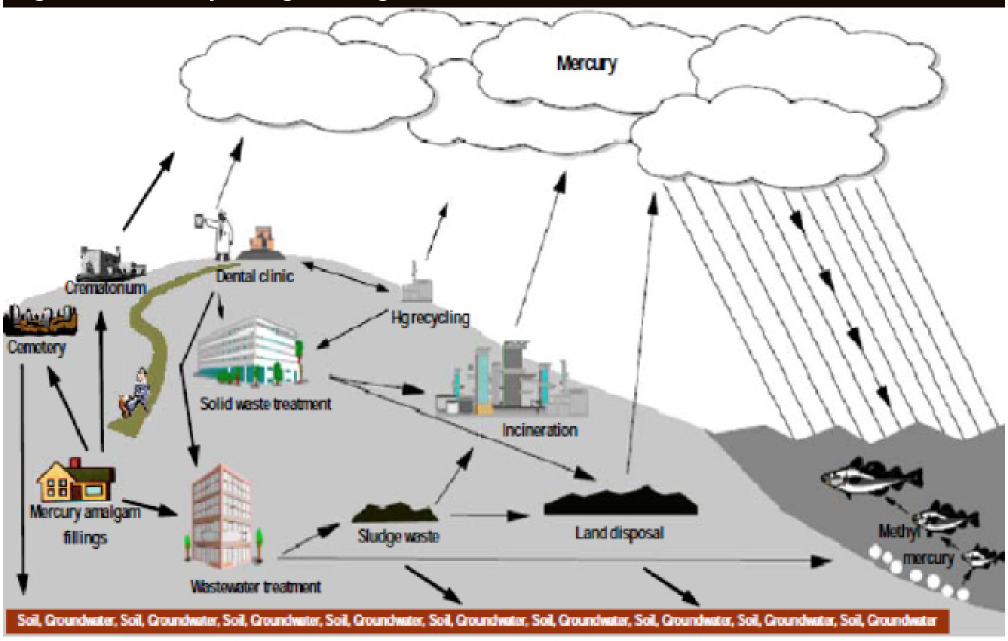


Figure 1 illustrates the general flow of Hg through the dental clinic or laboratory and downstream. While it shows how Hg wastes join the general waste stream and enters the environment, it does not include Hg emissions to the air which may occur in various stages during handling and placing of Hg amalgams or as releases from the wastewater system. Dental personnel may be exposed to the different sources of Hg vapors in the duration of [19]:

- Accidental Hg spills
- Malfunctioning amalgamators;
- Leaky amalgam capsules or malfunctioning bulk Hg dispensers;
- Trituration, placement and condensation of amalgam
- Polishing or removal of amalgam
- Vaporization of Hg from contaminated instruments, and;
- Open storage of amalgam scrap or used capsules

Table 5. US-based Exposure Reference Standards [20]

Agency	Hg concentration (ng/m^3)
OSHA[a] Ceiling limit[1]	100,000
ATSDR[b] MRL[2]	200
ATSDR Action Level (indoor)	>1,000
EPA[c] Rfc[3]	300

[a]OSHA - Occupational Safety and Health Administration
[b]ATSDR - Agency for Toxic Substances and Diseases Registry
[c]EPA - Environmental Protection Agency

[1]Ceiling limit - the concentration of mercury vapor cannot exceed this value at any time
[2]MRL - Minimal Risk Level
[3]Rfc - Reference Concentration

High levels of compounded Hg exposure from emission sources tested in the study are a cause of concern, especially in rooms with limited air flow and circulation. Table 5 lists human exposure limits for Hg vapor from three different US agencies. In the past, agencies were reluctant to provide suggested action levels because of the site specific nature of exposures, as well as differences in populations, exposure durations and specificity of hazards. However, the immediacy and extent of the potential health risk associated with Hg contamination warranted the development of these standards to also identify response activities under different exposure scenarios [21].

Health Guideline Values. The US EPA sets an Rfc of 300 ng/m^3 for inhalation exposure to Hg [20,21]. The reference concentration is a screening tool used to help risk assessors determine where to focus their investigations into hazardous exposures. Thus, it must be noted that adverse health effects do not necessarily result from exposure at the reference concentration. The ATSDR set an MRL of 200 ng/m^3 as 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. The agency also recommended an action level of 1,000 ng/m^3, which triggers remediation if exceeded in indoor air, such as removal of Hg source. Note that inspite of these reference levels the WHO has concluded that "there is no safe level of Hg in which there is no adverse effect."

Action levels. In the US, an action level is an indoor air concentration of Hg vapor which should prompt consideration of the need to implement a recommended response by public health and environment officials. The action levels for Hg are based on the data available in ATSDR's Toxicological Profile for Hg (1999) on the Hazardous Substance Databank of the Toxicology Data Network at the National Library of Medicine [2, 20, 21]. Indoor air concentration of >10,000 ng/m^3 requires isolation of humans from the source of exposure. When adjusted from an intermediate to chronic exposure to a continuous exposure scenario (i.e. 24 hours/day, 7 days/week), this concentration approaches levels reported in the literature to cause subtle human health effects. Applied to acute exposures with good accuracy by real-time instruments such as the Lumex RA-915+ mercury vapor analyzer, this value allows for interventions before health effects could be expected. In the study, four out of five schools have Hg sources exceeding the ATSDR action level, which warrant a response of isolation. Isolation may include (1) reducing the time people spend in a particular area, (2) closing the ventilation system connections leading to and from a specific portion of a building, (3) reducing the emission rate of vapors from the source, or (4) relocating some or all of the persons who normally occupy the building [21].

Policy Considerations. Given the contribution of dental amalgam to Hg pollution, several countries across the globe have created and are enforcing policies on Hg dental amalgams. In 2009, Sweden prohibited the use of dental amalgam for children and restricted its use for adults to cases where there is a particular medical reason for its use and where other treatments have been judged insufficient [13, 22]. Austria, Germany, Finland, Norway, Denmark and the United Kingdom have also advised dentists to specifically avoid Hg-containing amalgam during pregnancy [13]. Canada, Italy and Australia have also take steps to reduce amalgam use.

In the Philippines, DENR released Administrative Order (AO) No. 38, Series of 1997, or the Chemical Control Order (CCO) for Hg and Hg compounds [23]. This CCO applies to the importation, manufacture, processing, use and distribution of Hg and its compounds, and addresses the treatment, storage and disposal of Hg-bearing or Hg- contaminated wastes in the Philippines. It also identified the dental sector as one of the permitted end users of Hg in the Philippines. The CCO was created in lieu of the Republic Act (RA) No. 6969, also known as "Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1990". Under this law, the DENR is tasked to keep an inventory of toxic chemicals including Hg [23,24].

Although CCO 38 exempts the importation of dental amalgam from its prohibition on imports, it is supposed to maintain strict control over use, trade, and disposal. This is in line with both provisons of RA 6969 and CCO 38 [23].

As the study has seen trade of dental amalgam, its storage, transportation, use and ultimate disposal of Hg in dental clinics and institutions has escaped strict enforcement of both RA 6969 and CCO 38.

Of particular concern the study has witnessed is the disposal of dental amalgam waste into the general waste stream, which is environmentally unsound and a direct contributor to the Hg burden in the Philippine environment.

The Department of Health (DOH), in 2008, released AO 21, or the "Gradual Phase-out of Hg in all Philippine Health Care Facilities and Institutions," which aligns with DENR's AO No. 38 in clinics and hospitals where thermometers and other Hg-bearing medical devices were used [25]. Part of this AO was the formation of the Hg Minimization Program, detailing preference towards Hg alternatives, waste segregation and recycling, Hg collection and storage area. Included specifically in the coverage of AO 21 are dental clinics. What AO 21 has not made explicit is the mention of dental amalgam. It was the intention in the development of AO 21 is to expand the coverage of the AO and include other mercury products in healthcare facilities. Pursuant to AO 21, the DOH is moving towards a strategic plan on the phaseout of dental amalgam. Moreover, there is critical gap in the absence of clear guidelines in the implementation of AO 21 and the dental amalgam phase-out policy in dental clinics and schools where dental amalgam continues to be used aside from the commonplace Hg-bearing medical devices.

With the Philippine signing the Minamata Treaty last October 2013 the government has committed itself not to undermine the Convention and in this regard prepare itself for its obligations, including the reduction of the use of dental amalgam, with the view of phasing it down in the long term. Under Article 4 Annex A of the Minamata Convention, a country such as the Philippines is given a menu of nine strategies that it can adopt for phasing out dental amalgam use. Governments ratifying the Convention will need to implement two or more of these strategies [26]:

1. Set national objectives, aiming at dental caries prevention and health promotion, thereby minimizing the need for dental restoration;
2. Set national objectives aiming at minimizing its use;
3. Promote the use of cost-effective and clinically-effective Hg-free alternatives for dental restoration;
4. Encourage representative professional organizations and dental schools to educate and train dental professionals and students on the use of Hg-free dental restoration alternatives and on promoting best management practices;
5. Discourage insurance policies and programs that favor the use of dental amalgam over Hg-free dental restoration;
6. Encourage insurance policies and programs that favor the use of quality alternatives to dental amalgam for dental restoration;
7. Restrict the use of dental amalgam for dental restoration;
8. Restrict the use of dental amalgam to its en capsulated form;
9. Promote the use of best environmental practices in dental facilities to reduce releases of Hg and Hg compounds to water and land.

Due to the availability of Hg-free alternatives in dentistry, the phasing down and eventual phasing out of dental amalgam is likely to prove easier than the phasing our other Hg emission sources. This includes composites, (resin-free) glass ionomer cements, and ceramics, among others. A number of dentists practicing Hg-free dentistry have confirmed that restoration of damaged teeth is possible, and that the cost of using alternatives would be cheaper and more sustainable [1]. The economic reason tied to the prevalence of dental amalgam can be misleading, since dental amalgams would be one of the most expensive restoration materials if related environmental costs and (chronic) health effects caused by Hg are taken into account [27].

CONCLUSION and RECOMMENDATIONS

The study of Hg levels in dental clinics and institutions provided evidence that Hg emissions from dental amalgam can be substantial and usually exceed general accepted human exposure limits. The continued use of dental amalgam, especially in schools where this type of restoration is required to be undertaken by dental students, increases the risk of Hg hazard not only for students, dental practitioners, and school administration but also for the general population. Hg's inherent toxicity, its highly volatile nature leading to its efficient route of exposure, its persistence in the environment, the absence of clear-cut policies and the current state of the dental amalgam instruction system in the Philippines are all contributing factors to the burgeoning Hg dilemma.

The Hg levels in the air in all dental institutions, regardless of precautions taken, exceed the acceptable limits. Even if dental institutions provide interventions to this problem, such as the addition of exhaust systems and entrance/exit points in laboratories, these will only serve as band-aid solutions to direct Hg exposure and will continue on cultivating Hg emission sources. Thus, the route to protecting dental students and employees, especially young women and patients getting care, is to phase out the use of amalgam and phase in the alternative materials.

Henceforth, the following recommendations are put forward:

1. Discontinue placing dental amalgam in the clinics immediately. The findings of the study shows exposure to dental professionals, students, and almost everyone involved in the supply chain of dental amalgam from its trade, installation and disposal. In line with current policy and regulations of the Philippine government, such as AO 21 and most recently its signing of the Minamata Convention on Mercury, the Philippine government and different stakeholders should actively pursue the implementation of policies consistent with the elimination of Hg in all sectors including the phaseout of dental amalgam use by 2016.

2. Change the dental instruction system in the Philippines and eliminate the exposure of young students and dental professionals from dental amalgam in dental institutions. This means that cases involving the actual placement of dental amalgam by dental school students, may it be in a phantom head or human being, should be stopped. Dental students should not also be restricted to this method because of it being a requirement to their board exam. Moreover, Philippine dentistry should be striving for better, safer, and healthier technologies. Continued use of an antiquated and dangerous procedure, such as dental amalgams, has no place in the future of Philippine dentistry.

3. The findings of the study support the policy direction Secretary Ona and the DOH is taking to phase out amalgam by 2016. Moreover, Hg-free dental restoration alternatives should be explored and promoted. In addition to reducing Hg vapor in the air, the 2010 WHO report Future Use of Material for Dental Restoration notes that Hg-free materials "allow for less tooth destruction and, as a result, a longer survival of the tooth itself. Funding agencies should take the initiative and encourage use of non-mercury restorative materials as an alternative material instead of using dental amalgam". [27]

4. The Philippine Government should immediately ratify the Minamata Convention on Mercury. The trajectory of the government's policies on Hg is in compliance with the Convention, and its ratification will not pose an additional burden on the country. Further, by ratifying the Convention, the Philippines will ensure that global efforts towards Hg elimination are achieved sooner than later. Lastly, the Philippines stands to gain from the Convention's provisions,

especially on finance,
Hg-free alternatives, and technology transfer.

5. Environmentally sound management of storage of existing dental amalgam inventories and the disposal of the ensuing amalgam waste must be created and implemented. Dental practictioners, their staff, and most importantly, patients are exposed to the Hg fumes. It is imperative that proper storage methodologies and environmentally sound management of mercury waste be immediately undertaken through the joint leadership of the DOH and DENR. Moreover, guidelines for the removal process of this type of restoration technique must be properly evaluated.

The researchers of the study also recommend a more comprehensive approach on the exposure levels of dental professionals to Hg, through analysing Hg levels within occupational limits (8-hours). Complementing these efforts is the need for an analysis on the contribution of the dental sector on outdoor air (environmental).

The Hg challenge facing Philippine dentistry is both avoidable and manageable. It is avoidable because data on Hg exposure and alternatives are now widespread. The challenge is also manageable because as the DOH has shown with AO 21, existing structures under the DOH work, and the implementation of a Hg-Free dentistry can be achieved. What is now needed is for leaders of Philippine dentistry to come together and bring Philippine dentistry to a Hg-free dawn, for the benefit of current dentists, for the dentists that will pursue the noble profession after them, and most important of all for the benefit of Filiipino patients.

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