

Accelerating the Phase Down of Dental Amalgam in Africa and Developing Economies: A 'Leapfrogging' Strategy

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ABSTRACT

This paper briefly reviewed the environmental-human impact of dental amalgam with reference to the recent decision of the minamata convention's 3rd conference of the parties to accelerate phase down of dental mercury amalgam. The emergence of minimum intervention dentistry (MID) as the evidence based 21st century approach to the management of dental caries was also high - lighted as well as the desirable properties of the ideal 21st century tooth filling material. A 'leapfrogging' dental mercury amalgam phase down strategy was advocated for Africa and other developing economies that took cognizance of the poor infrastructure for sorting, collection, transport and treatment of wastes generally and mercury wastes in particular. Short term and Long term 'leapfrogging' phase down strategies were discussed. Developing economies should develop oral health policies with prevention, promotion, integration, partnerships and focus on basic package of oral care (BPOC) as cornerstone principles in order to protect the health of their citizens. They should also put in place concrete plans to develop general and mercury waste management infrastructures in the near future. This is important if they are to protect their environment and the health of their citizens from environmental pollution challenges that may arise in the near future.

Keywords

Dental amalgam phase down, dental caries, minamata convention, conference of the parties, 'Leapfrogging'.

Introduction

In the developed world, caries is one of the most prevalent diseases with 91 percent of adults experiencing caries in their life time [1]. Forty percent of children have tooth decay by the time they reach Kindergarten [2].

Dental amalgam has been the main restorative material for repairing tooth decay from the 19th century up to the 20th and early 21st

centuries because of its low cost, ease of placement in the wet oral environment and a resistance to change by the dental community despite overwhelming scientific evidence of its potential for environmental and human toxicity and a better understanding of the etio-pathogenesis of the caries process arising from research reports of outstanding clinical and laboratory science investigators [3-7]. This coincided largely with the 19th and 20th century era of 'drill and fill' dentistry where the symptom of the disease (cavity) was treated rather than the causes of the disease [5-7].

Increasing concentration of mercury in the environment and the devastating experience with mercury poisoning in Minamata and

its potential adverse effects on human health led environmental experts to raise alarm [8,9]. This led to moves to have a globally binding instrument to control anthropogenic releases (the minamata convention on mercury in 2013) [10]. Initially, focus was on industrial processes (burning of coal, artisanal gold mining, cement and oil industries; but it was later realized that there were other sources of every day anthropogenic releases such as batteries, paints, soaps, creams as well as dental amalgam [8]. This was what resulted in moves to include such sources (eg dental amalgam) in the globally binding instrument [10]. While other mercury added products (batteries, thermometers, soaps and creams, blood pressure cuffs, pesticides and biocides, switches and relays) were immediately programmed to be phased out by 2020, dental amalgam was given a temporary relief with a progressive phase down approach [10]. As stated in the convention papers this was because it was realized that there will be need to develop and introduce mercury free alternatives, particularly in developing economies with substantial populations of underserved communities [10]. This was not meant to be a loophole for prolonged phase down as the minamata convention made provision for listing any mercury added product in Annex A after a specified period of progressive phase down [10].

Developing economies typically have poor technology, systems and infrastructures to manage wastes generally and mercury wastes in particular. They also have poor access to oral health by significant groups of their population [11]. However, there is little justification for continued use of dental amalgam in developing economies considering its environmental-human health impact and the emergence of minimum intervention dentistry as the holistic, evidence based, patient centered approach to managing dental caries in the 21st century [5-7].

This paper will propose and justify a 'leapfrogging' strategy to accelerate phase down of dental amalgam in Africa and other developing economies (with significant underserved populations).

Environmental – human health impact of dental mercury amalgam

Mercury occurs naturally in the environment. Its concentration has been increasing gradually over the years. In addition, human industrial and other activities have resulted in further releases of mercury into the environment (anthropogenic emissions) [8,9].

Dental amalgam is 41-50 percent mercury and is manufactured with varying proportion of silver, copper, tin and other alloys [12-14]. A recent report by Bengtsson and Hylander et al. [13] reported that high copper alloy dental amalgams emitted more mercury vapor than the traditional types manufactured and widely used prior to 1970. This the authors attributed to the fact that the mercury is not strongly bonded to the base or alloy metals. The copper fraction was increased with a view to improve its compressive strength and corrosion resistance [13].

Most of the mercury in dental amalgam used in dental clinics end up in the environment through the solid (municipal or hazardous)

waste and waste water streams. From the patient who has amalgam fillings, the pathway to the environment includes; through cemetery to soil and ground water; through crematorium to the atmosphere and through the toilets to waste water treatment [3]. In summary, when dental amalgam is used, mercury will be released to the air, water and land, and some of it will eventually be taken up in fish and other living things, including humans [3]. Inorganic Hg (from natural or anthropogenic sources) becomes toxic in the environment when it is converted to methyl mercury (MeHg) by sulphur-reducing bacteria and other microbes. Methyl mercury (MeHg) is a potent neurotoxin that can cause physiological, neurological, behavioral, reproductive harm to fish and wildlife [3]. It is also an efficient bio-magnifier, resulting in increasing concentrations of MeHg in the ecosystem as it moves from water and sediment, to phytoplankton and plants, aquatic insects, spiders, fish and wildlife. Certain ecosystem conditions (e.g. wetlands) can encourage the production and bioavailability of MeHg [3,8,9].

Occupational and patient exposure

Direct human mercury exposure can occur through hand-mixing of mercury and metal powders; drilling of old amalgam fillings, extraction of teeth with dental amalgam and solid waste disposal bins [3]. It can also occur through slow release of mercury from fillings already in place in the mouth and emissions into the clinic from clinic wastewater system. Mercury has been reported to be able to pass through latex gloves [3].

Mercury is toxic to virtually all systems and organs in humans. Methyl mercury is a potent neurotoxin that damages children's brain even before they are born [3]. Developing economies have poor infrastructure for handling wastes generally and mercury wastes in particular. There is no organized system for collection, sorting, transport, storage and disposal of dental amalgam wastes [11]. Advanced mercury waste disposal technologies such as stabilization and solidification plants, specially engineered land and rock fills and permanent storage in underground facilities are also either nonexistent or poorly developed. Furthermore, there is no organized system to collect and export mercury wastes to countries with the required technology/facility [15].

21st century Dentistry/minimum intervention Dentistry/materials for MID

Twentieth century dentistry was characterised by the 'drill and fill' approach to the management of dental caries. This approach has also been variously referred to as the surgical/restorative/engineering approach [16-18]. It is in this era that dental amalgam emerged as the filling material of 1st choice because of its high compressive strength, low cost and ease of application in a wet oral environment [16]. However, healthy tooth tissue is destroyed in order to enhance its retention as dental amalgam is a non-adhesive filling material. Furthermore, though it is said to be cariostatic, frequently there is recurrent decay at the margins of the amalgam restoration. The tooth is progressively weakened by the need to replace defective amalgam restorations that it will eventually fracture and will require further advanced restorative treatments (crowns and or root canal treatments) and at some point during

the lifetime of the patient. Ultimately the tooth will be extracted. This is the 'restorative-cycle-spiral' reported by Elderton et al. [19], 21st century caries research has revealed that caries when diagnosed early can be arrested or healed by the application of non-surgical/nonrestorative preventive treatments [20-27]. Minimum intervention Dentistry (MID) is the new philosophy of managing tooth decay with the goal of making the teeth healthy and functional for life [28].

MID is the oral physician model of managing tooth decay which is focused on early diagnosis, caries risk and activity assessments, prevention, active involvement of the patient and members of the dental team in oral health promotion and caries control, maximum preservation of healthy tooth tissues, repair rather than replacement of defective restorations and frequent recalls to re-evaluate caries risk, caries control and oral health outcome [29]. The concept of MID though mainly applied to management of dental caries, has applications in periodontology, oral rehabilitation and oral surgery [28].

Eight clinical strategies for implementing MID in a clinical setting in a resource challenged environment can be delineated from the publications of Featherstone et al. [20,21] Young et al. [22] Ismail et al. [23,28] Domejean et al., [24,25] Brostek and Walsh [26] Frencken et al. [27], Ismail et al. [23,28] and include:

- Early caries detection and risk assessment;
- Oral Health Promotion;
- Optimal caries preventive measures (both in the clinic and at home);
- Remineralization of demineralized enamel and dentine;
- Recall visits to re-evaluate caries risk, compliance with dietary, oral hygiene and lifestyle counselling and to evaluate caries control;
- Minimally invasive operative intervention;
- Repair rather than replacement of defective restorations; and
- Recall visit to evaluate oral health outcome.

Taking a cue from Frencken et al. [27] recommendation, the first five strategies should be implemented throughout a patients' lifetime and only when there is cavitation (failure of oral health maintenance) should a restoration be placed [29].

21st century Dentists will practice more like a physician and counsellor than a dental surgeon [28]. The modern mission of caries management is to promote oral health (preventing and reversing the carious process); preserve dental and oral tissues and restore only when indicated [22,23,25-28].

What restorative material is ideal for MID?

The goal of MID is to keep teeth (and all oral tissues) healthy and functional for life as no restorative material can adequately replace the physical, chemical and biological characteristics of the natural tooth tissues (enamel, dentine and cementum) [26,30]. The ideal MID restorative material should have the following characteristics [24-26,31,33,35]:

- It must act as a reservoir for apatite forming ions (Fluoride,

Calcium, Phosphate, and Strontium)

- It must be capable of ionic release to demineralized enamel and dentine; and
- It must have the ability to recharge apatite forming ions from saliva.

The biological activity and compatibility with oral tissues of 21st century restorative materials are more important than its compressive strength relative to that of enamel. The major manufacturers of solutions and materials for MID restore/repair/replace include GC Corporation [31], 3 M ESPE [32], Shofu [33], DMG GmbH (resin infiltration) [34], Pulpdent [35], Ivoclar Vivadent [36], and Advanced Dental Systems [37] to mention a few. Glass ionomer-based restoratives have distinct advantages over other materials for MID because of their unique properties which include [26,26,31,33]:

- Biocompatibility with residual dentine and enamel;
- Hydrophilic properties- therefore they can be placed in the wet oral environment without the need for strict isolation/ placement of a rubber dam (saliva is 99% water);
- It chemically bonds to enamel and dentine (no etching with acids required);
- It acts as ionic reservoir for apatite ions;
- It is capable of ionic exchange (of apatite ions) with demineralized dentine and enamel;
- It is capable of ionic recharge (of apatite ions) from saliva; and
- The restoration matures with time with increasing hardness in the hydrophilic oral environment.

New bioactive composite restorations (e.g. Beatifil[®] by Shofu and Activa[®] bioactive by Pulpdent[®]) without bisphenol are also being introduced into the market but are still rather expensive for developing economies [33,35].

Developing countries will need to remove import charges on high viscosity glass ionomer restoratives to ensure their widespread availability before placing restrictions on dental amalgam which will be discontinued worldwide shortly [11].

African group proposal for amendment of Minamata convention at COP3

COP 3 outcome and preparations for COP 4

Six African countries (Botswana, Chad, Gabon, Guinea Bissau, Niger and Senegal) submitted a proposal to conference of the parties of the Minamata convention on mercury (COP 3) to phase down dental amalgam by 2021 and phase out by 2024 "except where no mercury free alternatives are available." This generated heated debate at COP 3 with World Dental Federation (FDI), International Association for Dental research (IADR) and World Health Organization (WHO) and many countries vigorously opposing the move [38]. However, it should be noted that in the articles of the convention it was clearly stated that any party can bring a proposal to move an item from one article to the other; therefore, these countries were not doing anything extraordinary in submitting such a proposal. What is surprising is the strident

opposition (even with the exception clause) by those who vehemently opposed the proposal as premature and ill-timed. They were particularly concerned with its potential outcome on underserved communities in developing economies [38].

Preceding the COP 3 meeting in Geneva in November 2019, about 30 African countries met in Ghana and decided to support the proposed amendment [39]. However, it was significant that at the end of the meeting, COP 3 decided to accelerate phase down of dental amalgam [38].

As a result of this decision dental amalgam will now feature at COP 4 scheduled for October 31st to November 1, 2021 in Bali, Indonesia [38]. The ball is now in the courts of African and other developing economies to act on the 5 recommendations of COP3 and supply the necessary data and information to the secretariat of the Minamata convention (Figure 1).

Submission by the contact group on technical issues

The Conference of the Parties,

1. *Encourages* Parties to take more than the two required measures in accordance with Annex A, Part II, of the Convention to phase down the use of dental amalgam;
2. *Requests* the Secretariat to request information from parties on the implementation of any such additional measures taken by Parties related to Annex A, part II, of the Convention;
3. *Calls on* the Secretariat to request information from Parties and others on information pursuant to paragraph 7 of Article 4 by 1 July 2020;
4. *Requests* the Secretariat to compile the information received pursuant to paragraph 3, clearly identifying the sources of the information it contains, and provide that information to Parties no later than 1 December 2020;
5. *Requests* the Secretariat to prepare by 30 April 2021 an information document for the fourth conference of the Parties that contains the information received from Parties pursuant to paragraph 2 and the compilation of information from paragraph 4, respectively.

¹ The text of the present draft decision has not been formally edited.

Figure 1: COP 3 decided to accelerate phase down of dental mercury amalgam.

A ‘Leapfrogging’ Strategy for phase down/out of mercury dental amalgam in Africa and other developing economies.

Some developed economies in Europe and Asia (Norway, Sweden, Denmark, Japan etc.) have phased out dental amalgam over 10 years back [3]. Developed economies have well developed infrastructure for managing wastes generally and mercury wastes in particular [12]. In developed economies there is widespread installation of amalgam separators and systems to collect and treat mercury wastes from dental practices [40,41]. In contrast developing economies (particularly in Africa) lack the necessary infrastructure for general and mercury waste management. An organized system for mercury waste collection, sorting, transport, storage or treatment are frequently lacking [11]. The WHO recently reported that environmental pollution is responsible for 35% of the burden of human diseases in Sub-Saharan Africa compared to 25% worldwide [42]. There is therefore no justification for widespread installation of amalgam separators in Africa.

Hylander et al. [12] reported continuous emissions of mercury vapor from dental clinics despite the installation of separators. Obviously, separators cannot handle mercury vapor. Furthermore, Bengsston and Hylander [13] also reported increased mercury emissions from the so called improved (high copper) mercury

dental amalgam manufactured since the 1970s.

Therefore, much will be achieved by a speedy movement from phase down to phase out with dental training institutions as the focus for all ‘leapfrogging’ phase down activities [3,43]. African countries ‘leapfrogged’ telecommunications technology. There was no widespread installation of landlines before the deployment of 3G and 4G mobile technology (Figure 2) [3]. It is in this context that African countries should be encouraged and supported to adopt a ‘leapfrogging’ strategy to phase down/phase out dental amalgam (Figure 3). Dental amalgam restorations are directly inserted in a patients’ mouth frequently without informed consent unlike other mercury products phased out this year (2020) [44]. It has been reported that there is continuous emission of mercury vapor from this restoration throughout a patients’ lifetime with potential for direct toxicity to all organs and systems in humans [3,12,13]. However, some authorities cited by the American Dental Association have maintained that this has not been proven beyond reasonable doubt [40].

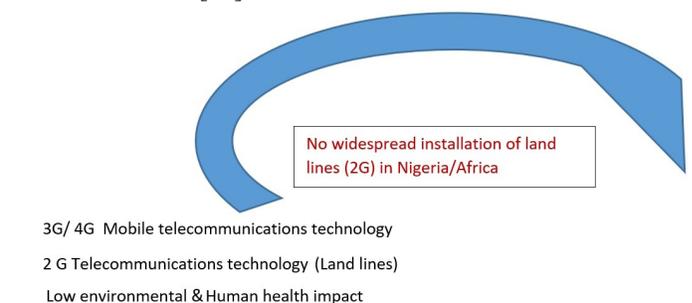
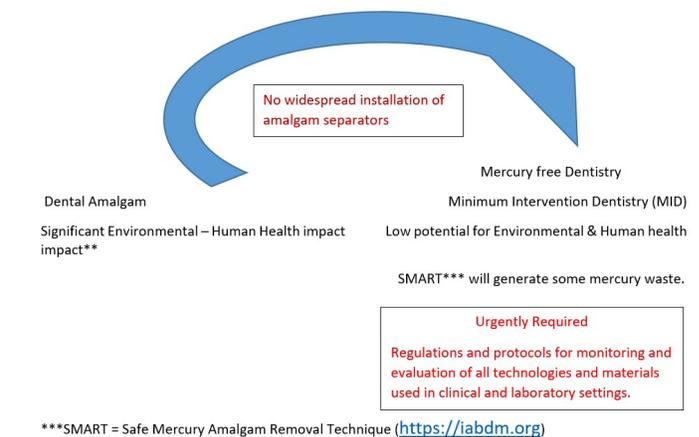


Figure 2: ‘Leapfrogging’ in telecommunications technology.



***SMART = Safe Mercury Amalgam Removal Technique (<https://iabdm.org>)

Figure 3: ‘Leapfrogging’ in mercury dental amalgam phase down.



Figure 4: Participants from 25 countries at the UN/World Alliance for mercury free dentistry workshop in Bangkok May 2018. The theme of the workshop was Promoting Dental Amalgam Phase Down Measures Under the Minamata Convention and Other Initiatives, For “Especially Women, Children and, Through Them, Future Generations.



Figure 5: Participants in a group photograph with Prof. Jo Frencken (seated 4th from Right) at the Mercury Free Dentistry Seminar & Curriculum Update Workshop, July 24th 2019, Abuja, Nigeria.

The essential components of a ‘Leapfrogging’ Strategy

The essential components of a ‘leapfrogging’ dental amalgam phase-down strategy for Africa and other developing economies can be grouped into two main categories [11,28]:

Short term strategies

- The frontline strategies;
- The supporting strategies;
- The Dental Faculties/other dental training institutions.

Long term strategies

- Prevention, promotion, integration and partnerships (PPI) as cornerstones of National Oral Health policy for Africa/developing economies
- The development of local capacity to manufacture high viscosity and hybrid glass ionomer / bisphenol free bioactive composite long-term restoratives.
- Future plans for establishment of a medical waste monitoring agency and waste management infrastructure.

The short- term frontline (immediate) strategies.

This consists of activities targeted at immediately phasing down dental amalgam. These activities should be implemented without delay:

- Draw up a national action plan;
- Adopt a timeline for non-use of dental mercury amalgam in vulnerable groups-pregnant/lactating women, children (1-15years);
- Update Dental school’s curricula (MID curriculum update);
- Secure custom duty waiver for high viscosity/ hybrid glass ionomer restoratives and other bioactive restoratives (bioactive composites);
- Modify insurance coverage to pay for minimum intervention dentistry and discontinue payments for dental amalgam.

- Secure funding to subsidize students’ training (400, 500 and 600 levels).
- Educate consumers and parents.

The supporting strategies

These are strategies that are meant to complement and enhance the seven frontline strategies in the long-term:

- Upgrade Simulation laboratories with ICT, Professors’ station and E-learning infrastructure
- Modify government programs
- Promote non-use in stand-alone government / armed forces dental clinics

The Dental Faculties / Teaching Hospitals as the focus for all phase down activities

At his presentation in Bangkok at the United Nations/World Alliance for Mercury Free Dentistry sponsored workshop in May, 2018 Arotiba [3] submitted that the dental Faculties should be the focus of all phase down activities in developing economies. He recommended that dental faculties should update their curricula, promote mercury free dentistry (MID) through regular workshops, conferences and seminars on mercury free dentistry and ensure that their clinics become mercury free as soon as possible (Figure 2). Arotiba also proposed far reaching recommendations with regard to the training of modern (21st century) dentists [3,11,43].

ICT and E-Learning enhanced simulation laboratories

An information and communication technology (ICT) enhanced simulation laboratory in the dental Faculties with Professors station and interactive smart board will facilitate e-learning and rapid dissemination of the principles and strategies of MID to both students and general dental practitioners in remote locations [3,11,43].

Long-term Strategies for phase down of dental amalgam for Africa and other developing economies. Prevention, promotion, integration and Partnerships (PIIP) as cornerstones of National Oral Health policy for Africa/developing economies.

Oral health policies of African countries and other developing economies should have as their cornerstones four principles of Prevention, promotion, integration and partnerships (PIIP) with focus on basic package of oral care (BPOC) [45].

BPOC consists of:

Oral Urgent Treatment

Oral Urgent Treatment (OUT) is an on-demand service providing basic emergency oral care.

The three fundamental elements of OUT are:

- Relief of oral pain
- First aid for oral infections and dento-alveolar trauma
- Referral of complicated cases.

OUT can be provided by trained non-dentist personnel.

Affordable Fluoride Toothpaste

Use of affordable fluoride toothpaste (AFT) is one of the most

important preventive measures in managing tooth decay. However, fluoridated toothpaste is often too expensive for disadvantaged groups in low- and middle-income countries.

Approaches to AFT aim at enabling everyone to clean teeth twice daily with quality fluoride toothpaste.

Atraumatic Restorative Treatment

Atraumatic Restorative Treatment (ART) [46] is a caries management approach, consisting of a preventive (fissure sealant) and a restorative component (restoration).

ART can be performed inside and outside a dental clinic, as it uses only hand instruments and a powder-liquid high-viscosity glass-ionomer, and requires neither electricity nor running water. It is relatively painless, minimizing the need for local anesthesia and making cross-infection control easier.

It is noteworthy that the restorative material recommended for BPOC is high viscosity glass ionomer long term restorative (e.g. Fuji IX GP). African governments should remove import duties and taxes on these types of restorative materials in order to make it more affordable and widely available [6]. This will be a significant development as it will render untenable the arguments of those advocating continued use of dental amalgam in poor developing countries for underserved communities [38].

Partnerships

Partnerships with all stakeholders in oral healthcare will be an essential component of the PPIP strategy to accelerate phase-down of dental amalgam. Stake holders will vary from country to country and even within the same country. Stakeholders should include dental professional associations, insurance and health maintenance organizations, ministries of environment, health, education, women affairs, agriculture, science and technology, chambers of commerce and industries, research institutes, university departments of chemistry etc.

Future plans

Africa and other developing economies have to develop a framework for regular monitoring and assessment of the environmental and health impacts of all technologies and materials used in clinical and laboratory settings [11]. They should not use the ‘leapfrogging’ strategy as an excuse for not planning to develop a framework for handling wastes in general and mercury wastes in particular. This is very important as environmental pollution is reported by WHO to be responsible for 35% of the burden of human diseases in Sub-Saharan Africa [42]. The development of such an infrastructure will enhance the management of environmental pollution issues that may arise in the near future and safe guard the health of their citizens.

Developing economies should also initiate policies that will lead to the local manufacture of high viscosity glass ionomer restoratives and other bioactive bisphenol free composite restoratives [11]. This will entail strengthening the dental material science units of the faculties of dentistry with the requisite trained staff and

equipment to enhance research into local sources of raw materials for the local manufacture of bioactive dental filling materials. Our research institutes also need to collaborate more with our universities departments, dental faculties and local chambers of commerce and industries in this regard [3,11,43].

Conclusion

‘Leapfrogging’ strategy for mercury dental amalgam phase down is a feasible and desirable strategy to adopt for Africa and other developing economies with poor infrastructure for managing wastes generally and mercury wastes in particular. This strategy will allow them to accelerate phase down of mercury dental amalgam and to plan to develop the requisite general and mercury waste handling infrastructures. The focal point for the ‘leapfrogging’ strategy should be the dental schools in order to train future generations of dentists and update the knowledge of general dental practitioners. In the interim period, a plan to collect, safely store and safely dispose of the residual mercury waste generated during the phase down period should be immediately implemented by the relevant government agencies. Furthermore, they should also plan to develop the requisite infrastructure for handling wastes generally and mercury wastes in particular. The Swedish chemical agency model is highly recommended (www.chemi.se) [46] for Africa and other developing economies if they are to safeguard the health of their citizens.

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