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Dental Amalgam, Mercury Exposure, and Best Management Practices: A Comprehensive Review

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ABSTRACT

Dental amalgam has been used for more than a century as a cost-effective, durable restorative material, yet it remains controversial due to its mercury content and its potential impact on occupational health and the environment. Mercury is a well-recognized neurotoxin, and dental personnel are particularly susceptible to chronic exposure during amalgam manipulation, removal, and inadequate waste disposal. In the environment, inorganic mercury released from dental settings may convert into methylmercury, a highly toxic compound that bioaccumulates in aquatic ecosystems and poses serious public health risks. Studies in India highlight significant gaps in awareness and adherence to mercury hygiene protocols, with improper disposal practices, lack of protective measures, and absence of regulatory compliance frequently reported. Globally, the Minamata Convention on Mercury has catalyzed efforts to reduce or eliminate amalgam use, with several countries instituting complete bans or major phase-down strategies. This review consolidates current evidence, discusses environmental and occupational hazards of mercury exposure, examines international and national policy directions, and outlines best management practices for safer amalgam handling and disposal. Strengthening institutional protocols, professional training, and adherence to environmental guidelines is essential for ensuring safe and sustainable dental practice.

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INTRODUCTION

Dental amalgam has served as a reliable restorative material for over 150 years due to its mechanical strength, longevity, affordability, and forgiving clinical handling characteristics. Despite its advantages, the use of this material has decreased globally because nearly half of it consists of elemental mercury, which can pose significant occupational and environmental hazards. Mercury vapor is released during trituration, placement, and removal of amalgam restorations, exposing dental personnel to chronic low-level inhalational toxicity. In addition, improper disposal allows mercury to contaminate wastewater, soil, and aquatic systems, where it may convert into methylmercury, a highly toxic compound capable of bioaccumulation in the food chain.[1] These cumulative risks underscore the importance of informed policies, strict hygiene protocols, and responsible phase-down practices in modern dental care.

Occupational and Environmental Concerns

Mercury exposure in dentistry is primarily related to vapor released during amalgam manipulation or removal and from inadequate disposal. Long-term exposure is associated with neurocognitive impairment, motor dysfunction, reproductive toxicity, renal injury, and immune alterations. Environmental concerns are equally significant: mercury-containing particles entering wastewater may settle in sewage sludge or be released into open water systems, where microorganisms convert inorganic mercury into methylmercury, a potent neurotoxin.[1] Once in aquatic environments, methylmercury bioaccumulates in fish and shellfish, presenting a major public health concern due to biomagnification.

These concerns become more critical in countries where awareness, infrastructure, and regulatory oversight remain limited. A study from India revealed that 40.6% of dentists discarded excess amalgam into common waste bins, while nearly one-quarter handled amalgam with ungloved hands. More than half did not use high-volume suction or rubber dam during amalgam removal, resulting in significant aerosolized exposure.[2] Another survey estimated that nearly 51 kg of mercury was released annually from dental clinics in New Delhi alone due to inadequate waste segregation practices.[3] The combined occupational and environmental risks demand immediate implementation of standardized mercury hygiene protocols.

Global Response: Minamata Convention and International Policies

The Minamata Convention on Mercury, adopted in 2013 and enforced from 2017, represents the most significant global initiative to reduce mercury exposure across industrial, medical, and environmental sectors. Named after the infamous Minamata disaster in Japan, the treaty mandates the phase-down of dental amalgam through national strategies such as promoting preventive dentistry, encouraging mercury-free alternatives, improving recycling, and training healthcare providers.[4] More than 130 countries, including India, have ratified the convention.

Several countries have implemented aggressive policies to eliminate dental amalgam. Norway introduced a complete ban in 2011 except under rare circumstances, while Sweden banned amalgam in 2009. Finland, Denmark, and the Netherlands have reduced amalgam usage to less than 5% of all restorations by promoting adhesive restorative materials and preventive oral health strategies.[5] These policy-driven transitions demonstrate that amalgam phase-down is feasible when supported by education, infrastructure, and legislative action.

National Measures in India

India has actively participated in mercury-reduction initiatives as part of its Minamata obligations. Several leading institutions have eliminated mercury thermometers and sphygmomanometers and significantly reduced amalgam use, retaining it only in select clinical situations where it is unequivocally indicated.[6] National recommendations advocate minimally invasive approaches, improved caries prevention, and preference for resin-based composites, glass ionomer cements, and bioactive alternatives. Special emphasis has been placed on reducing amalgam use in pregnant and lactating women, children under 15 years, and patients with material sensitivities.[7] These directives represent an evolving shift toward safer and environmentally responsible dentistry across the country.

Best Management Practices for Mercury Handling and Waste Disposal

International bodies such as the WHO, ADA, and EPA emphasize on strict and best management practices (BMPs) for safe amalgam use. Encapsulated amalgam is strongly recommended to eliminate the hazards associated with bulk mercury handling. During placement or removal, high-volume suction, adequate operatory ventilation, and rubber dam isolation significantly reduce mercury vapor exposure.[7,8] Extracted teeth with amalgam, used capsules, and chair-side trap debris should be collected in airtight, labelled containers and transferred to authorized recyclers. Amalgam separators, which remove up to 95% of particles from dental wastewater, form a critical component of waste management and are legally mandated in several countries. Conversely, unsafe practices such as disposing of amalgam in general waste, rinsing contaminated instruments in sinks, or using chlorine-based line cleaners substantially increase mercury release and must be discontinued.

Challenges in Implementation for Public and Private Dental Settings

Despite established guidelines, many dental institutions—particularly in developing countries—face challenges such as limited financial resources, high patient volume, lack of amalgam separators, inconsistent training, and inadequate enforcement of biomedical waste management regulations. Public hospitals serving low-income populations may still rely on amalgam due to its affordability and reliability, especially in situations where moisture control is compromised. Private practitioners may also underestimate the environmental implications of improper waste disposal. To address these challenges, institutions must prioritize training, periodic audits, installation of amalgam separators, and integration

of mercury hygiene into undergraduate and postgraduate dental curricula.

CONCLUSION

The shift toward mercury-free dentistry is driven by compelling scientific evidence, global environmental commitments, and ethical responsibility. Although dental amalgam continues to offer advantages in selected clinical situations, its use must be judicious and accompanied by strict adherence to mercury hygiene and waste disposal protocols. Strengthening policy implementation, improving professional training, and adopting environmentally responsible practices are essential to ensure a safe and sustainable future for dental healthcare.

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