

Implementing Mercury Free Dentistry (Minimum Intervention Dentistry) in Dental Education in Africa and Developing Economies

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ABSTRACT

This paper highlighted the scientific rationale for the 4 major caries management systems/pathways (CaMPs) which paved the way for the emergence of minimum intervention dentistry (MID) as the evidence based, holistic, patient centered and prevention focused approach to managing dental caries in the 21st century. Clinical principles and strategies for implementing MID in dental education and practice were discussed and a new definition of MID proposed.

The GC Corporation minimum intervention treatment plan (MITP) was used as a template for the integration of outstanding features of caries management by risk assessment (CAMBRA), international caries diagnosis and assessment system and the international caries classification and management system (ICDAS-ICCMS) and Brostek and Walsh's minimum intervention dentistry in general dental practice (MIDGDP).

The outstanding features of the new integrated minimum intervention treatment plan (IMITP) were highlighted and proposed with a scoring system as a template for implementing MID in dental education and practice in Africa and developing economies. In addition, these outstanding features of IMITP were proposed for integration into CAMBRA and ICDAS-ICCMS-Caries care international-4D (CCI-4D) for an objective, patient centered and measurable evaluation of the outcome of counselling, preventive and restorative interventions of minimum intervention dentistry.

Keywords

Mercury free dentistry, 21st Century dentistry, Minimum intervention dentistry, Dental Education, developing economies.

Introduction

Dental caries is a biofilm-mediated, sugar-driven, multifactorial, dynamic disease that results in phasic demineralization and remineralization of dental hard tissues [1]. It is a complex biofilm disease which changes dynamically with its environment and the local chemistry of the tooth site, pellicle and saliva [2]. Twentieth century management of dental caries was dominated by the “drill and fill” approach. This has been variously referred to as the ‘surgical’ or ‘engineering’ or ‘restorative’ approach. This treated

the manifestation of the disease (cavity) rather than the causes of the disease and resulted in progressively larger cavities, more complex restorations, increasing costs (to both patients and the healthcare system), eventual loss of the tooth and poor oral health outcome [3-5].

Cariologists, therefore, began to investigate better ways of managing the burden of tooth decay. A better appreciation of the etio-pathogenesis of the caries process resulted in the development of 4 caries management systems /pathways (CaMPs) and the emergence of minimum intervention dentistry (MID) as the evidence-based approach to manage tooth decay in the 21st century. The goal of minimum intervention dentistry (MID) is to preserve

all oral tissues in a healthy and functional state for life [6-9]. While countries in the developed world (Europe, Australia, North America and Japan) have adopted the MID philosophy more than a decade ago, there has been a slow implementation of this philosophy in developing economies [10]. The worldwide agreement to phase down the use of dental amalgam (the minamata convention on mercury) due to its human and environmental toxicity has resulted in a new drive for developing economies to implement mercury free dentistry (minimum intervention dentistry) in dental education and in general dental practice [10,11].

The minamata convention on mercury listed one of the priorities as ‘encouraging representative professional organizations and dental schools to educate and train dental professionals and students on the use of mercury-free dental restoration alternatives [10,11].’

African countries met in Accra, Ghana on 30th October 2019 and decided on a time schedule for phase down (2020-2021) and phase out (2022-2024) of dental amalgam [12]. The European parliament voted in 2017 to phase down till 2030 [13]. This action was not surprising since Europe possesses the required finance and technology to manage mercury wastes [14]. In developing economies, organized systems for collecting, sorting, treatment and safe disposal of mercury generated from dental clinics are either poorly developed or absent. Dental mercury will therefore end up polluting the clinics, the air, soil, underground water systems, fishes and other aquatic foods; and methyl mercury will be taken up by humans particularly the most vulnerable groups –pregnant/lactating women and children from 1-15 years [15]. Developing economies can therefore not afford a prolonged phase down of dental amalgam [16]. Significant progress has been made by different African countries since the Abuja declaration on mercury in 2014; and 30 African countries have ratified the Minamata convention [12,17].

The objective of this paper is to present a cost effective strategy for implementing mercury free dentistry (minimum intervention dentistry) in dental education and practice in developing economies. It is our hope that this will enhance the acceleration of phase down of dental amalgam as recently agreed upon by the Minamata convention on mercury 3rd conference of the parties (COP 3) on 29th November 2019 in Geneva, Switzerland [18].

21st century dentistry (Minimum Intervention Dentistry - MID). There were some scientific reports during the 20th century which were not in support of the predominant ‘drill and fill’ approach to caries management which were poorly interpreted and ignored (for example the publications of Dirks et al 1961 [19], Massler 1967 [20], Mount 1991 [21], Dawson and Makinson 1992 [22], Fusayama 1997 [23] and Anusavice, 1998 [24]). The major findings of these reports include:

- Fluoridation of public drinking water reduces the occurrence of dental caries by 50%;
- The caries inhibitory action of fluoride can also be achieved by the application of high concentration of fluoride (varnishes)

on the tooth surface;

- The ‘drill and fill’ approach to the management of caries did not control the disease but resulted in the eventual loss of the teeth and;
- The need to move away from GV Black’s drill and fill restorative philosophy to the use of adhesive dental materials, remineralization techniques, prevention and monitoring of early carious lesions.

At the European festival of oral science held in Cardiff, Wales, UK in 2002, Dan Ericson, Edwina Kid, Dorothy McComb, Ivan Mjor and Michael J Novak outlined the principles of the emerging philosophy of “minimally invasive dentistry [3].” The authors highlighted the five principles of MID reported by Tyas et al in 2000 as consisting of [25]:

- Accurate diagnosis of risk, disease and lesions;
- Primary prevention;
- Just in time’ restoration;
- Minimally invasive operative procedures; and
- Secondary prevention.

Mjor and Eriksen in 2008 espoused one of the far sighted principles of mid: “The decision to place the first restoration in a previously unrestored surface of a tooth is a crucial event in the life of a tooth, because a permanent restoration in the true sense of the term permanent does not exist” [26].

Another cornerstone principle of MID is the preference for repair rather than replacement of defective restorations. Reports by Gordan et al. [27,28,29] and Moncada et al. [30] highlighted the following advantages of repair:

- Maintenance of the restorations original form thereby reducing or eliminating stress of the tooth;
- Damage to adjacent teeth is avoided;
- Repair prevents postoperative sensitivity as a result of re-exposure of dentinal tubules and;
- Repair avoids more complex restorations.

The challenge had been how to implement the new principles in dental practice and in dental education particularly in poor developing countries with significant populations of underserved communities. Four caries management systems/pathways emerged from different parts of the globe to promote the new approach to caries management- minimum intervention dentistry (MID):

1. North America

Caries Management By Risk Assessment (CAMBRA) developed and promoted by Featherstone, Andrew Young, V. Kim Kutsch and the California Dental Association/University of California, USA/ Canada (2002) [5,31-33].

2. Europe/Japan

(MITP) developed by GC corporation developed and promoted by By GC corporation Europe MID Advisory Board led by Sophie Domejean and others (2007) [6,34,35].

3. Australia

Caries Management System (CMS) developed and promoted by Evans RW et al. from the University of Sydney, Australia. (2008) [8].

4. United Kingdom/United States of America

International Caries Detection and Assessment System – International Caries Classification and Management System ICDAS-ICCMS was developed and promoted by Nigel Pitts, Amid Ismail and others from Kings College London UK and Temple University, USA respectively [8,36,37]. The caries care 4D cycle reported recently by Matignon et al. was developed from the ICDAS-ICCMS system [38].

Caries management system (CMS) is not concerned directly with the management of cavitated or symptomatic caries lesions other than recognizing their need for operative care [7]. It is also not concerned with the management of patients with acute rampant caries due to extreme salivary insufficiency [7]. In this regards CMS is not a complete caries management pathway as it made no specific recommendations for restoring cavitated lesions or repairing/replacing defective restorations. However, CMS has outstanding features/resources that will be indispensable for implementing MID in dental practice and in dental education. Such outstanding resources include a 24 hour snacking questionnaire, the plaque index of Silness and Loe, tooth decay information leaflet, oral hygiene instruction leaflet, bite wing caries rating scale, lesion management protocol, homecare, professional care and recall protocols [7].

Tyas [39] defined minimal intervention dentistry as an approach to the management of dental caries with the aim of minimizing the loss of tooth structure by disease or by iatrogenic intervention.

GC Europe MID Advisory Board defined Minimum Intervention Dentistry as “a holistic, patient-centered, evidence based approach to caries management with preservation of healthy tooth tissue [6,34,35].”

The guiding philosophy of MID is Kidds’ admonition that ‘restorative treatment (of early caries lesions) should be delayed to provide maximum possibilities for natural lesion repair and arrest [40].’ Domejean et al identified the six principles of MID as consisting of [6,34,35]:

- Early caries diagnosis and caries risk/activity assessment;
- Prevention;
- Re-mineralization of early caries lesions;
- Minimally invasive operative techniques;
- Repair of defective restorations; and
- Patient education and motivation (Oral health promotion).

Tyas et al. [39,41] pointed out that the aim of MID is to keep teeth healthy and functional for life and specified the following five strategies to achieve this objective:

- Early caries detection and risk assessment;
- Optimal caries preventive measures (both in the clinic and at home);
- Remineralization of demineralized enamel and dentine;
- Minimally invasive operative intervention; and
- Repair rather than replacement of restorations.

Frencken et al. [42] further reinforced Kidd’s admonition by explicitly stating that the first three of Tyas et al.’s [41] MID strategies (oral health maintenance-OHM) should be employed throughout a patients’ life time and only when oral health maintenance has failed (cavitation) should minimum operative intervention be employed. He further submitted that prevention is the cornerstone of MID (21st century dentistry) because dental caries is a chronic multifactorial, behavioral, lifestyle disease that requires diet, lifestyle habit and behavioral changes to reduce risk factors [41].

The integrated minimum intervention treatment plan (IMITP) - (Figure 1).

The GC Corporation minimum intervention treatment plan (MITP) framework is a simple approach for implementing MID in dental education and practice in resource challenged practice environments [6,34,35]. However, additional features from other CaMPs and publications should be incorporated as follows (Figure 1):

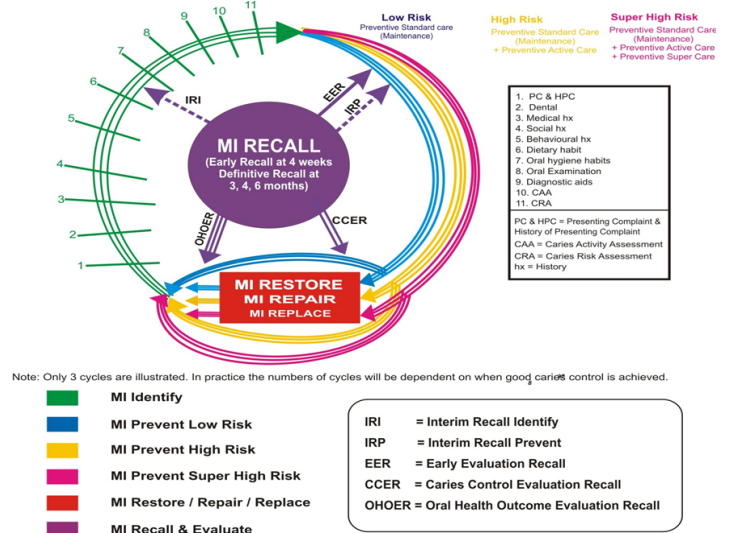


Figure 1: The integrated minimum intervention treatment plan (IMITP).

- Color – coding of the 4 phases of MITP –MI identify (green); MI prevent –low risk (blue); MI prevent –high risk (yellow); MI prevent- super high risk (pink); MI Restore/repair/replace (red) and MI recall and evaluate (purple) [39];
- Integration of the 3 risk assessment levels -low (low and moderate), high (high) and super high risk (extreme high risk) [31-33];
- Integration of Brosteck and Walshs’ early evaluation recall with a rating scale and (43);
- Integration of ICDAS-ICCMS caries control and oral health outcome evaluation recall also with a rating scale [37].
- The three rating scales (early recall, caries control and oral health outcome allowed an objective evaluation of progress or otherwise of the counseling, preventive and restorative treatments in dental practice and in dental education. The rating scales can also be deployed as instruments for the objective evaluation of students’ performance; and
- Furthermore, the ICDAS-ICCMS and American Dental

Association (ADA) tooth and site-specific treatment recommendations could be integrated into the IMITP framework [44].

From these integrated features emerged a new definition of minimum intervention dentistry (MID):

‘MID is the ‘oral physician’ model of management of oral disease (dental caries inclusive) which is focused on risk assessment, oral health promotion, targeted preventive non-restorative treatments, maximum preservation of healthy oral tissues, active involvement of the patient and all members of the dental team in oral health promotion and disease control, and frequent recalls to re-evaluate oral hygiene, caries control, oral health outcome and minimally invasive restorations only when there is frank cavitation’.

The concept of MID though mainly applied to management of dental caries has applications in periodontology, oral rehabilitation, and oral surgery and will predictably permeate all specialties of dentistry in the near future [8].

For easy implementation of MID in dental practice and in dental education, 11 progressive clinical steps/strategies can be delineated [6,8,34,35,41-44]:

- Early caries diagnosis;
- Caries activity and risk assessments;
- Oral health promotion (dietary, oral hygiene and lifestyle counselling);
- Optimal targeted (risk adjusted) in-clinic caries preventive measures;
- Optimal targeted (risk adjusted) patient home care caries preventive measures;
- Remineralization of demineralized enamel and dentine;
- Early counselling evaluation recall (for high risk and super high risk patients);
- Caries control evaluation recall;
- Motivational counselling when indicated.
- Minimally invasive operative intervention (including resin infiltration for early proximal caries);
- Repair rather than replacement of defective restorations; and
- Oral health outcome evaluation recall.

The first 6 strategies are essentially equivalent to the first three of Tyas et al. [41] MID strategies (oral health maintenance) highlighted by Frencken et al. [42] as ‘life time strategies’ (oral health maintenance) essential for the control of tooth decay.

The Integrated Minimum Intervention Treatment Plan (IMITP) framework for clinical evaluation of students. From Figure 1 it is discernable that the assessment of students’ performance in clinical practice will involve close scrutiny of the 4 phases of the IMITP cyclical framework:

- MI identify;
- MI prevent;
- MI restore; and
- MI recall,

MI Identify

MI identify is essentially similar for the 3 major complete caries management pathways (CAMBRA, GCC MITP and ICDAS-ICCMS). This phase is the most critical phase as it is the foundation of MID approaches on which the caries risk assessment classification and targeted preventive non - surgical treatments are anchored. The essential components of MI Identify can be divided into 12 steps for easy implementation and assessment of student’s performance as follows [6,34,35]:

- Presenting complaint and history of presenting complaint;
- Dental history;
- Medical history;
- Drug history;
- Social history;
- Behavioral history;
- Dietary habit;
- Oral hygiene habits
- Oral examination;
- Use of diagnostic aids for early caries diagnosis;
- Caries activity assessment; and
- Caries risk assessment.

The terminal goal of MI identify is to classify patients into the appropriate risk level and implement appropriate targeted preventive non restorative, non-surgical therapeutic interventions both in the clinic (by the dental team) and at home (by patients) [6,34,35]. Faculties of dentistry in developing economies will need support financially to acquire simulation dental radiographic equipment for training students to competently take good bitewing radiographs prior to commencing clinical dental practice.

New early caries diagnostic technologies (e.g. fibre-optic trans-illumination-FOTI) [45] will also have to be introduced. Therefore, it is essential that the technical engineering features of FOTI be introduced to students during the simulation laboratory phase of training [45]. Herein lies a challenge for dental educators to design simulation models for early caries diagnosis. It follows that MI Identify should be heavily weighted in comparison with other phases of IMITP (30% is suggested as indicated in Figures 2 and 3). The fine details of the weighting should be left to each faculty in restorative and pediatric dentistry to decide.

MI Prevent(preventive nonrestorative, nonsurgical treatments)

Prevention is the cornerstone of MID because dental caries is a chronic multifactorial, behavioral, lifestyle disease that requires diet, lifestyle habit and behavioral changes to reduce risk factors [6,34,35]. Prevention should therefore also be heavily weighted in relation to the remaining 70% mark. In this regards we will suggest that prevention be allocated 30% as well. The targeted preventive treatments are grouped according to risk levels into three (Table 1) [6,34,35]:

- Preventive standard care (oral health maintenance-OHM) for low risk patients.
- OHM + Preventive active care (PAC) for high risk patients.
- OHM+ PAC + Preventive Special care (PSC) for super high-risk patients.

It is noteworthy that OHM is the only intervention recommended for low risk patients and is an essential component of high and super high-risk levels. Furthermore, in addition to OHM, PAC is also an essential component of PSC. For patients that do not have frank cavitation or defective restorations, all the dentist will need to do is implement targeted preventive treatments and recall the patient at intervals depending on risk level to evaluate caries risk, caries control and oral health outcome.

Low Risk	High Risk	Super High Risk
Preventive Standard Care –PSC (Oral health maintenance- OHM)	Preventive Active Care (PAC) Components of P.A.C. include: PSC (Oral health maintenance -OHM) + i. Professional Decontamination including; -Professional mechanical tooth cleaning (PMC); -Chlorhexidine mouth wash; -Excavation of caries infected dentine. - Transitional/stabilizing restorations ii. Remineralization therapies: -500ppm fluoride tooth paste; -fluoride varnish; -fluoride gel; -fluoride mouth wash; -Casein phosphopeptide-Amorphous Calcium Phosphate (CPP-ACP). iii. Fissure sealant application is indicated for temporary teeth, immature permanent teeth.	Preventive Special Care (PSC) (Salivary etiologic factors) Components of P.S.C. include: Oral health maintenance (OHM) + Preventive Active Care (PAC) + i. Counselling against the consumption of acidic drinks; ii. Management of anorexia/gastro-esophageal reflux disease; iii. recommendation of regular consumption of milk and cheese products to increase salivary PH; iv. Delayed tooth brushing after consumption of high sugar foods; v. The use of chewing gum containing xylitol or calcium amorphous sulfate (CPP-ACP). vi. Recommendation of mouth rinses and tooth-pastes containing baking soda; and vi. The application of sodium diamine fluoride (SDF).

Table 1: Targeted Preventive (nonrestorative treatments) [8,34,35,37].

MI Restore/Repair/Replace

The remaining 40% should be equally distributed between MI restore/repair/replace and MI recall and evaluate (i.e. 20% each). However, when there is no frank cavitation necessitating restore/repair/replace, the whole 40% should be allotted to MI recall and evaluate. This scenario will likely be most frequently encountered when students use high viscosity glass ionomer restoratives or bioactive long term hybrid restoratives (- Fuji IX GP Extra, Equia (GCCorp) [46], Amalomer (Advanced healthcare Ltd) [47], Ketac molar, Ketac nano (3M Espee) [48], Ionostar molar (Voco dental) [49], Rok (SDI) [50], Chemfil rock (Dentsply Sirona [51]) and Beautifil (Shofu) [52]) as a preventive transitional restoration in MI prevent for patients presenting with large carious lesions as frequently encountered in developing economies with poor oral health awareness and poor access to healthcare facilities.

However, whenever a medium viscosity glass ionomer is used as a transitional restoration, there will be need to replace the transitional restoration with a long-term restorative at the restore phase of the MITP [6,34,35].

The Minimum Intervention Treatment Plan Recall (IMITP Recall) (Figure 2)

The atraumatic restorative treatment (ART) with fissure sealing and minimally invasive restoration components should be incorporated into students simulation and clinical training in developing economies. ART is an integral component of the basic package of oral care (BPOC) recommended by the World Health Organisation for underserved communities in developing economies [53,54].

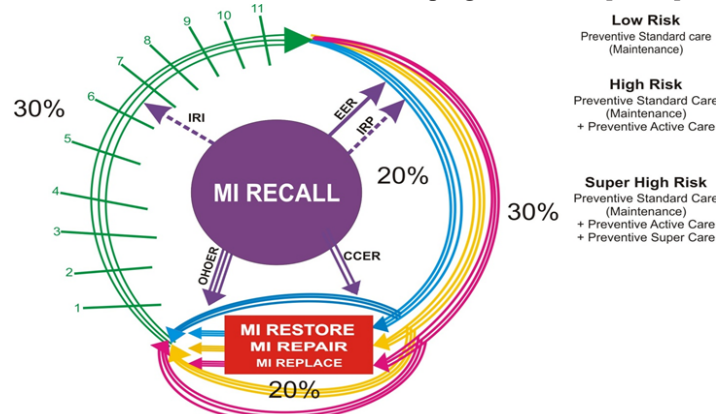


Figure 2: The IMITP students assessment scheme I (patients with cavitation).

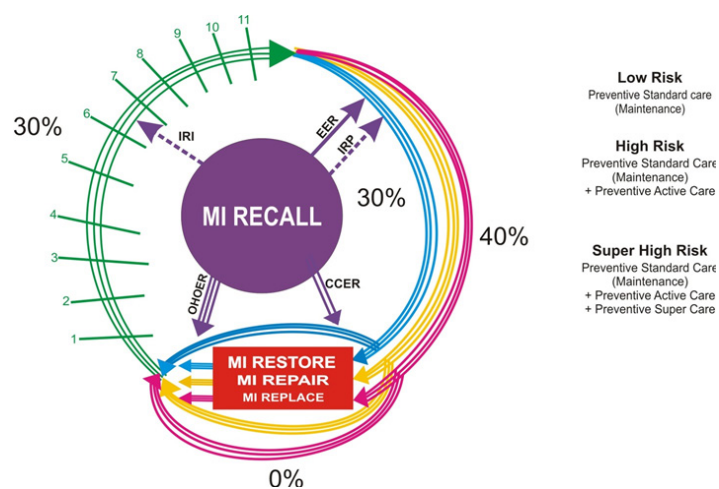


Figure 3: The IMITP students assessment scheme II (patients with no cavitation).

The Integrated minimum intervention Treatment Plan Recall –IMITP Recall (Figure 4)

Recall is a central, cornerstone principle of IMITP and is adjusted according to risk level. There will be two major types of recalls in IMITP: interim recall and definitive (evaluation) recall. Definitive recalls are IMITP recalls necessitated by the need to monitor progress or otherwise of the counselling, targeted preventive (non-surgical) treatments and the oral health outcome after completion of MI restore or replace or repair with long term restoratives. In this

regards objective (measurable) instruments (rating scales) were introduced for both dental education and general dental practice (Tables 1, 2 and 3) based on the ICDAS-ICCMS criteria [37].

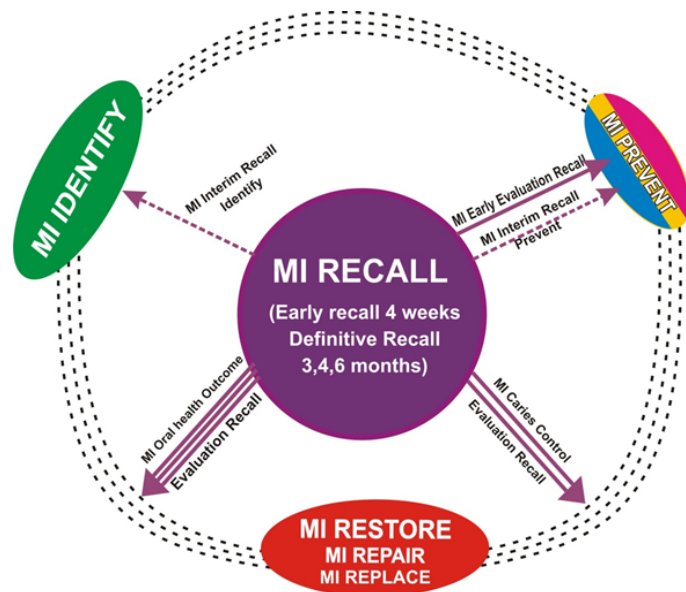


Figure 4: The Integrated Minimum Intervention Treatment Plan (IMITP) Recall.

Interim (non-evaluative) recalls are recalls necessitated by non-availability of requisite diagnostic (MI identify) or preventive (MI prevent) clinic solutions / consumables that will enable the practitioner to arrive at the appropriate caries risk assessment classification or complete the targeted in- clinic preventive treatments - e.g. non - availability of diagnostic MI identify solutions - e.g. Cariscreen [55] or expensive re-mineralization agents- e.g. Recaldent [56]. This may frequently occur in developing economies. Interim recalls may be evaluated but should not be billed.

The 3 evaluation rating scales for early recall, caries control recall and oral health outcome evaluation recall (Tables 2, 3, 4) will constitute the major weighting scores for the recall phase of IMITP. With regards to scoring, the proposed scores are as indicated in tables 2, 3 and 4.

	Good	Poor
Compliance with lifestyle counselling	1	2
Compliance with oral hygiene counselling	1	2
Compliance with dietary counselling	1	2
3 = Commendation & Encouragement		
4 - 6 = Repeat Counselling indicated (motivational counselling)		

Table 2: Early recall evaluation rating scale [37].

	No	Yes
White spot lesions / new caries / recurrent caries present?	1	2
↑ Plaque biofilm activity (acid production)	1	2
Grugival soft tissue inflammatory changes present?	1	2
3 = Good Proceed to MI Restore		
4 - 6 = Poor Continue the MITP cycle until good caries control is achieved		

Table 3: Caries control evaluation rating scale [37].

Health Promotion		
1. No. of sound teeth maintained sound	(↑ ~ ~ ~ ↓)	1 2
2. No. of previously treated teeth maintained free of new caries	(↑ ~ ~ ~ ↓)	1 2
Disease Control		
iii. Inactive versus Active lesions	(↑ ~ ~ ~ ↓)	1 2
iv. Stable Radiographically detected lesions	(~ ~ ~ ↓)	1 2
v. Change in number of teeth with PUFA	(↓ ~ ~ ~ ↑)	1 2
Patient Centered Quality Matrix		
vi. Patient satisfaction (good ; poor)		1 2
vii. Patient compliance with appointments (good ; poor)		1 2
viii. Reduction in Caries risk	(↓ ~ ~ ~ ↑)	1 2
ix. Patient compliance with OHI and Dietary Counselling (good ; poor)		1 2
X. Cost of care (↓ se ↑ se)		1 2
GOOD OUTCOME = 10 - 12		POOR OUTCOME = 13 - 18

PUFA = Pulp, Ulceration, Fistula and Abscess ↑ = increased ~ ~ ~ = unchanged ↓ = decreased

Table 4: Oral health outcome evaluation rating scale [37].

With the implementation of the philosophy of MID in dental practice and in dental education it is envisaged that the need for restorations and re-restorations (with the attendant increased cost of dental care) will be reduced. Only one principle of cavity preparation remains relevant. – “cavity should follow the outline of the caries lesion with maximum preservation of healthy tooth tissue [27,39].” However, resin infiltration technique and minimally invasive restorations (box, minibox, tunnel preparations etc.) will have to be integrated into simulation training sessions and implemented at clinical practice levels [3,57].

This proposed scoring system for students’ evaluation places less emphasis on restorative treatment and will teach the students to have a high threshold for ‘drill and fill.’ This is a very important attitudinal change that students need to embrace early to effectively practice 21st century dentistry as no current restorative material can competently reproduce the biological and physical properties of enamel and dentine [4,43]. Furthermore, students’ clinical requirements should be based on number of patients managed holistically through the MID phases and not on the number of

restorations placed. Faculties of dentistry in developing economies need to implement portfolio assessment without delay [57]. This will enable a holistic evaluation of the students' clinical practice.

Integrated caries management by risk assessment (ICAMBRA)

CAMBRA is the first risk based 21st century caries management system/pathway. It was first reported by Featherstone in 1999 [5]. CAMBRA identified disease indicators, protective and pathological factors and proposed the caries balance concept which determines whether caries progresses, halts or reverses [31,32,36]. Caries risk assessment (CRA) is an assessment of the risk of future caries by carefully weighing the disease indicators, risk factors against existing protective factors. 33 Many caries risk assessment forms are available but few has been validated and widely used like the CAMBRA CRA forms [31-33]. CAMBRA recognized the fact that conventional restorative approach alone will not control the disease and recommended appropriate non-surgical (chemical) preventive treatments [31-33].

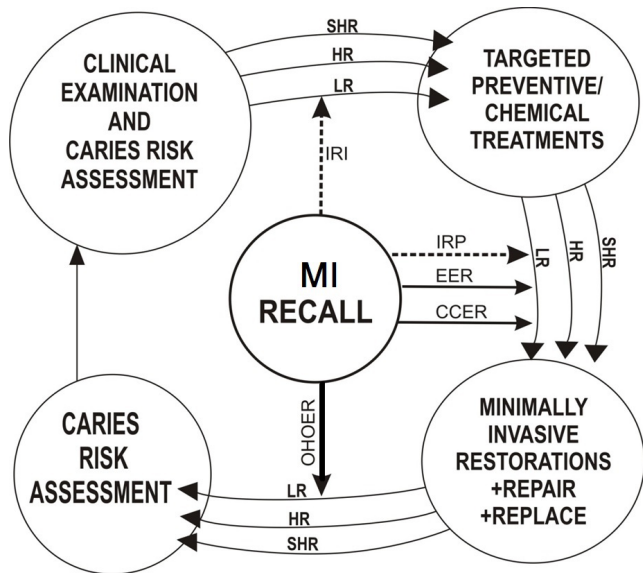


Figure 5: Integrated caries management by risk assessment (ICAMBRA).

In its simplest form, CAMBRA consists of 4 clinical strategies [5]:

- Assessing the risk for future caries lesions;
- Reducing the pathological factors;
- Enhancing the protective factors and;
- Minimally invasive restorative care.

For ease of implementation in a busy practice CAMBRA was reorganized into 5 phases: 32, 33

- Early caries risk assessment
- Clinical examination and caries risk and activity classification
- Targeted preventive (chemical) treatments
- Minimally invasive restorations and repair of defective restorations
- Risk adjusted recalls.

Integrated ICDAS-ICCMS Caries Care International 4 D (CCI 4D) - Figure 6

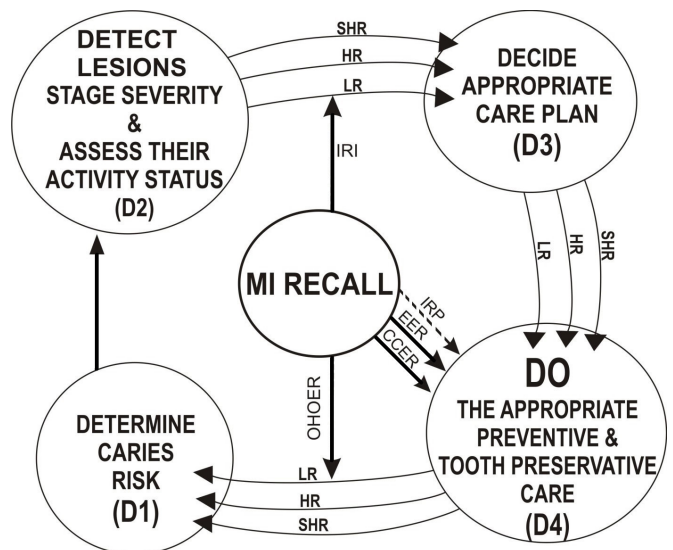


Figure 6: Integrated ICDAS-ICCMS caries care international (ICC-I-4D).

Caries Care International 4D (CCI-4D) was developed by Matignon et al. [38] from ICDAS-ICCMS caries management pathway. The objective was to simplify it for easy implementation in dental practice. CCI consists of 4 phases with a recall interval after the 4th D [38]:

- Determine (caries risk)-the first D
- Detect lesions, stage their severity and assess their activity status (the 2nd D)
- Decide appropriate care plan (the 3rd D) and
- Do the appropriate preventive and tooth preserving care (the 4th D).

IMITP evaluation recalls and the appropriate rating scales can also be integrated into CAMBRA (Figure 5) and ICDAS-ICCMS-CCI 4D (Figure 6).The integration of the rating scales constitute objective criteria for evaluation of progress or other wise of targeted preventive and restorative interventions in a holistic, patient centered, evidence based 21st century approach to the management of tooth decay in dental education and practice (Figures 2, 3, 4). Furthermore, tooth and site-specific treatment recommendations of ICDAS-ICCMS and American Dental Association can also be integrated into CAMBRA and CCI-4D [44].

Conclusion and Recommendations

Phase down of dental amalgam (‘dental mercury’) will have significant impact on dental education and practice in developing economies. Faculties of dentistry will have to move swiftly to update their curricula in order to train future generations of dentists in minimum intervention dentistry which is mercury free. This is important in order to protect their environment and the health of future generations. Dental faculties should be the foci of all phase down activities and should also lead the way in updating the knowledge and skills of general dental practitioners in minimum intervention dentistry through conferences, seminars and hands on workshops. The faculties of Dentistry should be specially supported by their respective governments and international

agencies with funds and equipment to fulfill these responsibilities. The time for action is now.

References

1. Pitts NB, Zero DT, Marsh PD, et al. Dental Caries (Primer). NATURE REVIEWS DISEASE PRIMERS. 2017; 3: 1-16.
2. Ismail A, Hasson H, Sohn W. Dental caries in the second millennium. J Dental Education. 2001; 953-959.
3. Ericson D, Kid E, McComb D, et al. Minimally invasive dentistry-concepts and techniques in cariology. Oral Health and Preventive Dentistry. 2003; 1: 59-71.
4. Elderton R. Principles in the management and treatment of dental caries. In: Elderton R editor The Dentition and Dental Care. 1990; 237-262.
5. Featherstone JD, Adair SM, Anderson MH, et al. Caries management by risk assessment: consensus statement. J Calif Dent Assoc. 2002; 31: 257-269.
6. Domejean-Orliaguet S, Banerjee A, Gaucher C, et al. Minimal Intervention Treatment Plan (MITP) Practical Implementation in General Dental Practice. J. Minim. Interv. Dent. 2009; 2: 103-123.
7. Evans RW, Pakdaman A, Dennison PJ, et al. The Caries Management System: an evidence-based preventive strategy for dental practitioners. Application for adults. Australian Dental Journal. 2008; 53: 83-92.
8. Ismail A, Tellez M, Pitts NB, et al. Caries management pathways preserve dental tissues and promote oral health. Comm Dent Oral Epidemiol 2013; 41: e12-e40.
9. Arotiba GT, Loto AO, Ijarogbe O, et al. Lessons from mercury dental amalgam phase down for developing economies. African Journal of Oral Health. 2019; 8: 29-39.
10. Julian Fisher, Benoit Varenne, Desire Narvaez, et al. The Minamata convention and the phase down of dental amalgam. Bull World Health Org. 2018; 96: 436-438.
11. Arotiba GT, Loto OA, Ijarogbe O, et al. Minimum Intervention dentistry in resource challenged practice environments. African Journal of Oral Health. 2019
12. <https://www.mercuryfreedentistsafrica.org/blog/cop3-african-region-push-dental-amalgam-phase-out-more-financial-support>
13. <https://noharm-europe.org/mercury-tracker>
14. Piper D, Duer J, Toda E. Practical source book on mercury waste storage and disposal. United Nations Environmental Program.
15. <https://mercuryfreedentistry.files.wordpress.com/2018/06/workshop-report.pdf>
16. <https://mercuryfreedentistry.files.wordpress.com/2015/04/abuja-declaration-for-mercury-free-dentistry-for-africa.pdf>
17. www. UNEP/MC/COP.3/CRP.19 29 November 2019
18. Backer Dirks O, Houwink B, Kwant GW. The results of 612 years of artificial fluoridation of drinking water in the Netherlands. The Culemborg experiment. Arch Oral Biol. 1961; 5: 284-300.
19. Massler M. Pulpal reactions to dental caries. Int. Dent J. 1967; 17: 441-460.
20. Mount GJ. Minimal treatment of the carious lesion. Int. Dent J. 1991; 41: 55-59.
21. Dawson AS, Makinson OF. Dental Treatment and dental health. Part 1. A review of studies in support of a philosophy of minimum intervention dentistry. Aust. Dent J. 1992; 37: 126-132.
22. Fusayama T. The process and results of revolution in dental caries treatment. Int Dent J. 1997; 47: 157-166.
23. Anusavice KJ. Criteria for placement and replacement of dental restorations. Fla Dent J. 1988; 59: 30-31.
24. Tyas MJ, Anusavice KJ, Frencken JL, et al. Minimum Intervention Dentistry-A review. Int. Dent J. 2000; 50: 1-12.
25. Mjoh I A, Holst D, Eriksen H M. Caries and Restoration Prevention. JADA. 2008; 139: 565-570.
26. Gordan VV, Garvan CW, Blasser PK, et al. A long term evaluation of alternative treatments to replacement of resin-based composite restorations: results of a seven year study. J Am Dent Assoc. 2009; 140: 1476-1484.
27. Gordan VV, Riley JJ III, Gorvan CW, et al. Alternative treatments to replacement of defective amalgam restorations: results of a seven-year clinical study. J Am. Dent Assoc. 2011; 142: 842-849.
28. Gordan VV, Mjor IA, Blum I, et al. Teaching students the repair of resin based composite restorations: a survey of North American dental schools. J Am Dent Assoc. 2003; 134:317-323.
29. Moncada G, Martin J, Fernandez, et al. Sealing, repair and refurbishment of class I and class II defective restorations: a three year clinical trial. J Amer. Dent Assoc. 2009; 140: 425-432.
30. Featherstone JD. The caries balance: the basis for caries management by risk assessment. Oral Health Prev Dent. 2004; 2: 259-264.
31. Kutsch V K. Dental caries: an updated medical model of risk assessment. The J Prosthet Dent. 2014; 111: 280-285.
32. Young DA, Featherstone JD, Roth JR, et al. Caries management by risk assessment: Implementation guidelines. J Calif Dent Assoc. 2007; 35: 799-805.
33. Domejean-Orliaguet S, Basso M, Miletic I, et al. 2009 MID booklet.
34. Domejean-Orliaguet S, Basso M, Miletic I, et al. MI Dentistry Handbook: A comprehensive guide to treatment plans and practice implementation of minimum intervention dentistry GC Corporation 2017.
35. Pitts NB. 'ICDAS': an international system for caries detection and assessment being developed to facilitate caries epidemiology, research and appropriate clinical management (editorial). Community Dent Health. 2004; 21: 193-198.
36. Ismail AI, Pitts NB, Tellez M. The international caries classification and management system (ICCMS) an example of a caries management pathway. BMC Oral Health. 2015; 15: 59.
37. Martignon S, Pitts NB, Goffin G, et al. Caries Care practice guide: consensus on evidence into practice. British Dental Journal. 2019; 227: 353-362.
38. Tyas MJ. Minimum intervention dentistry: Essential concepts. Thai Dental Association. 2009.

-
39. Ten Cate JM: Remineralization of caries lesion extending into dentin. *J Dent Research*.2001; 80: 1407-1410.
 40. Frencken JE, Peters MC, Manton JD, et al. Minimum Intervention Dentistry for managing dental caries – a review – Report of the FDI task group. *Int Dent J*. 2012; 62: 223-243.
 41. Brostek AM, Walsh LJ. Minimal Intervention Dentistry in General Practice. *OHDM*. 2014; 13: 285-294.
 42. Young DA, Featherstone JDB. Caries management by risk assessment. *Community Dent Oral Epidemiol*. 2012; 41: e53-e63.
 43. <https://www.mercuryfreedentistsafrica.org/blog/africa-cannot-afford-prolonged-phase-down-mercury-dental-amalgam>
 44. Tassery H, Levallois B, Terrer T, et al. Use of new minimum intervention dentistry technologies in caries management. *Aust. Dent J*. 2013; 58: 40-59.
 45. <https://www.gceurope.com/products/>
 46. <http://ahl.uk.com/index.php/products/amalomer>
 47. https://www.3m.com/3M/en_US/dental-us/
 48. www.voco.dental.us
 49. www.sdi.com.au
 50. www.dentsplysirona.com/en
 51. <https://www.shofu.com/en/products/restoratives/>
 52. Frencken JE, SongpaisanY, Pantumvanit P. Atraumatic Restorative Treatment (ART): Rationale, Technique and Development. *J Public Health Dentistry*. 1996; 56: 135-140.
 53. Frencken JE, Holmgren C, Helderma VP. WHO Basic Package of Oral Care (BPOC). 2002.
 54. Klutsch VK, Klutsch CL. Disease prevention: caries risk assessment. *Dentistry Today*. 2006: 1-6.
 55. www.recaldent.com/products/
 56. <https://www.dmg-dental.com/en/products/direct-restoration/restorative-materials/>
 57. Gadbury-Amyot CC, Overman PR: Implementing Portfolios as a programmatic global assessment measure in dental education *Journal of Dental Education* June 2018: 557-564.