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Feature

Mercury in Dental Amalgam, Online Retail, and the Minamata Convention on Mercury

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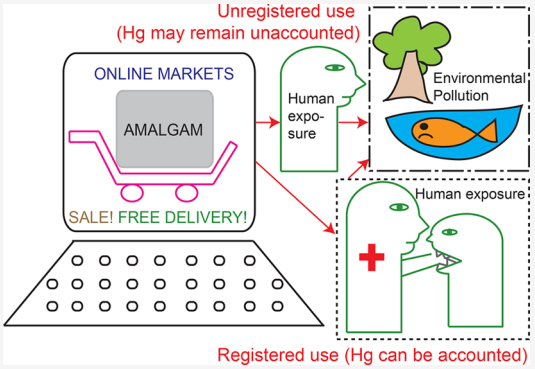
ABSTRACT: The Minamata Convention on Mercury (ref. 1) is a global treaty to protect human and environmental health from adverse effects of the toxic element mercury and its compounds. During the Third Conference of Parties (COP-3) in November 2019, elimination of the use of dental amalgam in oral health care was discussed. Dental amalgam is one of the most commonly used restorative materials in oral health care due to its strength and longevity (ref. 2). However, the use of mercury in an amalgam adds to global environmental mercury pollution and can contribute to adverse health effects on humans and other organisms. The outcomes of the COP-3 meeting included a call for information on the availability at a national scale, the economic and technical feasibility of alternatives, and the associated risks or benefits. In this feature, we discuss the risks and benefits of dental amalgam, the global tracking of availability and procurement, and the implications and realities for global phase out. We suggest a better accounting of mercury use in dental amalgam is needed with sales being made only to registered practitioners via a Know Your Customer approach.



Dental amalgam is one of the most commonly used restorative materials in oral health care.[3] Mercury-based dental amalgamates are considered to be strong and long lasting,[2] and they typically consist an equal mixture of elemental mercury and a metal such as copper, silver, tin, palladium, or iridium.[4] However, human health studies have shown an increased body burden of mercury in people with dental amalgams[5] and those in the dental professions.[6−8] A statement from the American Dental Association[9] citing studies undertaken between 1997 and 2010 took the position that dental amalgam is a "*safe and effective restorative option*". However, some new studies suggested a link between mercury exposure from dental amalgam and possible harmful health effects,[10,11] and Ajiboye et al.[12] argued on behalf of the International Association for Dental Research that additional research may be required to establish if dental amalgam has a causal relationship with adverse health effects.

Overall human exposure to mercury via dental amalgam will vary significantly depending on the amount of amalgam fillings a person has and the food consumed. For example, mechanical abrasion of amalgam fillings during everyday activities such as chewing or brushing may release mercury that becomes dissolved in the oral fluids.[13] Elemental mercury may be oxidized to divalent mercury depending on the oxidizing power of the ingested food or drink.[13] Elemental mercury vapor is inhaled into the lungs, up to 80% of which may be absorbed and distributed in major organs[14] and the remaining exhaled.[15,16] In the digestive system, ingested elemental mercury is poorly absorbed with a bioavailability of less than 0.01%, while inorganic oxidized mercury may have a bioavailability between 7% and 15%.[14] The total daily mercury intake from dental amalgam has been estimated as 1−27 μg/day, with most values under 5 μg/day.[17] This amounts to 0.077 (0.015−0.415) μg/kg body-weight/day for a 65 kg adult. Monte Carlo simulations have estimated that dental amalgam may contribute up to 50% of total daily mercury exposure for an average Canadian with amalgam-filled teeth.[17−19] Approximately 60% of this exposure was attributed to the inhalation of elemental mercury vapor and 40% to the ingestion of oxidized mercury in saliva.

Dental practitioners are occupationally exposed to mercury during activities such as amalgam preparation, storage, and placement/removal.[7] Factors that contribute to exposure include the number of dental amalgam restorations and removals made per week, the apparatus used for performing the procedure, use of personal protective equipment (masks, gloves), workplace ventilation, management of spills, and general workplace hygiene. Median concentrations of mercury

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in the breathing zone of dentists at different workplace regions (chair, skirting, capsule storage and preparation area or amalgamator area, waste amalgam storage area) have been reported to range between[20] 5.7 and 21.2 $\mu g/m^3$, with dentists having a several times higher body burden of mercury than control subjects.

The use of dental amalgam can also indirectly lead to mercury releases to the environment through amalgam disposal, tooth loss, and human cremation and burial.[21−23] It was reported in 2010 that as much as 1000 tonnes of mercury might be stored in the mouths of people in European Union (EU)27 countries.[21] It was further estimated[21] that 34−50 tonnes of dental-amalgam mercury in EU27 had a potential to become bioavailable in the environment, and from 31 to 46 tonnes would be sequestered (stored in hazardous waste landfills) or recycled. In the United States (US), 5.1 tons of mercury was reported to reach publicly owned treatment works (POTWs) through activities in dental clinics every year.[24] Between 500 and 600 tonnes were estimated to exist as dental amalgam in the Indian population.[22,23] Total emissions in India associated with dental amalgam to the environment were estimated to be 60−80 tonnes.[22,25] Globally, as much as 180−240 t of mercury has been reported to be released to the environment per year from dental amalgam sources.[26]

Dental amalgam is listed in Annex A-Part II of Article 4 of the Minamata Convention on Mercury,[1] for a phase down of its use taking into account a party's domestic circumstance and international guidance. Some individual countries have already completely banned the use of dental amalgam (e.g., Norway), with dentists later reporting a positive attitude toward use of alternate restorative material.[27] Plans to phase out the use of dental amalgam across the globe were recently discussed internationally. In the third Conference of Parties (COP-3) of the Minamata Convention in 2019, a consortium of African countries, namely, Botswana, Chad, Gabon, Guinea Bissau, Niger, and Senegal, proposed to move dental amalgam to Annex A-Part I of the convention with definitive phase-out dates of 2021 for dental amalgam use in deciduous teeth, children less than 15 years old, and pregnant or breastfeeding women, and for dental amalgam in entirety by 2024 (except when no mercury-free alternatives are available).[28] However, several parties and observers objected to the proposal,[29] based on the time frame of the plan (2021 or 2024), financial and technical implications, availability and feasibility of alternatives, and provision of support for a stepwise approach without which adverse impacts on public health may actually increase. For example, a more rapid phase-out of mercury-based products from oral health care would be onerous in India, where 70% of the population has caries, and of these 58% visit a dentist.[25] Such hurdles were acknowledged in the subsequent decision of the COP-3 (MC/COP3/2019/15).

Replacement strategies for mercury amalgam are closely tied to the durability and cost of alternative filling materials, as well as environmental mitigation measures in place at national levels. In general, dental amalgam and glass ionomer cement (GIC) may be of similar costs to a patient, and composites can be at least 1.3 times more expensive. For example, in government-run hospitals in India, the costs per filling can be ∼USD 0.66−1.3 for dental amalgam, USD 0.66−3.9 for GIC, and USD 1.3−5.2 for composites (personal communication, n = 7 dentists); and in private establishments ∼USD 4.0−13.2 for dental amalgam, USD 5.3−13.2 for GIC and USD 6.6−19.9 for composites, although a higher variability is possible. However, dental amalgam has arguably a better performance and longevity and could be considered cheaper to a patient compared to GIC in the long term. Alternative composite fillings in the United States were also 1.3 times more expensive than dental amalgam (USD 185 vs USD 144, respectively);[30] however, the added costs of mandatory environmental protection and mitigation measures such as the removal of mercury from crematoria flue gas and from wastewater sludge before disposal to agricultural land, collection and recycling of dental amalgam, and sequestration of mercury increases the price of dental amalgam by a further USD 41−67 resulting in amalgam fillings being more expensive than alternatives. Likewise, while composites were reviewed to be 1.3 times more expensive than dental amalgam over a restoration and 2 times more expensive over a patient's lifetime in Canada, the annual cost of operating amalgam separators for mercury waste management was estimated to be more than CAD16 million.[31] Passing on the cost of environmental mitigation strategies when using dental amalgams has not yet been applied in India. While its inclusion will shift the economical balance more in favor of alternatives, there must be clarity on who will be responsible for paying the additional costs (consumers, government, or manufacturer). Passing on these additional costs to consumers is also of concern. Unless significant measures are taken to provide cheaper, long-lasting, and easily available alternatives,[32−34] a gradual phasing out of mercury-based materials risks widening oral health inequalities, especially in economically less well-off populations.[32]

An additional challenge in the control of dental amalgams is their easy procurement online. Sales of mercury-containing products including dental amalgam on e-commerce Web sites have increased tremendously, with little control on who is buying, making it difficult to trace mercury after sales. Without intensive supervision and the cooperation of e-commerce platforms, the uncontrolled retail sales of mercury-based substances will continue and hamper efforts to phase out these products and enforce associated environmental measures.

Many examples exist of countries struggling to restrict the flow of mercury trade through online platforms. Despite the banning of mercury use in 2014 in Indonesia, it can be easily procured illegally online.[35] Likewise, popular e-commerce Web sites in the Philippines are reportedly selling mercury-containing products without proper validity and certification.[36,37] While the EU introduced Market Surveillance Regulation to monitor the sale of products from non-EU countries through online portals[38] and a Classification and Labeling Program (CLP) to control the Internet sale of hazardous chemicals,[39] it has still found it difficult to manage chemicals including those containing mercury being sold on online platforms.[40,41]

A useful strategy to curb online sales could include policies such as know your customer (KYC), where sellers are required to verify the identity of the customers. This KYC approach has been implemented by the Organization for Economic Co-operation and Development (OECD) to stem the illegal trade of pesticides.[42] The national competent authority maintains a list of distributors (wholesalers and retailers) who in turn are required to record the quantity of stored and distributed pesticide and whether the purchaser to which they sold the product is a professional user with a registration number. A list of professional users is also maintained, and the user has to keep a detailed record of bought, used, and stored pesticide(s) for at least five years. In India, all courier companies importing

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goods, including chemicals, from outside India are required by the Indian customs to obtain KYC details from the purchaser.[43,44] Within India, some online platforms selling chemicals do require customers to complete a KYC form or provide a value added tax (VAT) registration or tax identification number (TIN). Having such a policy consistently applied to all dental amalgam/mercury sales platforms would be very useful in checking and accounting for mercury flows.

In summary, we note that the overall management of mercury use in dental amalgam and mitigation of its health and environmental impacts in India and globally will be challenging. Steps could include further exploration of the durability and cost of alternatives, training of dental practitioners and students in using the alternatives, better disposal practices by the practitioner,[45] education of practitioner and patient to the possible environmental and human health implications of mercury use,[46] and keeping a check on the overall flow of mercury to the dental sector by sales being restricted to qualified and registered professionals only.

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Notes

The authors declare no competing financial interest.

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