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End of an era or a premature goodbye? Dental amalgam's place in the curriculum

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ABSTRACT

Dental amalgam has been a restorative material in dentistry for over a century due to its durability, cost-effectiveness, and ease of placement. However, growing environmental concerns over mercury content, combined with advances in alternative restorative materials, have prompted a global shift in its clinical use. International regulations, such as the Minamata Convention on Mercury, have influenced dental schools to re-evaluate amalgam teaching within their curricula. This article explores the current role of dental amalgam in dental education, examining trends in teaching practices, student competency requirements, and the balance between clinical training and environmental concerns. A literature review of restorative dental training highlights significant variation in amalgam teaching across institutions, including South Africa. The review highlights the importance of integrating environmental sustainability, evidence-based material selection, and patient-centred care into restorative dentistry education. Recommendations include curriculum adjustments to ensure that dental graduates possess foundational knowledge of amalgam's properties, clinical indications, and safe handling protocols while prioritising minimally invasive techniques and mercury-free alternatives in alignment with global teaching trends. Are South African dental institutions adequately prepared for a complete phase-out of dental amalgam? This is a narrative review that summarises the existing research, including the author's research.

Keywords

Dental amalgam, dental education, dental schools, resin composite, mercury

INTRODUCTION

Dental amalgam is a widely used material for restoring teeth due to its durability, strength, and low cost. However, dental amalgam contains mercury, a toxic heavy metal that poses a risk to human health and the environment. Improper handling and disposal of dental amalgam waste can lead to the release of mercury into the air, water, and soil, potentially harming ecosystems and human health. Mercury exposure can cause various adverse health effects, including neurological and developmental disorders, respiratory problems, and kidney damage. Additionally, mercury can accumulate in the environment and bioaccumulate in aquatic organisms, potentially harming ecosystems.[1] Managing dental amalgam use and waste properly is crucial for minimising the potential risks linked to mercury exposure. Chronic mercury exposure was associated with neurological symptoms (memory loss, anxiety, depression, tremors), renal dysfunction, and oxidative stress. Mercury's neurotoxic and cytotoxic effects were linked to damage in proteins, DNA, and cell membranes. Dental professionals consistently showed higher mercury levels in urine, blood, hair, and nails.[2]

The Minamata Convention on Mercury is an international environmental treaty established to protect human health and the environment from the adverse effects of mercury. It is named after the city of Minamata, Japan, where severe mercury poisoning occurred in the mid-20th century due to industrial pollution. This convention was adopted in October 2013.[3] Following the Minamata Convention, it is worth noting that ongoing discussions and initiatives have been taking place globally, including in South Africa, regarding the potential phase-down or phase-out of dental amalgam due to environmental and health concerns associated with mercury. The South African Dental Association (SADA) has recognised the need to properly manage dental amalgam use and waste, to minimise mercury exposure and its environmental impact. SADA encourages dentists to follow best practices for amalgam handling. These include using amalgam separators to capture and dispose of amalgam waste in a safe and environmentally responsible manner. The International Association for Dental Research (IADR) further affirmed the use of dental amalgam for the general population without allergies and renal diseases. It states that it should be available as the best restorative option when alternatives are less than optimal for clinical, economic, or practical reasons. In addition, IADR supports the phase-down approach and increased prevention to reduce the need for restorative care.[4] The World Health Organisation (WHO) supports the phase-down as well as the phase-out approach. At the country level, policymakers need to implement measures recommended by the Minamata Convention, with clear timelines and a stepwise approach, to protect both our environment and health.[3]

Several studies have investigated the use and management of dental amalgam in different countries. In South Africa, dental amalgam is widely used; however, its use in both the public and private sectors is declining as tooth-coloured restorations gain popularity.[5] This trend is observed in Australia, New Zealand, Brazil, and the United States. Some countries that have banned or imposed restrictions on the

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use of dental amalgam include the European Union, Norway, Sweden, Finland, Denmark, the Netherlands, and Japan.

According to the British Dental Academy (BDA), alongside the Council of European Dentists (CED) and the FDI World Dental Federation (FDI), the BDA has maintained that dental amalgam, alongside other restorative materials, must remain available as one of the tools in the armoury of the dental profession for the repair and maintenance of damaged teeth. The BDA advocates that the treating clinician is best placed to discuss the available options with the patient and to obtain valid consent for the treatment offered. Whilst alternative materials do exist, none currently fully replicate the clinical and economic effectiveness of amalgam. BDA further agrees with the Minamata Convention and the World Health Organisation (WHO) that additional research is needed on the health and environmental impacts of new restorative materials.[6]

The teaching and training trends of dental amalgam globally

United Kingdom

The British Dental Association policy statement on amalgam use is 'No use of amalgam in the treatment of deciduous teeth; in children under 15 years; or pregnant or breastfeeding women, except when strictly deemed necessary by the practitioner, or on the grounds of specific medical needs required by the patient'.[6]

It was found that students in the UK and Ireland gain more experience in placing posterior composites than in placing dental amalgam. This shift in the teaching trend is due to the growing emphasis on minimally invasive dentistry.[7] A study found that the first pre-clinical skills experience in the restoration of posterior teeth is now with resin composite material, rather than amalgam, for the majority of students.[8] It is further anticipated that the future generation of dentists and dental therapists who join the dental professional workforce will be more skilled in placing composite restorations rather than amalgam. This would mean that this generation of practitioners will be more conservative in their approach to cavity design. The old approach of GV Black's, "extension for prevention," should now be transformed into a more prevention-oriented, patient-centred approach. In most UK dental schools, amalgam placement is no longer taught on child patients.[7] However, in the latest research emerging from the United Kingdom, the consensus is that there is a disparity between what is being taught at universities and the real-world demands. A study conducted by Jebur *et al.* in 2023 highlighted the fact that 'dental schools need to be aware that amalgams are used more frequently by graduates than anticipated and that they perceive themselves to be under-prepared in the use and placement of amalgam restorations. The clinical and educational impact of this understanding is that undergraduate dental curricula should take steps to improve the knowledge and practical skills of dental students in placing amalgams to better prepare them for real-world practice and ensure safe practice.'[9]

America

The American Dental Association policy statement confirms that dental amalgam is a safe, durable and affordable material that has been used to restore the teeth of over 100 million Americans.

According to a study by Ben-Gal *et al*. (2011), posterior composite resin restorations now outnumber amalgam restorations in the United States.[10] It further stipulates that dental faculties should define criteria, based on up-to-date clinical studies, for using new materials.

A study conducted in North America among 33 dental schools assessed whether dental schools are adapting their curricula to align with current trends in dentistry and what rationale supports this adaptation. This study determined whether amalgam or resin composite is being used more frequently to restore posterior teeth. The study revealed that there were no clear guidelines for cavity preparation of composite restorations, compared to the explicit guidelines for preparing amalgam restoration cavities. Dental schools will benefit when a clear consensus is reached.[11]

A further study, published in June 2019, examined the transition of pre-clinical paediatric dental clinics from amalgam to other restorative dental materials. This study, conducted among 44 dental schools, revealed that US dental schools were not ready to phase out dental amalgam training. It highlighted that amalgam is still widely used in paediatric predoctoral training as a restorative material for both primary and permanent teeth.[12]

Asia

This third edition of the Position Statement on the Use of Dental Amalgam was adopted by the Malaysian Dental Council (MDC) on 13 January 2020. The Position clarifies the policy of the MDC on the use of alternative restorative materials, compared to dental amalgam, and recommends best practice in the management of restorative materials.[13]

In a 2020 study conducted in Malaysia, among final-year dental students, it was revealed that more students chose tooth-coloured restorations over amalgam, with the primary reason being the conservation of tooth structure.[14]

A study conducted in Lahore, Pakistan, aimed to evaluate dentists' attitudes towards posterior composite restorations, specifically regarding case selection and concerns. It was found that the conservation of tooth structure and aesthetics were the primary reasons for selecting posterior composites.[15] Dental amalgam seems to be less frequently used among Saudi dentists. Recent dental graduates used amalgam less frequently compared to experienced dentists. Aesthetics and patients' desires were found to be the major reasons for restricting the use of amalgam amongst participants.[16]

A study conducted in India in 2023 found a clear shift away from amalgam towards composite resins. This shift was driven by concerns regarding mercury toxicity, as well as a general trend towards aesthetic tooth-coloured restorations.[17] Countries can play a key role in the Phase-down of dental amalgam use by requesting cooperation from dental schools. Dental schools can be encouraged to develop curricula that train students to use mercury-free alternatives, provide continuing education for those already in practice, and educate current and future dentists about the environmental impact of amalgam.[18] In some countries, dental schools have adopted these criteria into their curricula.[18]

In Japan, the teaching of dental amalgam restorations is no longer emphasised in the educational system.[17] This was probably due to the fear that gripped the Japanese nation after the Minamata poisoning incident in the mid-1950s.

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Europe

The European Union policy statement on the use of dental amalgam is as follows: 'to reduce the use of mercury-added products in line with the intention of the Minamata Convention, and that the first material used in the treatment of deciduous teeth and pregnant women, alternate materials to amalgam should be the first choice'.[19]

In Sweden, amalgam teaching was not carried out for many years before its ban. To reduce spills and exposure, mercury hygiene was emphasised. Pre-encapsulated amalgam was used. Dental schools have since demonstrated the efficacy of mercury-free alternatives and can also provide information on best management practices.[20] In Denmark, dental schools are actively collaborating in efforts to phase out amalgam. The use of mercury-free alternatives is part of the dental school's obligatory training.[20] In the Netherlands, dental schools stopped teaching the placement of amalgam between 1995 and 2005.

In the EU, the majority of professionals (70%) and students (60%) believe dental amalgam poses some health risks to patients. Dentists (32.9%) and students (36.4%) reported moderate health risks to staff, with regional differences noted in these perceptions. Both groups suggested that professional organisations share more information on the safety and environmental impact of amalgam and mercury.[21]

Africa

Nigeria initiated a campaign called the Abuja Declaration in 2001, a civil society campaign aimed at eliminating the use of amalgam in Africa. This declaration's impact was felt throughout Africa, resulting in 'Africa Day' for Mercury-free dentistry, which is held annually on 13 October.22

One implementation of the declaration is to change the dental school curriculum to emphasise the use of resin composites, glass ionomers and other minimally invasive and amalgam-free restorative materials. It aims to de-emphasise the teaching of amalgam and thereafter phase out instruction in amalgam. The declaration aims to provide training in mercury-free restorations to older dental practitioners.[23] Some of the other policy measures that Africa has promoted are to stop the placement of amalgam restorations in children and females of child-bearing age, not just pregnant or lactating women, by 2020. This was stipulated in the Tanzanian guidelines.[23]

According to a study conducted in Ibadan, Nigeria, it was found that amalgam, as a choice of restorative material, is gradually being replaced by composite.

In African countries, such as Uganda, Kenya, and Tanzania, it has been found that the phase-down of amalgam is feasible if dental schools adhere to specific guidelines. These include creating awareness of the environmental risks associated with dental amalgam, promoting alternatives to dental amalgam, emphasising oral health promotion to reduce caries (thereby avoiding the need for restoration), supporting best management practices, and environmentally sound waste management.[23] In a baseline study conducted at a Nigerian dental school in 2016, prior to the implementation of the Minamata phase-down policies, it was found that almost 60% of all restorations placed are mainly dental amalgam. Two of the recommendations further made in the study were that more emphasis should be placed on MID (Minimal Invasive Dentistry) and mercury-free dental materials.[24]

South Africa

The South African Dental Association (SADA) supports the call for a gradual phase-down in the use of dental amalgam as a restorative material. SADA supports the call for more research to be conducted on suitable alternative materials that are comparable to amalgam.[25]

It was stated that developing countries will face challenges in phasing down amalgam due to the lack of comparable alternative restorative materials. However, following ratification of the Minamata Convention, a phase-down of dental amalgam is necessary to reduce mercury exposure. It was recommended that oral health care practitioners promote the use of alternative materials such as composites, glass ionomers, and ceramics, especially in occlusal cavities and deciduous teeth; employ best management practices for the safe disposal of amalgam, offer more oral health education on preventing caries, and support more research on the discovery of suitable alternative restorative materials.[26] In a study carried out at a dental school in 2017, it was found that 'dental amalgam is no longer the preferred material for the restoration of posterior teeth in the South.[27] Resin composite was the most widely used material to repair or replace defective amalgam restorations.[27] In a study at a dental school that was conducted in 2023 by Essa *et al*, it was concluded that 'while the pre-clinical and clinical teaching requirements of amalgam restorations have been decreased at all universities, the economic climate in South Africa is not conducive to a complete phase-out of amalgam restorations.[28] Thus, the complete phase-out of amalgam restorations is unanimously discouraged due to affordability concerns for the masses.' This coincides with the findings of a study conducted in 2021 by Bissoon and Moodley, which found that 'the dental curriculum should be reviewed to ensure that the university keeps up with international trends while still considering the economic climate of South Africa.'[29]

DISCUSSION

The teaching of dental amalgam is continuing. However, the emphasis now placed on amalgam is either equal to or less than that on dental composite. Recent systematic reviews continue to show that dental amalgam remains a safe and durable restorative material, with no consistent evidence of clinically significant adverse health effects and strong long-term performance in posterior restorations.[30-31] This is further affirmed by both the American Dental Association (ADA) and the South African Dental Association.[25] The use of amalgam material is suitable for areas that are not aesthetically demanding and for surfaces that require extensive tooth restoration, which may include one or more cuspal surfaces. In the mid-1990s, amalgam was the material of choice for posterior restorations. However, by the late 1990s, resin composite was becoming the predominant choice of material in the teaching of posterior restorations. This trend continues to the present at dental schools, according to a study by Essa *et al* (2023)[28] The reason for this shift is that newer composite materials are found to be longer-lasting and more durable compared to earlier composite materials.[32] The teaching of dental amalgam is declining in most dental schools in the United States and Europe, with a greater emphasis being placed on composite materials in their pre-clinical laboratories and clinics.[33] Additionally, it was found that dental practitioners with more than thirty years of experience in dentistry often lack extensive experience in the placement of adhesive materials.[34] In 2019, a study conducted in Turkey revealed that composite has replaced

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amalgam in the dental curriculum.[35] A review conducted by Burke (2004) showed that in North American dental schools, the trend is toward the greater use of resin composites.[36] However, there is a greater emphasis on dental amalgam for Class II cavities. A recent study conducted in Canada by Khodayari *et al* in 2023 found that 'later dental graduates and private practitioners reported decreased amalgam use.'[37] As amalgam remains a safe and effective dental material, its removal may not be prudent. Dental educators play a crucial role in the future of amalgam opinion and use.

European dental schools have shown a shift towards resin composites. A 2006 study highlighted that 60% of dental schools used resin composite for Class II restorations in their teaching. A study in Australia revealed that the use of dental amalgam in dental training had decreased from 58% to approximately 23% (Burke, 2004).[38] A more recent study in Australia found that the use of dental composites increased by 1.4% per year from 2010 to 2019, compared to a 30.2% decrease in the use of dental amalgam.[39]

A South African government gazette published in March 2025 highlighted the regulations regarding a phase-down approach to dental amalgam.[39] This was promulgated by the Department of Environmental Affairs, Forestry and Fisheries (DEFF). The purpose of these regulations was to ensure the environmentally safe management of mercury, to establish measures for the phase-down and phase-out of mercury-added products, to regulate the manufacturing process of mercury products, and to regulate the manufacture of mercury stocks. These regulations stipulate that, concerning dental amalgam, the following regulations must be adhered to: dental amalgam must only be used in a pre-encapsulated form not exceeding 0.58 ml. Any facility using dental amalgam must be equipped with amalgam separators for the retention and collection of amalgam particles, as specified by the manufacturer's instructions. These separators must be installed in all facilities by 01 April 2026, and ensure a minimum retention level of at least 95% of amalgam particles. Another specification is that no practitioner should release dental amalgam into the environment under any circumstances (FDI World Dental Federation.[40]

These regulations will have a direct impact on the teaching and practice of dental amalgam in training institutions, as many institutions lack amalgam separators.

A dental amalgam symposium was held in March 2025, featuring dental schools from South Africa. Representatives from five schools participated. The concerns raised were the environmental impact of dental amalgam and the lack of dental amalgam separators at dental schools. The participants agreed on the Phase-down approach to dental amalgam, as most institutions have decreased their use of dental amalgam and are now using more resin-based restorations. This finding aligns with a 2021 study conducted at a dental school in KwaZulu-Natal, South Africa, which revealed that training with resin composites accounts for more than 50% of dental restorations placed by students.[5]

CONCLUSION

Dental amalgam use remains prevalent globally, including in South Africa, but there is an increasing shift towards resin-based materials as an alternative. Resin materials offer numerous benefits, including aesthetically pleasing tooth-coloured restorations, adhesive bonding, and a reduced environmental impact, which contributes to their growing popularity in dental practice. The implementation of Minamata Convention policies reveals a distinct difference in amalgam use, which is based on countries and income status. The higher-income countries exhibit more vigorous implementation policies compared to lower-income countries.[3] Regarding the teaching and training of dental amalgam, three-quarters (74%) of high-income countries reported having regulations for dental amalgam waste disposal in dental facilities and dental schools. In contrast, a mere 10% of low-income countries reported this practice.[3]

Within the South African context, the integration of dental amalgam in undergraduate curricula varies across institutions. While some dental schools have begun to reduce the emphasis on amalgam, placing greater focus on composite resins and minimally invasive techniques, others maintain amalgam training, due to contextual needs, such as public sector demand, cost-effectiveness, and clinical applicability. This shift in curricular focus seeks to align local dental education with global trends and regulatory momentum toward the phase-down – and potential future phase-out – of mercury-containing dental materials.

This raises a pertinent question: Are South African dental institutions adequately prepared for a complete phase-out of dental amalgam, and how will they balance educational reform with the clinical realities of practice, particularly in resource-constrained settings?

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Conflict of Interest

The authors declare that they have no competing interests.

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The principal author (SB) contributed substantially to the conception and design, as well as the acquisition, analysis, and interpretation of the data. The co-author (RM) assisted with the discussion and literature review. All authors critically revised the article for its valuable intellectual content and approved the final version for publication.

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The Continuing Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

