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Caries management pathways preserve dental tissues and promote oral health

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Abstract – In May 2012, cariologists, dentists, representatives of dental organizations, manufacturers, and third party payers from several countries, met in Philadelphia, Pennsylvania, to define a common mission; goals and strategic approaches for caries management in the 21th century. The workshop started with an address by Mr. Stanley Bergman, CEO of Henry Schein Inc. which focused on the imperative for change in academia, clinical practice, and public health. For decades, new scientific evidence on caries and how it should be managed have been discussed among experts in the field. However, there has been some limited change, except in some Scandinavian countries, in the models of caries management and reimbursement which have been heavily skewed toward 'drilling and filling'. There is no overall agreement on a caries' case definition or on when to surgically intervene. The participants in the workshop defined a new mission for all caries management approaches, both conventional and new. The mission of each system should be to preserve the tooth structure, and restore only when necessary. This mission marks a pivotal line for judging when to surgically intervene and when to arrest or remineralize early noncavitated lesions. Even when restorative care is necessary, the removal of hard tissues should be lesion-focused and aim to preserve, as much as possible, sound tooth structure. Continuing management of the etiological factors of caries and the use of science-based preventive regimens also will be required to prevent recurrence and re-restoration. These changes have been debated for over a decade. The Caries Management Pathways includes all systems and philosophies, conventional and new, of caries management that can be used or modified to achieve the new mission. The choice of which system to use to achieve the mission of caries management is left to the users and should be based on the science supporting each approach or philosophy, experience, utility, and ease of use. This document also presents a new 'Caries Management Cycle' that should be followed regardless of which approach is adopted for caries prevention, detection, diagnosis, and treatment. To aid success in the adoption of the new mission, a new reimbursement system that third party payers may utilize is proposed (for use by countries other than Scandinavian countries or other countries where such systems already exist). The new reimbursement/incentive model focuses on the mission of preservation of tooth structure and outcomes of caries management. Also described, is a research agenda to revitalize research on the most important and prevalent world-wide human disease. The alliance of major dental organizations and experts that started in Philadelphia will hopefully propel over the next months and years, a change in how caries is managed by dentists all over the world. A new mission has been defined and it is time for all oral health professionals to focus on the promotion of oral health and preservation

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of sound teeth rather than counting the number of surgical restorative procedures provided.

> Embracing change is a quality that is necessary for survival in business and academia. The trigger that change is needed in the way we manage dental caries is the current high burden of this disease globally. The current methods are not enough and we need to develop new tools and approaches to combat the epidemic of dental caries.
>
> Stanley Bergman, CEO, Henry Schein Inc., Opening remarks at the Workshop

Dental caries is the most prevalent disease that has afflicted humans throughout history. The emergence of the current caries epidemic started in the late 19th century with the ubiquitous availability of processed sugar, the advent of food manufacturing and subsidies, as well as the marketing of sugared drinks and confectionery (1). The disease is not caused by a single factor but the interaction of several factors, some of which result in detrimental changes in bacterial ecology in the biofilm that adheres to the tooth surfaces (2, 3). The fermentation of mono-and, disaccharides, and cooked starch by some bacterial species in the biofilm is necessary but not sufficient alone to cause caries. The increase in acidity of the biofilm as a result of the fermentation of carbohydrates leads to a detrimental emergence of bacterial species that can survive in acidic environments and generate increased levels of acids through fermentation of carbohydrates (2).

Humans possess several defensive and protective mechanisms that can halt, reverse, or lessen disease progression. The emergence of the caries epidemic, especially in high-income and upper social classes of the 19th century, led to the rapid evolution of the field of restorative and surgical treatment of tooth structure destroyed by caries (1). The focus on dental restorative care continues to drive the management approach and reimbursement or incentive systems all over the world.

Throughout the 20th century, scientific evidence has accumulated on the limitation of relying only on a restorative approach to manage dental caries. The scientific evidence supports the proposition that risk-adjusted preventive strategies can manage dental caries by preventing the initiation, reversing early signs of caries, and preserving tooth structure (4, 5). Unfortunately, these approaches have not been widely adopted because the cultures of dental education, accreditation, licensing, dental practice, as well as reimbursement and incentive systems in most countries are still focused on rewards based on the number and complexity of restorative procedures. Moreover, unfortunately and paradoxically, the success of primary prevention using fluoride either in water, toothpastes or applied topically and the reduction in the prevalence and severity of dental caries in most of the developed countries has led to acquiescence in the quest to manage caries based on a medical or biological model (6). The success in caries prevention at the population level has influenced some policy makers to conclude that the caries problem is controlled and is less problematic than it was during the preceding several decades. This sense of success has had a detrimental effect on continuing the research and development of new strategies to control the major dental/oral disease in terms of cost. In the US alone, the total cost of treating dental caries and its sequelae is estimated to be around $60 billion annually (Dr M. Weitzner, United Health Care, Personal communication). This cost does not include the quality of life lost, the impact on morbidity and mortality, nor the burden imposed on children and population groups that do not have access to dental care and do not seek care at all.

Over the last decade, new philosophies or systems have been proposed for caries management that have similar focus but different emphasis on the caries-management cycle (7–15). These new approaches have been developed by a small cadre of committed researchers, educators, cariologists, and dentists. Moreover, new detection or diagnostic tools also have been developed and marketed. These new approaches have received some acceptance and adoption but neither did they have a revolutionary change in the reimbursement system nor in how dental students and dentists manage caries. It seems that new tools for detection of caries early before cavitation without appropriate education or revised incentives may lead to overtreatment because the same model of restorative-focused care with a new tool does not change how caries is being managed to employ remineralization and less-invasive treatment technologies. The focus on restorative management of caries

discourages research into new diagnostic and remineralizing technologies as well as the use of known remineralizing agents such as fluoride.

Given the state of division between science and practice in caries management and to leverage the energy of the different interest groups in this area, a workshop was held in May 2012 in Philadelphia that included a large group of researchers, clinicians, dental industrialists, and dental insurance representatives, among others. The workshop succeeded in defining new common mission and goals to change the way caries is managed. This report summarizes the conclusions of the workshop that was held at Temple University Kornberg School of Dentistry between May 29 and 31, 2012.

In this report, the editors are responsible for all content not authored by the key contributors who wrote sections describing their systems for detection, diagnosis, and management of caries. The editors did not change these sections because they reflect the systems as defined by their primary developers. The editors assume full responsibility for the content in all other sections.

Rationale for the caries management pathways (CaMPs) approach

As stated earlier, the debates among those who have focused on managing dental caries as a biological disease process have so far not resulted in any significant change, globally, in dental education and patient care. This outcome does not diminish the encouraging progress achieved in some areas; it merely underlines the scale of the problem in closing the science into routine practice–implementation gap. Each philosophy or system developed over the last two decades was not mutually exclusive from others, and each group has focused on promoting an approach toward caries management that was developed with thoughtful consideration by caries experts and has a foundation based on a particular perspective on current science. At the Workshop, as expected, agreement on one system seemed to be beyond the realm of the immediately achievable. Hence, the objective of the Caries Management Pathways workshop was to promote a new set of principles and goals for caries management that all approaches, including the current restorative-focused approach, should follow to achieve a new shared mission that focuses on promoting oral health through accurate diagnosis and appropriate treatment of caries based on available scientific information.

Caries management pathways: common mission

The mission of any current, new, or future caries management system must be to:

Preserve dental tissues first and restore only when indicated

This mission should guide all decisions from data collection, synthesis and diagnosis, through to preventive and restorative care. It will also guide the selection of dental materials and tooth preparation techniques and, most importantly, it should guide dental education and establish a scientific basis for reimbursement. To preserve tooth structure, any management approach must justify why tooth structure is removed surgically and why a restoration is placed. The detection of a caries lesion by itself must not automatically lead to a decision to restore it.

Caries management pathways: common goals

The new mission can only be achieved by adopting the following goals for caries management:

- Achieve and maintain dental health, prevent progression of existing initial lesions and restore moderate or extensive lesions by use of risk-adjusted clinical decision making.
- Minimize the use of surgical intervention.

These goals present the dental community in many countries with a radical departure from past and current approaches to restorative care that have been ingrained in the philosophy of drilling, removal of all stained tissues, pro forma cavity designs (that are not lesion-specific or focused on unique patient factors), and filling the newly created cavity.

Caries management pathways: guiding principles

To achieve the Mission and Goals, the CaMPs also require adopting and implementing the following risk-adjusted, patient-centered strategies in clinical

practice (population-based strategies are not covered in this document):

- Engage patients with activities focused on understanding the caries disease process and creating caries preventive and behavioral norms at home.
- Advocate and support efforts to reduce the promotion and sale of sugar-containing products like high-fructose corn syrups (HFCS) in drinks, snacks, and foods.
- Focus on supporting and reimbursing clinical primary (initiation) and secondary (arrest or reverse) preventive approaches.
- Follow the principles of minimally invasive surgical techniques.
- Develop and implement incentives to enhance the adoption of appropriate care of dental caries.

To achieve these goals, the following system (Fig. 1) was developed to describe the steps in any systems that aim to achieve the mission and goals of CaMPs.

This document focuses on the classification and activity status of caries lesions, individual caries risk assessment, as well as diagnosis and management. These steps can be performed using the different approaches described in this document. Diagnosis is a pivotal step in the process of caries management because it integrates information from assessment of medical, dental and social history, clinical staging of caries lesions; lesion activity, individual caries risk status, and additional data to develop management plan for the patient and tooth surfaces with the ultimate goal of preserving tooth structure and promoting oral health.

In CaMPs, the quality of care is not assessed by the quality of restorations but rather by the preservation and promotion of dental health which may be measured by the prevention and arrestment of any caries activity in an individual over a period of time. Quality of care should also be evaluated based on how future disease is prevented. These new outcomes should drive the design of new reimbursement/incentives models, in which the focus should be on preserving tooth structure and promoting oral health rather than replacing natural dental tissues with any restorative material.

Caries management cycle

To achieve the mission and goals, the management of dental caries should follow an iterative cycle, or a Caries Management Cycle that targets patients' risk factors that lead to the initiation and progression of caries, as well as management of carious lesions, which must be staged or classified based

Fig. 1. Caries management pathways, 2012.

on the extent of demineralization and tissue destruction.

The intersection between risk reduction at the patient level and lesion treatment at the tooth level is an area that has not yet been fully researched. This document contains opinions of experts, based on current scientific evidence in cariology on how to manage different stages of caries lesions in patients with different propensities to develop caries.

The Caries Management Cycle consists of the following steps which address both management of the disease at the patient level as well as the tooth level:

Patient assessment

Caries management starts with collection of information on the following domains:

— Personal data: Demographic, employment, level of education, and contact information.
— Chief complaint: Reason(s) why the patient is seeking care.
— Medical history: Medical conditions that can impact on the caries process, such as salivary diseases and use of medications, eating disorders, among others.
— Dental history: Previous dental care experience, regularity of care, and overall level of care.
— Fluoride history: Exposure to community water fluoridation, dietary fluoride supplements, fluoridated salt, fluoride toothpaste and professionally applied fluorides.
— Social history: Changes in lifestyle that may impact on dietary intake (e.g., moving to study at a college; unemployment).
— Behavioral status and Anxiety level: Is the patient anxious about receiving dental care?
— Dietary screening: Frequency of exposure to sugary drinks and snacks.
— Care practices at home: frequency of brushing [with fluoride toothpaste] and flossing.
— Use of bottled water versus drinking tap water that is optimally fluoridated
— Fluoride history: Exposure to systemic and topical fluoride throughout life.

Clinical assessment

Clinical examination of hard dental tissues and the biofilm is a major and determining step in the success of caries management. The examiner should evaluate and collect information on the following conditions:

Previous restorative care

Previous dental restorative treatment provides an indicator of past and future caries-risk status.

Plaque (biofilm) status

The presence of a thick biofilm and overall plaque removal level in the mouth are indicators of caries risk.

Staging of the caries lesions

There are different systems for classification of caries lesions. The CaMPs workshop has proposed classifying lesions based on extent of the caries demineralization in enamel and dentin, and activity (active and inactive). The three stages of caries are: initial, moderate, and extensive/severe. The criteria for each stage are provided for each existing system either in use or proposed by different groups or organizations. This document describes the following detection criteria proposed by different groups:

International caries detection and assessment system (ICDAS)

The ICDAS group [Christopher Deery (University of Sheffield), Hafsteinn Eggertsson (USA), Kim Ekstrand (University of Copenhagen), Christopher Longbottom (Dundee University), Nigel Pitts (Dundee University) and David Ricketts (Dundee University)] on behalf of the ICDAS Coordinating Committee has submitted the following definitions of the stages of caries under the CaMPs framework:

Sound occlusal, approximal and free smooth surfaces will have no visible (ICDAS code 0) (for definition of ICDAS codes please refer to the Appendix 2) or radiographic signs of caries.

Initial caries will be characterized by the first [Editor: clinically noncavitated] visual change in enamel (seen only after prolonged air drying or restricted to within the confines of a pit or fissure) (ICDAS code 1) or a distinct visual change in enamel (seen on a wet or dry surface) (ICDAS code 2) in occlusal or approximal/smooth surfaces. On the occlusal surface, such lesions will: (i) not be visible as radiolucency, or (ii) the radiolucency is limited to the outer 1/3 of the dentine on a

conventional intraoral radiograph, most commonly a bitewing view. On approximal surfaces, the majority of these lesions are characterized by a zone of increased radiolucency confined to enamel, including lesions extending up to but not beyond the DEJ (16).

Moderate caries will be characterized clinically by either a localized enamel breakdown (without clinical visual signs of dentinal involvement) (ICDAS code 3) or an underlying dark shadow from dentin (ICDAS code 4). Radiographically, on the approximal surface, the majority of lesions will have a radiolucency extending through the enamel and into the outer or middle third of dentine, a few may appear confined to enamel. On the occlusal surface, although most lesions will have a radiolucency extending into the outer or middle third of dentine, some may not be radiographically visible due to the amount of sound buccal and lingual enamel and dentine which attenuates the x-ray beam.

Severe caries will be characterized by a distinct cavity with visible dentine (ICDAS code 5) or an extensive distinct cavity with visible dentin involving more than half of the tooth surface (ICDAS code 6). Radiographically, this will correspond to a radiolucency extending through to the pulpal third of dentine or reaching the pulp.

Caries management by risk assessment (CAMBRA) (Douglas Young, University of the Pacific, USA, John D.B Featherstone, University of California San Francisco)

The CAMBRA Coalitions' (a special collaboration of diverse groups of independent organizations based across the United States) leaders in the USA (Douglas A. Young, John D.B. Featherstone, Margherita Fontana, Mark Wolff, Brian B. Novy, Michelle Hurlbutt, and Deborah Horlak) have adopted ICDAS, visual/tactile, and radiographic methods of classification of caries lesions to assist with the implementation of the CAMBRA philosophy of management of caries by risk assessment. The group has provided definitions for the three stages of disease adopted at the Caries Management Workshop for occlusal caries.

Initial caries lesions are defined as ICDAS codes 1 through 3 (Editorial Comment: Please note that the CAMBRA group includes ICDAS code 3 in initial and moderate lesions) on occlusal sites. In approximal sites, these lesions will radiographically correspond to E1, E2 and D1. For facial/lingual sites, lesions are defined as [either] noncavitated or partially cavitated. (The definition of radiographic lesions is as follows: E1 = outer ½ of enamel. E2 = inner ½ of enamel and dentin into thirds: D1 = outer 1/3 of dentin, D2 = middle 1/3 of dentin, and D3 = inner 1/3 of dentin).

Moderate caries lesions are defined as ICDAS codes 3–5 in occlusal sites. In approximal sites, these lesions will radiographically correspond to D1, D2, and early D3. For facial/lingual sites, lesions are defined as partially cavitated to fully cavitated.

Severe caries lesions are cavitated lesions at the ICDAS code 6 level (more than half of the tooth surface is lost) and, radiographically, the lesion extends into the inner one-third of dentin (D3). For facial/lingual sites, lesions are defined as extensively cavitated.

Caries management system (CMS) (Wendell Evans, University of Sydney, Australia)

Initial caries in the primary teeth or permanent dentitions on occlusal or nonapproximal smooth surfaces, as defined by the Caries Management System (CMS), includes white or brown spot lesions (ICDAS 1 and 2) or enamel cavity (ICDAS 3), the base of which is confined to enamel. Such cavity may have an associated C3 or C4 radiographic radiolucency. On approximal surfaces, initial caries is diagnosed radiographically and, in permanent teeth, includes C1, C2, and C3 lesions (C1 and C2 only for primary teeth). In principle, initial lesions should be managed by nonsurgical means.

- C1 – radiolucency confined to outer half of enamel
- C2 – radiolucency confined to inner half of enamel and may reach the dento-enamel junction (DEJ)
- C3 – radiolucency just across DEJ
- C4 – radiolucency within dentin outer third
- C5 – radiolucency extends into dentin inner two thirds

Moderate caries is interpreted as noncavitated dentin lesions that should not, in principle, be managed surgically. On occlusal or nonapproximal smooth surfaces, they are evident as grey-blue

dentine shadows (ICDAS 4) that may or may not be associated with enamel breakdown. Moderate caries on an approximal surface is diagnosed radiographically as C4 (C3 for primary teeth). In principle, the management of moderate lesions entails intensive nonsurgical intervention to arrest lesion progression, therefore avoiding cavitation and need for restoration. Cavitated C4 lesions (or C3 lesions on primary teeth) (confirmed on tooth separation) should be restored, except that primary teeth should not be restored within 12 months of exfoliation (Clue: less than half of the root remains).

The CMS does not deal with *Severe caries* other than to identify and refer cavitated permanent teeth (coded ICDAS 5 or 6, or radiographic code C5, or otherwise by inspection of separated teeth) or primary teeth (coded ICDAS 5 or 6, or radiographic codes C4 or greater) for restorative care.

American dental association caries classification system (ADA CCS) (Gregory G. Zeller, American Dental Association, Chicago, Illinois)

In 2008, the ADA convened a broad stakeholder group at the ADA Caries Classification Conference (17). The ADA Council on Scientific Affairs, in collaboration with other ADA Councils and subject matter experts, used the initiatives of the Conference to develop the current ADA CCS, which is now in clinical validation testing to measure sensitivity, specificity, reliability, and usability. The ADA CCS is included in the proposed FDI World Dental Federation Caries Matrix (18).

The ADA CCS allows characterization of the extent of a lesion on a tooth as an 'initial, moderate, or severe lesion' based on the clinical findings regarding the progression of the lesion. The ADA CCS also offers the capability to characterize the site of origin of a lesion as 'pit and fissure, approximal, cervical/smooth surface, or root'. The ADA CCS focuses on examination findings regarding extent (progression) and site of origin and does not currently proscribe the subsequent use of the other necessary elements of an overall caries management system that ultimately results in treatment decisions.

The ADA CCS lesion extent and origin categories (Appendices 3 and 4) are based on visual and tactile clinical examination. Radiographic findings of carious lesions, if available, should also be included, although radiographs are not required or indicated in every instance.

In the ADA CCS, clinical and, if available, radiographic findings together demonstrate the extent of a carious lesion as one of the following three categories:

Initial caries is defined as visible noncavitated or cavitated (may be 'microcavitated') lesions limited to the enamel.

Moderate caries lesions represent either enamel breakdown (may be 'microcavitated' enamel) with noncavitated carious dentin or loss of root cementum with noncavitated carious dentin.

Severe caries are lesions that demonstrate extensive cavitation of the enamel and dentin.

In addition to lesion extent and site of origin, after determination of overall clinical surfaces involved in lesion activity and of risk assessment, the patient and provider may make a joint treatment decision among the currently available nonsurgical (nonrestorative therapeutic preventive and remineralization approaches) or surgical (restorative) treatment options. As additional safe and effective treatment approaches become available through scientific advances, these new therapies and technologies can be added to the treatment arsenal without modifying the clinical caries classification findings component of the overall aries management system.

Normative (conventional) caries system (Complied by Amid I. Ismail based on personal knowledge of the US and other caries decision approaches used in practice. This is the approach that the CaMPs Workshop and this document would hopefully change to adopt the new Mission for caries management.)

The current and widely followed system worldwide, relies on the use of an explorer for tactile detection of caries combined with visual inspection for signs of cavitation or discoloration. This system has wide adherence because of its simplicity and perceived certainty by dental practitioners. The system, however, suffers from low reliability in detecting caries and uncertainty in defining when to restore or not restore caries lesions (19,

20). Moreover, the decision to restore is not based on the size and extent of the caries demineralization because all lesions are restored once there is perceived visual or tactile recognition of cavitation or of caries in dentin or there is radiographic evidence of radiolucency reaching beyond the dentoenamel junction (DEJ).

Users of this system, if they decide to adopt the mission of preserving tooth structure and restoring only when necessary may use the following new approach:

Initial caries: Although it is strongly recommended that these lesions are not penetrated by an explorer, practitioners may classify these lesions based on *lack of cavitation* (discontinuity in enamel or dentin caused by caries) and the presence of either no radiographic evidence of caries (occlusal surfaces) or caries not extending beyond the DEJ and within the outer one-third of dentin. These lesions cannot be assessed using a 'sharp explorer' but rather they can be identified after a detailed visual examination of clean and dry teeth.

Moderate caries: These lesions either are cavitated into enamel (walls and floor are in enamel) or noncavitated with radiographic evidence of caries extending up to the outer on third of dentin, passing the DEJ.

Severe caries: These lesions show cavitation into dentin or radiolucency extending into the middle or inner dentin in the direction of the pulp chamber. Radiographically, the lesion reaches into the middle or inner one-third of dentin.

In summary, users of the current system of caries classification which relies on visual tactile detection can modify their approach to identify initial, moderate, and severe caries based on presence of cavitation, signs of caries demineralization, and radiographic evidence of caries.

Lesion activity

Assessment of caries activity at the lesion level is an integral part of the clinical examination and should be carried out concurrently when lesion stages (initial, moderate, extensive) are determined by the examiner. Unfortunately, there is no consensus on indicators to assess activity and moreover, the current clinical assessments are at best a guess-estimate. Nonetheless, the assessment of activity must be included as part of a clinical examination.

The ICDAS, CAMBRA coalitions, Nyvad's and CMS systems have specific clinical characteristics for assessing activity. In the ICDAS system, active lesions are defined as follows:

Occlusal surfaces: erupting posterior teeth, especially of permanent molars

Approximal surface: Below or above the contact point

Location relative to gingiva: Within 0.5 mm of gingival line

Surface morphology: Deep pits (also called fossae where two fissures or grooves meet) and fissures or grooves

Noncavitated dentinal lesions: All are considered active

Open cavities: In plaque stagnation areas.

The CAMBRA coalition defines caries lesion activity (21) as follows: (Parameters in bold indicate activity and those in regular font indicate no activity)

- Initial caries risk status – **High**, **Moderate**, or Low
- Visual appearance – **Cavitation/shadow**, **whitish**, or brownish
- Location of the lesion – **Plaque stagnation area**, **natural**, or not,
- Tactile feeling – – **Rough enamel/soft dentin**, or smooth enamel/hard dentin
- Gingival status (if the lesion is located near the gingiva) – **Inflammation**, **Bleeding on Probing**, or No Inflammation, No Bleeding on Probing
- Surface luster – **Matt**, Shiny
- Plaque – **Sticky**, Not Sticky
- Age of the lesion – <3, >3 years

The CMS system (12, 13) regards all lesions as active at baseline. Lesions are deemed to be arrested when, following treatment, lesion size (or depth) shrinks or ceases to increase.

The Nyvad et al. (14, 15) approach defines activity as follows (The Editor has included this system for completion even though it was not presented at the Workshop.):

- Active caries on intact surface: Surface of enamel is whitish/yellowish opaque with loss of luster; feels rough when the tip of the probe is moved gently across the surface; generally covered with plaque. No clinically detectable loss of substance.
  Smooth surface: Caries lesion typically located close to gingival margin.
  Fissure/pit: Intact fissure morphology; lesion extending along the walls of the fissure.
- Active caries with surface discontinuity: Same criteria as score 1. Localized surface defect

(microcavity) in enamel only. No undermined enamel or softened floor detectable with the explorer.
- Active caries (cavity) Enamel/dentin cavity easily visible with the naked eye; surface of cavity feels soft or leathery on gentle probing. There may or may not be pulpal involvement.

Synthesis and diagnosis

Patient risk status

Caries risk assessment (CRA) denotes the process of establishing the probability of an individual patient developing new caries lesions (enamel or dentin) over the near future, and is one of the cornerstones in patient-centered caries prevention and management (22). CRA should be included in contemporary treatment plans to assist the clinician in the decision-making process concerning treatment (nonoperative and operative), recall appointments and the need for additional diagnostic procedures. An ideal CRA system should have high validity and reliability and it should also be easy to use in practice at a low cost (23). Caries risk assessment should always be performed at the child's first dental visit and then regularly throughout life, or when social or medical life-events are occurring. There are no clearly superior methods for predicting future caries.

The CaMPs workshop participants have agreed on the need for determining current and future risk status of each patient. Caries risk can be classified as low, medium, high, and extreme. Some of the systems to be described in this section combine the 'high' and 'extreme' classifications, whereas the CAMBRA system has a specific definition and management approach for those with 'extreme' caries.

It is imperative that a management plan addresses throughout the care process, the patient risk status, which is the philosophy followed by CAMBRA. This means that risk assessment and reduction of risk burden should be reviewed and prescribed at each dental visit. A well-designed management plan will address patient risk status and lesion management within the context of the caries risk management. The management grid should integrate: (i) patient risk status, (ii) lesion activity and status (iii) stage of tissue destruction. The CaMP Workshop recommends the following four groups of management approaches that should be the focus of reimbursement or incentives:

- Appropriate Home Care = AHC
- Clinical Preventive Treatment (Primary) = CPTP
- Clinical Preventive Treatment (Secondary) = CPTS
- Preservative Surgical Treatment = PST

These management levels can be applied singly or in any combination to reduce the patient risk and treat individual lesions. For example, whereas every low-risk patient should have tailored AHC, some may benefit from CPTP, with a review frequency that is risk-adjusted. A high caries-risk patient may require all of the level of care from AHC to PST or if such a patient does not have active current disease, the focus should be on AHC and CPTP, with a more rigorous review and monitoring schedule than a low-risk patient.

There are several risk assessment tools available for the general practitioner, although the evidence for their validity is limited in both children and adults. The initial ICDAS system focused on lesion classification and did not explicitly describe specific CRA tools. However, the ICDAS-ICCMS (International Caries Classification and Management System) focuses on clinical caries management and does assess the risk status of patients.

The ICDAS – ICCMS considers that a patient's caries risk assessment is the basic component in the decision-making process for adequate prevention of dental caries and for setting and resetting individual recall intervals. Evidence from the literature suggests that Caries Risk Assessment should always be performed at a child's first dental visit and then regularly throughout life, at least every second year, or when social or medical life-events are occurring. Several risk assessment methods and models are available for the general practitioner, but there are no clearly superior methods for predicting future caries. The use of structured protocols combining socio-economic, behavior, general health, diet, oral hygiene routines, clinical data, and salivary tests or computer-based systems are considered best clinical practice.

In general, the use of risk models is typically more accurate than using few or single factors and this seems especially true for young children. In general, the accuracy ranges 60–90%, depending on the age, and the selection of patients at low risk is slightly more effective than finding those with high caries risk. Any clinical sign of likely active lesions (ICDAS code >0) on smooth, occlusal, and proximal tooth surfaces should be taken as a signal

for the implementation of individually designed preventive and disease-management measures.

The four key elements of the ICCMS (22, 24) are: *Initial Patient Assessments* (collecting personal and risk-based information through histories and systematic data collection); *Lesion Detection, Activity, and Appropriate Risk Assessment* [detection and staging of lesions, assessment of caries activity, and caries risk assessment using appropriate methods – such as Cariogram (with or without microbiological tests) or CAMBRA]; *Synthesis and Decision-Making* (integrating the patient level and lesion level information); and *Clinical Treatments (Nonsurgical & Surgical) with prevention* (ensuring that the treatment planning options available are prevention-orientated and include nonsurgical options whenever appropriate). These steps in the management system are intended to be revisited in a cyclical manner, with monitoring and review at risk-based intervals; they could readily be delivered using appropriate Caries Management Pathways. The ICCMS development team is also examining the potential of using new and more user-friendly computer-assisted methods of risk assessment.

Among the most frequently named systems reported in the literature are: (i) the CAT Tool (Caries Assessment Tool) proposed by the American Academy of Pediatric Dentistry (25), (ii) the Caries Risk Assessment Form (CRA) (26), published in the Journal of the California Dental Association and advocated by the different CAMBRA coalitions in the USA, (iii) the American Dental Association (ADA) CRA forms (27), and (iv) the Cariogram (28). In general, there are differences in the total number of factors assessed by each tool (7–24), in the domains considered for the assessment (e.g., Socio-demographic, microbiological, salivary, etc.) and the target populations. They also vary in the specific categorization of risk, as some use only high- and low-risk categories, others incorporate a medium category and/or even an extreme-risk category. Nevertheless, there seems to be an overlap across systems in the main known caries etiological factors and disease indicators, such as caries experience, plaque, fluoride exposure, diet, salivary flow, and overall general health condition.

The only system with data evaluating its validity in prospective cohort studies is the Cariogram (23, 28–32) which was found to be clinically useful in identifying caries risk levels for the elderly and to a more limited extent in assessing children's caries risk. Still, its usefulness for achieving better health outcomes and cost savings across different settings such as private practice and public health scenarios and in populations outside and inside Scandinavia remains unknown. The inferences related to CRA form published in the CDA journal are more limited, as no specific prediction outcomes were presented in the validation study (33). However, there seems to be an indication that in adults seeking dental care, the risk assessment established by the CRA form published in the CDA journal does correlate significantly with the development of cavitation. No prospective studies documenting the validity of the forms proposed by the ADA and the AAPD have been published. In Australia, caries risk reduction was demonstrated in the randomized controlled trial in general practices of the CMS protocols (34, 35).

Regardless of the risk assessment system to be used, it is important to recognize that caries management and conservative restorative treatment based on caries risk status reduce caries increments over time compared to traditional nonrisk-based dental treatment (36). As past caries experience is the most important single risk component for more caries at all ages, any clinical sign of likely active demineralization on any tooth surface should be taken as a signal for the implementation of individually designed preventive and risk reduction strategies. Based on the best available evidence, the foundation for conducting caries risk assessment is definite and reinforces the fact that risk assessment should be routinely carried out, even if there is no complete consensus on this topic among the dental profession.

CRA assessment form published in the CDA journal

The variables included in this CRA form are a combination of disease indicators, pathological and protective factors that are assumed to be able to be used in combination to assess overall caries risk and to guide therapy and treatment planning (26, 37–41). The disease indicators are markers that are indicative of a current or past carious process but they are not causative factors (visible cavities or radiographic penetration of the dentin, radiographic approximal enamel lesions, white spots, and restorations placed because of cavitation during the last three years). The risk factors or pathological factors are described as variables related to the probability of occurrence and progression of disease including existing lesion progression and the formation of new lesions (visible heavy plaque,

frequent snacking, inadequate saliva flow, and high bacterial load measured by culture or ATP bioluminescence). Some other factors are those which expose the individual to the causal chain: deep pits and fissures, recreational drug use, medications/radiation/systemic diseases, exposed roots, and orthodontic appliances. The protective factors in this form are biological or therapeutic factors or measures that can collectively prevent the demineralization process, enhance remineralization or offset the challenge presented by the pathological factors (adequate saliva flow, fluoride exposure, antibacterial rinses, xylitol, and calcium phosphate supplementation.

Caries risk assessment form published in the CDA journal considers information from 18 different factors for children 0–5 years of age, whereas the same tool for adults (6 years and above) consists of 24 factors. In both cases, CAMBRA suggests the use of saliva flow and bacterial load as a baseline reference for new patients or at every recall appointment depending upon the patients' risk level.

CARIOGRAM risk assessment tool

The Cariogram is an interactive PC program for caries risk evaluation (28). It takes into account the interactions between caries-related factors and expresses a graphic assessment of the risk. It considers the interaction of the different caries-causing factors/parameters of the patient. It also provides recommendations for targeted preventive measures that could be implemented to overcome new caries formation. The program functions as follows: scores from 0 to 3 for the nine caries risk factors are entered (caries experience, related diseases, diet contents, diet frequency, plaque amount, salivary MS level, fluoride program, saliva secretion, and saliva buffer capacity), and the program then presents a caries risk assessment of the patient according to a weighted evaluation (not just adding the factors), in the form of a pie diagram. The program contains about 5 million combinations of factors considering the total pattern of risk factors. The final result is expressed as the chance of avoiding caries.

The Cariogram may be used without the inclusion of salivary tests (saliva secretion, buffer capacity and MS level). However, the predictive capability of the Cariogram may be significantly impaired with the exclusion of this information, as has been demonstrated in studies conducted among children (32).

CMS risk assessment tool

According to the CMS (12, 13), caries risk is determined on the basis of the caries incidence rate. Risk reduction strategies aim to reduce exposures to risk factors and enhance protective factors. The guidelines to determine a patient's caries risk for both adults and children are presented below.

Adults. At baseline visit, risk status is determined solely on the basis of clinical findings. *Low-risk* adults have no cavities but may have approximal lesion C3 bitewing radiolucencies; *medium-risk* adults exhibit enamel cavities and/or C4 bitewing radiolucencies; *high-risk* adults exhibit dentine cavities and/or C4 or C5 bitewing radiolucencies. At recall, *low risk* is confirmed if caries incidence is <1 lesion per year or no progression of approximal lesions observed at baseline; *medium risk* if incidence is one new lesion per year or progression of those observed at baseline; *high risk* if incidence is two lesions per year.

Children and adolescents. Two risk categories; low-risk and at-risk. Risk status is determined at baseline visit solely on the basis of clinical findings. *Low-risk* children have no white spot lesions, no bitewing radiolucencies, no hypoplastic molars, no sites with Plaque Index score = 3, dmfs +DMFS = 0. Otherwise, children who exhibit any of these signs are deemed *at risk* of caries.

The ADA CCS and the conventional approach to caries management do not include CRA assessment tools and management strategies. The ADA CCS is intended to classify the examination findings associated with the extent and origin of carious lesions and is not currently linked to the use of a specific CRA tool or to an overall caries management system

Caries management plans

In this section, the approaches for management of patients as well as carious lesions are described. This section presents the recommended management strategies by each group who attended the CaMPs workshop. It is important to emphasize the intersection, in management decisions, of patient risk status and lesion status at the tooth surface level. The Workshop proposes the following grid for decision making:

Patient risk	Lesion status			
	No lesions	Initial lesion	Moderate lesion	Severe lesion
Low	Home: Background care Clinic: no restorative treatment but sealants may be placed in young patients with deep pits and fissures Recall: annual	Not applicable as lesions present	Not applicable as lesions present	Not applicable as lesions present
Medium	Not applicable Cannot be medium-risk without lesions	Home: Reinforcement of background care Clinic: sealants, varnish, gels, foams for at-risk surfaces Recall: 6 months	Home: Reinforcement of background care Clinic: sealants, varnish, gels, foams for at-risk surfaces Recall: 6 months If lesion is inactive or the activity of lesion unclear – consider monitoring of lesion and success of therapeutic interventions over 6- month recall period or If lesion is considered active – restore using minimal surgical intervention to preserve tooth structure	Home: Reinforcement of background care Clinic: sealants, varnish, gels, foams Recall: 6 months Restore lesions using minimal surgical intervention to preserve tooth structure
High	Not applicable Cannot be high-risk without lesions	Home: Reinforcement of background care + use of enhanced topical fluorides Clinic: sealants, varnish, gels foams for at-risk surfaces Recall: 3–4 months	Home: Reinforcement of background care + use of enhanced Fluoride products, high fluoride toothpaste, mouth rinse, etc Clinic: sealants, varnish, gels foams for at-risk surfaces Recall: 3–4 months Restore lesions using minimal surgical intervention to preserve tooth structure	Home: Reinforcement of background care + use of enhanced Fluoride products, high- fluoride toothpaste, mouth rinse, etc. Clinic: sealants, varnish, gels foams for at-risk surfaces Recall: 3–4 months Restore lesions using minimal surgical intervention to preserve tooth structure

International caries detection and assessment system (ICDAS)

How specific lesions are managed at the various stages will depend upon the patients' caries risk status, activity of the lesion, and the surface-type affected. Other factors also inform these management decisions, such as the patient's expectations, wishes, and compliance as well as regional or national professional norms.

The groupings below include integration of clinical visual and radiographic information, as the radiographic method is in most widespread use as an adjunct to clinical visual examination around the globe. Analogous metrics should also be used when integrating additional diagnostic information gleaned from detection aids such as: Fibre Optic Transillumination (FOTI), temporary elective tooth separation, DIAGNOdent, CarieScan PRO or QLF.

Management of 'sound' surfaces

For sound occlusal, approximal and smooth surfaces, if the patient is at low-caries risk, a background level of oral health care with the use of fluoride toothpaste should be maintained. For those patients at high risk, personalized modification of risk factors should be implemented, these include improved oral hygiene, use of fluorides, saliva stimulation, use of pit and fissure sealants, and modification of diet. These interventions can,

at the lesion level, be grouped under the headings of Appropriate Home Care (AHC) and Clinical Preventive Treatments supporting Primary prevention in the absence of disease (CPTP).

Management of initial caries

Occlusal tooth surfaces. The management of initial lesions on the occlusal surface will depend upon whether the lesion is inactive (nonprogressing) or active (progressing). For inactive lesions in low-risk patients, no additional treatment is required over and above the background level of oral health-care maintenance. If such a lesion occurred in a high-risk patient, personalized modification of risk factors should be implemented over that of background level of oral health care. Management of active initial lesions on the occlusal surface will depend upon its eruptive status. If partially erupted, one or more of the following options can be implemented: oral hygiene can be modified to brush the occlusal surface bucco-lingually behind the adjacent mesial tooth, topical fluoride can be applied, or a temporary sealant can be applied (glass ionomer). Once fully erupted so the entire occlusal surface is clear of the mucosa, resin fissure sealant can also be applied.

Approximal tooth surfaces. Radiographic detection information tends to dominate for these surfaces (42), but clinical visual information can still be of value. Activity status of a lesion identified clinically or radiographically on the approximal surface can be helped by assessing the gingival status next to the lesion. Gingival bleeding after gentle probing (or flossing) indicates that the lesion is active versus no gingival bleeding after gentle probing indicates that the lesion is inactive (43). For inactive (nonprogressing) lesions on approximal surfaces, if not visible on a radiograph or radiographically confined to enamel or to the outer third of dentine, no additional management is required. For active lesions not visible on radiograph or radiographically confined to enamel, personalized modification of risk factors should be implemented – modification of oral hygiene procedures might include the use of dental floss. Proximal sealing or infiltration with a resin after etching the surface using hydrochloric acid (Editors' comment: more research is needed on infiltration before the technique can be adopted) may be a treatment option if the lesion continues to progress (44–47). For lesions with radiolucency into the outer third of dentine, the use of temporary tooth separation should be considered to confirm the integrity of the tooth surface (48–50). If an active lesion is found to be microcavitated, then operative intervention is indicated; if not microcavitated, sealants or infiltration may be an option.

Facial–lingual smooth tooth surfaces. For inactive lesions on smooth surfaces, no additional management is required. For active lesions, personalized modification of risk factors should be implemented and modification of oral hygiene procedures using behavioral change techniques should be considered. If an active lesion is found to be microcavitated, then sealing or operative intervention is considered or depending upon the age of the patient and the overall risk assessment, the lesion may be kept free from plaque by meticulous oral hygiene practices, if feasible for a patient. The interventions for this stage of caries can, at the lesion level, be grouped under the headings of Appropriate Home Care (AHC), Clinical Preventive Treatments supporting Primary prevention in the absence of disease (CPTP), Clinical Preventive Treatments supporting Secondary prevention (CPTS), as well as Preservative Surgical Treatment (PST).

Management of moderate caries

Occlusal tooth surfaces. The management of moderate lesions on the occlusal surface will depend upon whether the lesion is active or inactive and on whether it is radiographically visible or not. Inactive lesions not visible on a radiograph should be managed according to patient risk: if low-risk (patient >35 years of age), no additional treatment is required, if high-risk (<35 years old), the lesion may be sealed depending upon assessment of the risk of developing caries. Inactive lesions with a radiolucency into dentine should also be managed based upon caries risk: if low-risk, fissure seal as caries risk and activity can change; if high-risk, fissure seal or consider minimally invasive caries removal and restoration. Active lesions not visible on a radiograph should be fissure-sealed and when visible radiographically, fissure-sealed or restored following minimally invasive caries removal, depending upon the caries risk.

Approximal tooth surfaces. Radiographic detection information tends to dominate for these surfaces, but clinical visual information can still be of value. As with all initial to moderate lesions, management will be influenced by caries activity and in

this respect, the gingival status will help in determining whether a lesion is inactive (no gingival bleeding after gentle probing) or active (gingival bleeding after gentle probing). Inactive moderate approximal lesions with no radiolucency or radiographically confined to enamel need no additional management, however, such lesions should be monitored clinically and radiographically to confirm no lesion progression over time. Consideration should also be given to temporary tooth separation to confirm whether a microcavity is present or not for approximal lesions: if cavitated, – operative intervention is required. Inactive moderate approximal lesions that extend radiographically into the outer or middle third of dentine should be either monitored, undergo sealing/infiltration, minimally invasive caries removal and restoration, or in primary teeth, receive a Hall crown or nonrestorative treatment by opening up the cavity so the lesion can be readily brushed free of plaque. Again, temporary tooth separation is useful to determine if the lesion is microcavitated or not. Active moderate approximal lesions that are not radiographically visible or radiographically confined to enamel require personalized modification of risk factors. Active lesions radiographically visible also require modification of risk factors and monitoring, but may additionally require sealing/infiltration, minimally invasive caries removal and restoration, or in primary teeth, receive a Hall crown or nonrestorative treatment.

Facial–lingual smooth tooth surfaces. Clinical visual information is paramount for these lesions. As with all initial to moderate lesions, management will be influenced by caries activity and in this respect, the gingival status will help in determining whether a lesion is inactive (no gingival bleeding after gentle probing) or active (gingival bleeding after gentle probing). Inactive moderate smooth-surface lesions need no additional management; however, such lesions should be monitored clinically to confirm no lesion progression over time. If cavitation is evident, preservative operative intervention is required. Active moderate smooth surface lesions require personalized modification of risk factors.

The interventions for this stage of caries can, at the lesion level, be grouped under the headings of Appropriate Home Care (AHC), Clinical Preventive Treatments supporting Primary prevention in the absence of disease (CPTP), Clinical Preventive Treatments supporting Secondary prevention (CPTS), as well as Preservative Surgical Treatment (PST).

Management of severe caries

The management of severe lesions in occlusal, approximal, and smooth surfaces will involve a minimal surgical approach and preparation of the area directly affected by the caries, as necessary, taking into account preservation of tooth structure, as well as the chosen restorative material. Signs and symptoms of pulpal involvement will inform the specific treatment decision. The treatment choices available are: Single-stage excavation with well-sealed restoration; Stepwise excavation (involving at least two separate appointment surgical intervention steps); Hall crown (for primary teeth); nonrestorative treatment; indirect pulp cap; direct pulp cap; Root canal treatment; or Extraction. All of these treatments will be combined with personalized modification of risk factors, as delineated in the previous section.

The interventions for this stage of caries can, at the lesion level, be grouped under the headings of Appropriate Home Care (AHC), Clinical Preventive Treatments supporting Primary prevention in the absence of disease (CPTP), Clinical Preventive Treatments supporting Secondary prevention (CPTS), as well as Preservative Surgical Treatment (PST).

Management of root caries

There is limited research and lack of general agreement on how root caries is managed. The ICDAS group (51) has proposed that for sound root surface sites, if the patient is at low caries risk, a background level of oral health care with the use of fluoride toothpaste should maintained. For those patients at high risk, personalized modification of risk factors should be implemented: these include improved oral hygiene (including flossing and/or other inter-dental cleaning aids), use of fluorides, saliva stimulation and modification of diet.

- For ICDAS code 1R lesions (noncavitated): if the lesion is arrested, management should be as for a sound root surface.
- For ICDAS code 1R lesions (noncavitated) which are active, management should involve the above preventive regime of oral hygiene, together with fluoride varnish application, repeated four times per year, plus saliva stimulation.
- For ICDAS code 2R – cavitated – lesions, the management of arrested lesions is identical to that for ICDAS 1R arrested lesions and sound surfaces.
- For ICDAS code 2R inactive (leathery) lesions, the management should involve the preventive

regime of oral hygiene, together with fluoride varnish application, repeated four times per year, plus saliva stimulation, with or without a minimal restoration.
- Management of ICDAS code 2R active lesions involves minimal removal of the affected tissue and restoration, together with the above preventive regime for root caries sites repeated four times per year.

The interventions for this stage of caries can, at the lesion level, be grouped under the headings of Appropriate Home Care (AHC), Clinical Preventive Treatments supporting Primary prevention in the absence of disease (CPTP), Clinical Preventive Treatments supporting Secondary prevention (CPTS), as well as Preservative Surgical Treatment (PST).

Caries management by risk assessment (CAMBRA)

Management of 'sound', initial caries, moderate caries, and severe caries

Caries management by risk assessment coalition leaders advocate that caries lesions are managed with minimal removal of tooth structure to ensure that an adequate seal for the dental material used.

Management of 'sound' surfaces

Occlusal tooth surfaces. The management of these surfaces will depend on risk level but will generally consider nonsurgical approaches. Nonsurgical preventive maintenance should be continued and sealants may be considered optional for primary prevention of at-risk (deep) pits and fissures.

Management of initial caries

Occlusal tooth surfaces. The management of initial lesions on the occlusal surface will depend upon the risk level but will generally consider nonsurgical approaches. For low-risk individuals, sealants are not indicated for inactive lesions; however, sealants may be considered optional for primary prevention of at-risk (deep) pits and fissures. Nonsurgical preventive maintenance should be continued and sealants may be considered optional for primary prevention of at-risk (deep) pits and fissures. For all other risk categories (moderate, high, extreme) sealants are recommended.

Approximal tooth surfaces. For lesions radiographically confined to enamel, chemical treatment or preventive maintenance is recommended.

Facial/lingual tooth surfaces. These are generally noncavitated lesions that may be active or inactive. Active white- or brown-spot lesions receive chemical therapies based on caries risk assessment (CRA).

Management of moderate caries

Occlusal tooth surfaces. The management of moderate lesions on the occlusal surface for all risk levels will generally consider minimal removal of tooth structure to ensure adequate seal for the dental material used.

Approximal tooth surfaces. For lesions radiographically confined to outer 1/3 of dentin, chemical or preventive therapy is recommended along with demonstration of lesion progression or regression and/or elastomeric tooth separation. For lesions radiographically confined to middle 1/3 of dentin, a minimally invasive restoration is most likely going to be required but this is not absolute and it is based on lesion activity/progression.

Facial/lingual tooth surfaces. These are generally partially or fully cavitated lesions. Partially cavitated lesions may receive nonsurgical chemical therapy or minimally invasive restoration depending on clinician and patient discussion of treatment options. Fully cavitated lesions may receive a minimally invasive restoration.

Management of severe caries

Occlusal tooth surfaces. These lesions are managed conservatively with caries removal when near the pulp, ensuring adequate seal for the dental material used. Active infected dentin on all cavitated lesions should be removed unless it puts a vital, asymptomatic pulp at risk. In the case of a healthy pulp, conservative caries removal (even if it means leaving infected dentin) and sealing off the nutrient source via a seal restoration is preferred over a pulp exposure on a viatal tooth.

Approximal tooth surfaces. For lesions radiographically confined to inner 1/3 of dentin, minimally

invasive restoration is needed. Conservative caries removal when near the pulp of a vital, asymptomatic tooth is recommended assuming adequate seal, blocking the nutrient source, can be maintained.

Facial/lingual tooth surfaces. These are generally fully cavitated lesions. Conservative caries removal when near the pulp is recommended ensuring adequate seal for the dental material used.

In addition to lesion risk management, the National CAMBRA Coalition recommends the following risk-based management:

Low Caries Risk: Healthy and low-risk patients should receive effective lifestyle counseling including oral hygiene, dietary counseling, and over-the-counter (OTC) fluoride toothpaste twice a day. An option is, if the patient already uses a mouth rinse, a 0.05% NaF mouth rinse might be recommended or if the patients uses sucrose or chews gum, a xylitol replacement might be recommended as a healthy lifestyle alternative.

Moderate Caries Risk: Moderate caries risk patients receive the same treatment as a low caries-risk patient with the addition of: (i) 0.05% NaF mouth rinse twice a day (at bedtime and after breakfast), (ii) professionally applied fluoride applications every 4–5 months (i.e., NaF varnish application on all surfaces), and (iii) 6–10 g of xylitol per day with a minimum of three exposures to 2 g each time (i.e., Chew two pieces of gum for 5 minutes, at least three times each day).

High Caries Risk: High caries risk patients receive the same treatment as a moderate caries risk patient with the addition of: (i) 5000 ppm fluoride toothpaste twice a day in place of OTC toothpaste (closely following the product instructions for use). The 0.05% NaF mouth rinse is not necessary, (ii) If high levels of cariogenic bacteria are identified by ATP bioluminescence or culture, an antibacterial treatment may prove beneficial (36).

If fluoride and antibacterial treatments are not effective, optional alternatives may be considered by supplementing the treatment with (i) Calcium and phosphate products and (ii) pH- neutralization strategies.

Extreme Caries Risk: Extreme caries risk patients are those individuals exhibiting xerostomia/hyposalivation and high caries risk. They require the same treatment as a high caries risk patient and the addition of professionally applied fluoride applications every 3 months. Other options such as calcium and phosphate supplementation or pH neutralization might also be considered.

The above scheme should allow some flexibility to treat a highly cariogenic biofilm and/or pH abnormalities for those clinicians employing specific tests for one or both of these in their CRA process. Other offices simply choose to place patients into an 'at-risk' or 'not-at-risk' category. The number of caries risk categories is not as important as having appropriate evidence-based treatment options that will tip the patient's individual caries imbalance toward a healthy oral environment and arrest or prevent further disease.

Caries management system (CMS)

CMS principles

The CMS defines patient and tooth-level interventions. Fundamentally, caries risk is managed through a combination of home-care and professional-care inputs at both *patient* and *tooth* levels.

Patient level. Patient-level interventions address the modifiable risk factors that sustain the disease. *Home-care* input entails: twice-daily toothbrushing with fluoride toothpaste (TDTFT); use of fluoride and antimicrobial rinses, if appropriate, together with healthy food selection. *Professional care* inputs include: case presentation; motivational interviewing to achieve oral home care behavior change; oral hygiene coaching; oral health education and encouragement to limit sugar intake and reduce between-meal snacking frequency, as well as nontooth-specific whole-mouth interventions.

Tooth level. Tooth-level interventions address sites at risk and specific lesions. *Professional- care* inputs at this level include specific tooth-surface treatments, for example, fissure sealant, spot varnish application, and restoration.

Outcomes that are monitored include: *patient level* (i) behavior change, (ii) maintenance of low plaque scores, and (iii) reduced caries lesion incidence; *tooth level* (i) lesion arrest, (ii) lesion remineralization, and (iii) the status of sealants and restorations.

CMS protocols

Risk assessment, caries management, monitoring, and recall schedules for children and adults are

specified in separate protocols (for details, see refs 12, 13). Interventions are risk-specific and, more importantly, criteria are provided to indicate when, and when not, to intervene surgically (Appendices 5 and 6). Briefly, caries in low-risk patients is managed primarily through home care. Medium-risk patients are scheduled for fluoride varnish treatment and monitoring initially at each treatment visit, then 6-monthly. High-risk patients, as for medium risk except that fluoride varnish applications are scheduled at 3-monthly intervals. The expectation is that high-risk patients will be motivated to become medium, then low-risk.

General

All patients receive oral hygiene coaching and are encouraged to brush their teeth twice daily with fluoride toothpaste (TDTFT). The goal of such home care is to maintain 'sound' tooth surfaces as 'sound' (that is, to prevent caries incidence) and to arrest active lesions and maintain their arrested status.

Management of initial caries

The goal is to arrest white spot lesions (WSL) on smooth surfaces, thus preventing cavitation. WSLs on smooth and fissure surfaces are treated with fluoride varnish. Enamel breakdown lesions on fissure surfaces are sealed (resin sealants). Smooth and approximal surface WSLs are managed according to a risk-specific fluoride schedule (Appendices 5 and 6).

Management of moderate caries

Noncavitated dentin lesions are treated intensively according to the risk-specific fluoride schedule plus use of antimicrobials. Enamel cavities are treated with sealants. Enamel cavities on approximal surfaces, as identified following tooth separation, are restored.

Management of severe caries

Cavities into dentin in primary teeth are not restored within one year of exfoliation, otherwise, treatment of dentine cavities in primary and permanent teeth are treated by surgical means.

American dental association caries classification system (ADA CCS)

When the lesion extent classification is combined with the other elements of an overall caries management system, namely, location (tooth number, site of origin, and overall surfaces involved), caries activity or inactivity status, and patient-centered risk assessment, the caries management system pathway will provide information for a determination concerning which available nonsurgical (nonrestorative therapeutic preventive and remineralization approaches) or surgical (restorative) treatment is indicated for any particular initial, moderate, or severe carious lesion.

Management of 'sound' surfaces

Not provided for in the CCS.

Management of initial caries

Depending upon the lesion extent, lesion location (tooth number, site of origin, and overall surfaces involved), lesion activity (active/inactive), and patient caries risk assessment, a risk-adjusted treatment decision for nonsurgical or surgical intervention may be made by the patient with the provider. The indicated treatment for initial lesions will most frequently be nonsurgical.

Management of moderate caries

The indicated treatment for moderate lesions will most often be surgical.

Management of severe caries

Severe lesions will almost always require surgical treatment.

These trends within each category will always vary with patient when the ADA CCS lesion extent category, the lesion location (tooth number, site of origin, and overall surfaces involved), the lesion activity (active/inactive), and the patient caries risk assessment are all factored into a risk-adjusted decision made by the patient in conjunction with the provider, on whether and which nonsurgical or surgical treatment is indicated for the lesion.

Monitoring, review and recall

The purpose of monitoring is to determine whether or not (i) the risk factors have been modified and (ii) whether the desired clinical outcomes have been reached.

Patient level

This assessment entails questioning of the patient (or caregiver if the patient is a child or person with cognitive or other impairment) as to whether or

not the previously determined recommendations have been followed.

Clinical level

This aspect entails checking the clinical status (and radiographic status if appropriate) of the dentition to determine if there are new lesions and or whether or not previously identified lesions have progressed, arrested or regressed. On the basis of consideration of both the patient and clinical factors, the risk status is reconsidered and may lead to a new risk determination and, consequently, modification of the management plan, both in relation to patient and clinical factors. In the case where the behavior change recommendations were followed and the desired clinical outcomes were achieved, this information should be communicated to the patient (and caregiver) along with encouragement to continue with home care.

If the clinical status has deteriorated, this information should be communicated to the patient along with further questioning to review the previously identified risk factors and to discover any new risk factors. In addition, the dentist should aim to discover whether the previously determined recommendations were followed and if not, aim to discover what barriers prevented the desired behavior. The dentist should negotiate with the patient, as necessary, on how any barriers to the behavior change may be overcome. If there are many barriers to overcome, then the dentist should prioritize them and attempt to ensure the most important health behaviors are emphasized.

Recall

Recall is related to caries risk status – for greater risk, the recall frequency is higher and the time interval between them is shorter, and vice versa, if lesser risk, the recall interval can be extended, as previously described.

Non Restorative caries therapies

It should be appreciated that dispassionate reviews of the evidence base demonstrate that there is a paucity of high-quality evidence to support much of what dentists (and physicians) do and the surgical management of caries is no different from other areas of practice. Although some of the newer approaches may seem radical or unconventional to dentists in some countries or regions, the level of evidence to support these approaches is encouraging and in many cases, on par with conventional surgically driven methods.

When there are no clinical or radiographic signs of pulpal involvement the following nonrestorative and preventive caries therapies merit consideration. These therapies include oral hygiene procedures, application of topical fluorides, dietary assessment/advice, and pit-and-fissure sealants (52). Recent novel approaches include a range of remineralizing agents based on amorphous calcium phosphate (53). In primary teeth within a year of exfoliation, restorative care is not necessarily indicated (13).

Slicing – primary teeth

In addition, in primary teeth, to facilitate effective plaque removal in moderate and severe lesions, where conventional methods of restoration are inappropriate or not possible, consideration can be given to the operative removal of undermined enamel adjacent to the carious lesion making the lesion accessible to more effective tooth brushing. On the proximal surface, this has been referred to as a 'slice preparation'. Although this is a potentially useful technique, due to the lack of evidence, this approach should be restricted to situations where alternatives are limited (54) and when there is assurance that the caregiver will provide effective tooth brushing.

Sealing caries

Deliberate sealing of initial, moderate, and severe occlusal caries using conventional pit and fissure sealants without tooth tissue removal has been described in a number of clinical studies attempting to arrest caries progression (55). In an attempt to achieve a more predictable seal at the entrance to moderate and severe caries lesions, some researchers have advocated beveling the entrance to the fissure system and restoring with a more durable composite resin – the so-called 'ultraconservative caries removal' technique (56).

Although the use of pit and fissure sealant for the management of caries lesions is well supported by evidence, the use of proximal sealants is in its infancy and further research is required before its use can be advocated (57). In contrast to sealants which are applied to the surface of a tooth, resins have also been used to infiltrate noncavitated caries lesions (47, 58, 59). The evidence base for infiltration techniques is also limited, but while recognizing the more dramatic chemical removal of sound tissue intrinsically involved with this

method, infiltration of initial caries lesions has the potential to be a promising approach.

For primary molar teeth with moderate or severe caries lesions, preformed metal crowns placed without caries removal and/or tooth preparation (Hall Technique) have been advocated (60). Sealing in caries, in this way has led to fewer major and minor failures and has been shown to be more acceptable to patients and dentists than conventional tooth preparation and restoration.

The above techniques which have sealed caries into the tooth involve no attempt to re-enter the lesion to remove residual caries. In contrast, stepwise excavation involves sealing severe caries into the tooth for a period of 3–12 months and then re-entry to excavate the residual caries. This technique deprives organisms within the carious biomass of substrate from the oral cavity, leading to a reduction in the number and diversity of microorganisms and arrest of the lesion (61). During this period, pulp dentine complex reactions take place leading to a reduced risk of pulpal exposure on re-entry (62, 63). The evidence base for this technique is now strong. (Editor comment: The evidence for stepwise excavation cannot yet be classified as definitive. There is a need for wider adoption of this technique in practice and further evaluation of outcomes)

Dental curriculum and clinical competencies

The adoption of the mission and goals for caries management as described in the document should have significant impact on the education of current dental students and practicing dentists. A framework for the educational competencies required for dentists who practice today has been defined in the European Curriculum for Cariology for Undergraduate Dental Students (64). The curriculum is designed to address the following five domains: (i) the knowledge base in cariology; (ii) risk assessment, synthesis, and diagnosis; (iii) decision making for preventive nonsurgical therapy; (iv) decision making for surgical therapy; and (v) evidence-based cariology in clinical and public health practice. For each domain, the curriculum defines major and supporting competencies described below:

Major competences

Within each domain, at least one 'major competence' is identified as relating to that domain's activity. A major competence is the ability of a dentist on graduation to perform or provide a particular but complex service or task. Its complexity suggests that multiple and more specific abilities (supporting competences) are required to support the performance of any major competence.

Supporting competences are defined as specific abilities that are subdivisions of a major competence. Achievement of a major competence requires the acquisition and demonstration of all supporting competences related to that particular service or task. However, some supporting competences may also contribute to the achievement of other major competences.

For each of the five domains major and supporting competencies are defined. There is total convergence between the CaMPs' mission and goals and the structure and goals of the proposed curriculum. Moreover, for each domain, specific skills and content have been identified (65) that can be the basis for a comprehensive caries management program at any dental school in the world. Efforts are underway to develop online accessible material and resources to aid dental schools and dentists to achieve the desired competencies.

Barriers and implementation

There are a number of barriers to overcome to ensure that patient-centered prevention remains the priority and restorative intervention is only used as a last resort (66). The continuing development of a middle-level entry point to this type of staging of management decisions continues to be important for those new to this type of caries care (52, 67), whereas allowing those dentists who prefer to use a 6-point scale of caries to monitor outcomes of preventive care is also a key consideration. Simple and intuitive 'fast-track' options are being developed and should be evaluated. It is also important to look at more effective methods of communicating the benefits of the ICCMS to patients as well as third party payers.

There are both internal and external barriers to successful implementation of the CaMPs and the cariology curriculum described earlier. Change will take some time and will require introducing several key steps by coordinated groups, including professional dental organizations, researchers, cariologists, educators, manufacturers, and third party payers.

External to the dental profession, the single most important determinant of how caries is managed is the incentive system for students in dental schools and dental practitioners. Payment for procedures and not health outcomes has created a culture that is focused on restorative or surgical interventions. Patient and clinical assessments, synthesis, and diagnosis are not compensated well enough to entice practitioners to spend time analyzing the determinants of caries in a patient or a tooth surface. The mission of the CaMPs cannot be achieved with the current reimbursement system.

Another external factor that hinders change is the lack of knowledge among patients of what is the appropriate caries management outcome and the belief that dentists are right when they decide on surgically removing hard tissues. The lack of understanding of the uncertainty in decision making, especially false positive decisions, is a major reason that neither dentists nor patients question the decisions made in a dental office and is a reason why the intuitive decision making in caries management has rarely been challenged (i.e., because it is believed – 'decisions are accurate'). The comfort of the dental community with the current model of restorative care is unquestionably a major factor in perpetuating the status quo.

Another group which has been reluctant to change is dental educators. Dental students are 'grilled' into cutting plastic teeth, with no emphasis on tooth tissue preservation. Cariology, as a science, is poorly covered as a subject in curricula of most dental schools, because most of the time is devoted to performing restorative procedures. Research agencies have paid little attention to the scientific education of dental students and to the integration of science into dental curricula. Moreover, funding for caries research, especially in the US, has been a very low priority over the last three decades.

On the other hand, the community of researchers and cariologists is not unified in its approach to promoting change and has been divided into groups and alliances that promote one system or philosophy or another, even though they espouse the same values and content in their systems. Hence, instead of promoting one mission, several agendas are promoted.

Implementation science supports the development of interventions to address changes in the structure, process and outcomes that are desired by a group. The CaMPs workshop has defined a mission which is currently not emphasized en masse by all external and internal groups in the field of caries management. This guiding mission should be disseminated, explained, and promoted by all groups and individuals, regardless of the pathway leading to success in implementation. Structurally, new diagnostic and risk assessment tools, as well as new remineralizing technologies, should be developed to help transform the management of caries from a reparative focus to a preventive focus. The process of care should be changed to emphasize the importance of data collection, synthesis, and appropriate diagnosis to achieve the mission of tooth tissue preservation. Restorative procedures and materials should be revised based on the mission statement. For example, amalgam may be an inappropriate material in the 21st century because it requires removing tooth structure for mechanical retention. Its use may be limited to large cavitated lesions in posterior teeth. New bonding and sealing technologies should be developed. Most importantly, dentists should be reimbursed for managing a disease process, not simply for carrying out procedures. They should also be rewarded for keeping patients free from developing new caries lesions. This requires paying for the outcomes that are defined in the mission: preservation of natural tooth structure.

The most important change that is necessary is a refocusing of dental education and patient care from restorative procedures to managing the caries process. Without this change, caries management will remain dominated by the surgical approach indefinitely.

Finally, change can be facilitated by an informed public. With the potential for an international ban or restriction on the use of amalgam, caries management should be refocused on tooth- tissue preservation. The dental profession must share the understanding of caries prevention as described in this document with the public. Engaging the public in understanding the caries process, and how the patients as well as their dentist can preserve tooth structure, restoring only when absolutely necessary, may be by far the most important determining factor in moving the implementation of the CaMPs mission forward.

Reimbursement/Incentives for a new caries management system and outcomes

Development a new reimbursement or reward system in any country will be a formidable task with different solutions needed for different countries,

professional cultures, and economies. In America and in medicine, there is now more emphasis on payments for management of disease states (such as diabetes) rather than for individual tests and procedures. The mission of the CaMPs can direct the development of a new incentive system, customized to each country, to reward dentists (and dental students) for the following activities:

- Appropriate data collection (patient assessment and detailed clinical examinations including valid risk assessment).
- Making appropriate diagnoses and formulating treatment plans in consultation with patients.
- Payment for management of:
  (i) Healthy patients (primary prevention)
  (ii) Keeping healthy teeth from developing caries (primary prevention in patients with any caries level).
  (iii) Initial caries lesions.
  (iv) Moderate lesions.
  (v) Severe lesions.
  (vi) Monitoring the caries risk status of patients and individual teeth.
- Payment for additional care, such as endodontic therapy and fixed partial dentures.
- Payment for keeping patients free from disease and for preserving tooth structure.

The international dental federation (FDI) global caries initiative and CaMPs

The FDI and its 200-member organizations have a clear role and professional responsibility in 'leading the world to optimal oral health'. The Federation provides a platform to enable change-management and the implementation of a new model of care with respect to dental caries, the most common oral disease. The Federation is committed to playing a leading role in policy and advocacy at the highest level (Dr J. L. Eisele, June 2012, Personal communication), acting as a facilitator among different stakeholders and in educating dental practitioners through our national associations and partners. The FDI Global Caries Initiative (68) provides a scientific and political framework for actions and initiatives aimed at preserving tooth throughout life.

The inclusion of oral disease in paragraph 19 of the 2011 United Nations Political Declaration for the Control and Prevention of Noncommunicable Diseases (NCD) places dental caries in the global NCD agenda (69). The declaration reinforces the resolution adopted by the 60th World Health Assembly 2007 entitled 'Oral Health: Action Plan for Promotion and integrated Disease Prevention (70), which acknowledges the intrinsic link between oral health, general health and quality of life. This emphasizes 'the need to incorporate programmes for promotion of oral health and prevention of oral diseases into programmes for the integrated prevention and treatment of chronic diseases'. Thus, in seeking to define and develop appropriate caries care, we will need to ensure that it can be implemented within the wider health and development policy agenda.

In this review, we would like to present the global health policy context and explore how the dual aims of managing caries risk and preserving tooth structure can guide oral health policy and enable advocacy for appropriate caries care for the 21st century.

Managing caries risk as an integral part of global health

Oral disease – systemic health relationship is complex and with evidence of this fact, continually emerging. The adoption of a common risk factors approach (71) will enable multiple health conditions to be prevented, controlled, and managed by focusing on risk factors common to all of them. Health literacy directed at diet, smoking, alcohol, exercise, and cleanliness should be integrated (72). This has implications with regards to our future role and responsibility of the dentist. Our contribution to global health, primary health care, and integrated management of NCDs should be strengthened, as we already play an important role in covering health promotion, disease prevention, specialized treatment and rehabilitation, as well as providing early detection and surveillance.

Although an increase the numbers of dentists (Editor: in some countries) is imperative, so is the need to strengthen their impact on population health outcomes. Oral health profession leadership is required to help improve health system performance and outcomes. We will need to work with the World Health Organization (WHO) in its efforts to implement the 'transformative scale-up of health profession education (73). At the same time, governments are encouraging health professions to move toward inter-professional education and to deliver a practice-ready collaborative practice workforce, which will be more flexible and

allow for best use of scarce human and financial resources. As the Caries Management Pathways conference noted, dental education will need to reflect the interconnectedness of oral health, general health, and well being (74).

The notion of interconnectedness should also extend beyond health. Increasingly, dentistry is involved in global discussions on the environment and sustainable development. The WHO United Nations Environmental programme (UNEP) Health Environment Linkage reports that environmental hazards are responsible for an estimated 25% of the total burden of disease worldwide and nearly 35% in regions such as sub-Saharan Africa (75). Caries management pathways will need to adapt to the shift towards health in all policies (76) a 'whole government, whole Society' approach to national policy and planning. In developing appropriate dental care, we will need to examine our technologies and materials within the prism of public health and the environment.

Oral health is an essential component of good health and good oral health is a fundamental human right. WHO has appropriately emphasized the social determinants of health (SDH) in its global monitoring framework, thus reinforcing the close link between the SDH and NCDs (69). Health-related behaviors are modifiable, particularly if introduced early in life as recommended by the WHO's Commission on the SDH (77). Managing caries risk will need to recognize and view the social determinants of health as an essential element of appropriate caries care.

The most effective way to change behaviors is to change the environment and this will require a multisectoral approach to engage sectors outside health, for example transport, urban planning, infrastructure in promoting physical activity and healthy living (e.g., CHESS principles for health living environment) (78). Missing days in school impacts on education performance and outcomes, thus relates the general NCD concept to key determinants of health and a key MDG education goal (79). Loss of productive time at work reduces economic performance, which is a key impact of all NCDs and oral diseases.

Preserve tooth structure

There is no doubt that our current model of caries classification and management has improved the oral health of many millions of people around the world. But there is an ever-widening gap between what we now know about the caries process and what we do in clinical practice. Integrating the management of dental caries into global strategies for communicable and chronic diseases will provide a medical framework aimed at improving health through risk assessment and surveillance, disease prevention and health promotion, thus prioritizing preservation over restoration.

In response to this know-do gap, FDI launched the Global Caries Initiative (GCI 2009–2020) at the Rio Caries Conference in 2009 (80), with the goal 'to improve oral health through the implementation of a new paradigm for managing dental caries and its consequences, one that is based on our current knowledge of the disease process and its prevention, so as to deliver optimal oral and thus general health and well being to all peoples by 2020'. Central to the new model of caries management is the goal of preserving tooth structure throughout life.

The 2009 Rio conference identified key priority action areas: development of a common language for caries; the eradication of early childhood caries in children <3 years of age; the primary and secondary prevention of caries and health promotion activities. The focus on 0–3 age group will enable us to integrate oral health into maternal and child health initiatives and establish behavior that will minimize or indeed eradicate the destruction of tooth tissue in this age group.

The first phase of the GCI (2009–2012) has established a broad policy base in support of the new paradigm of caries management and developed instruments that will enable its implementation. A key milestone was the development of the FDI Caries Matrix, the first step to integrating current science into dental practice (18).

In its next phase, GCI will provide the tools and the instruments to support this shift in caries management pathways into the daily practice of dentists, public health care, and national policy. The GCI website www.globalcariesinitiative.org is set to become a platform for content sharing and knowledge transfer among FDI members, their constituency, and a wider audience (80). GCI should embrace interprofessional education to ensure relevance to population health needs and enable our dental graduates to respond to those needs within a collaborative practice-ready workforce.

Our roadmap toward appropriate caries care for the 21st century will only be successfully

achieved if it is part of an integral approach to global health. A recent editorial in The Journal of the American Dental Association notes that future caries management should enable the quantification of health outcomes, which is important for the future progress of our profession (80). Preserving tooth structure should be recognized as a health outcome.

Research agenda

In 2001, the National Institutes of Health sponsored a Consensus Development Conference on Caries Management throughout Life (81). For the last 11 years, the following observations and research agenda of the conference remained unnoticed by funding agencies:

- Existing diagnostic modalities require stronger validation.
- New diagnostic modalities are needed with appropriate sensitivities and specificities for different sites.
- Research on diagnosis of root caries, caries adjacent to restorations, is needed.
- Research on the use of an explorer in detecting occlusal caries which appears to add little information and may be detrimental.
- Existing diagnostic modalities appear to be satisfactory for diagnosing overt, cavitated lesions but are inadequate to diagnose noncavitated lesions, root-surface lesions, or secondary caries efficaciously.
- Specific recommendations for research included:
  (i) Research into diagnostic methods, including established and new devices and techniques, is needed.
  (ii) Development of standardized methods of calibrating examiners is also needed.
- Clinical trials of established and new treatment methods are needed. These should conform to contemporary standards of design, implementation, analysis, and reporting. They should include trials of efficacy.

These observations and research agenda defined in 2001 are still not adopted by the NIDCR/NIH strategic plan.

In addition to the former research agenda and other recent research agenda (85) additional areas for research include the following:

- Biofilm: Using new technologies, a full mapping of the bacterial and nonbacterial species in the biofilm should be conducted with a focus on identifying bacterial profiles and biofilm characteristics that are associated with health and disease.
- Salivary factors: Similarly, there is a need to map out the proteins, acid buffering, and initiators of remineralization that are associated with health and disease.
- Dietary factors: Research on new food, snacks, and drinks that are safe for teeth, more emphasis on nutritional literacy including its assessment and interventions to reduce the exposure to sugars and social determinants of dietary behaviors in children related to sugar consumption.
- Diagnosis: Using sequential detection systems, including new aids, to differentiate with high accuracy between sound, initial, moderate, and severe lesions.
- Lesion activity: Research on micro- or nano-tooth surface changes that are indicative of caries activity in addition to using the biofilm as a tool for assessing activity status of a lesion.
- Risk assessment: Development of practical tools for collection and analysis of biological and behavioral risk factors to predict the risk of developing caries.
- Research on best interventions to reduce exposure to risk factors associated with dental caries.
- Remineralizing technologies that inhibit the progression of initial caries or reverse these lesions.
- Restorative techniques and materials to preserve tooth structure and protect teeth from future caries development.
- Research on best methods of engaging patients in their own oral health.
- Research on best methods of training/retraining dental care providers how to communicate with their patients to ensure their understanding of caries prevention.
- Research on best methods of training/retraining dental care providers how to prevent dental caries.
- Demonstration projects on reimbursement for keeping patients caries-free.
- Research on best methods of educating policy makers regarding caries prevention.

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Appendix 1

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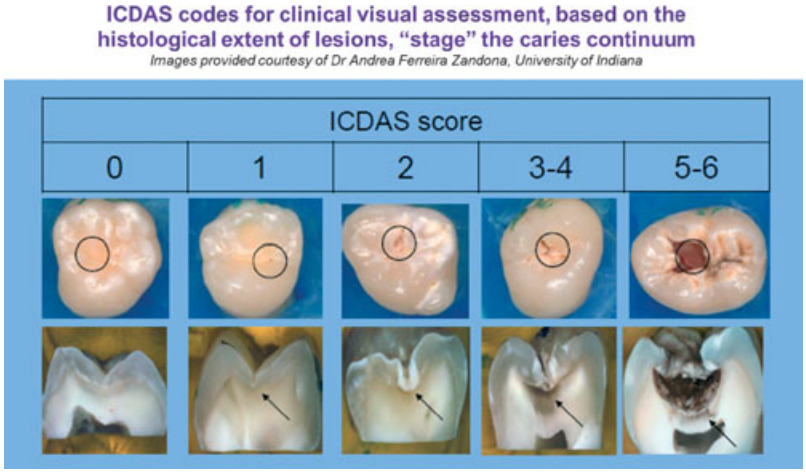
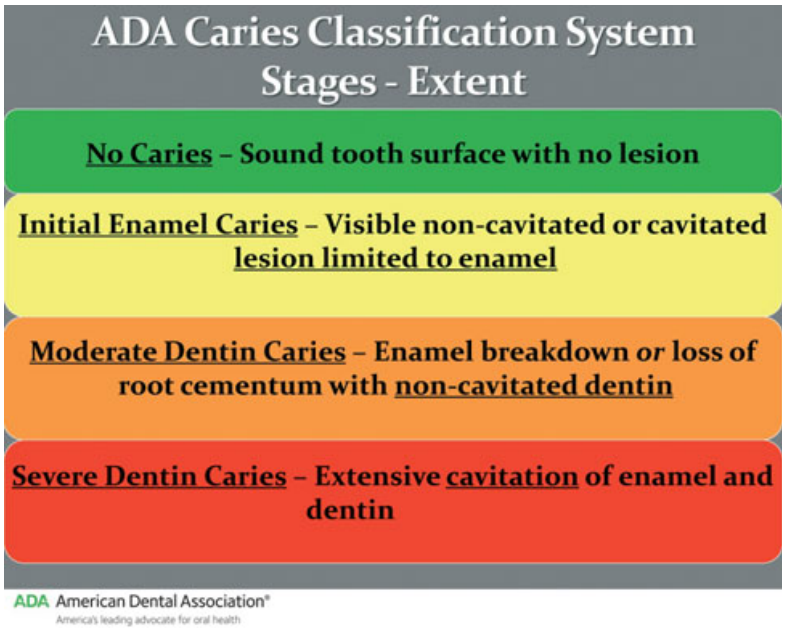
Appendix 2
ICDAS criteria

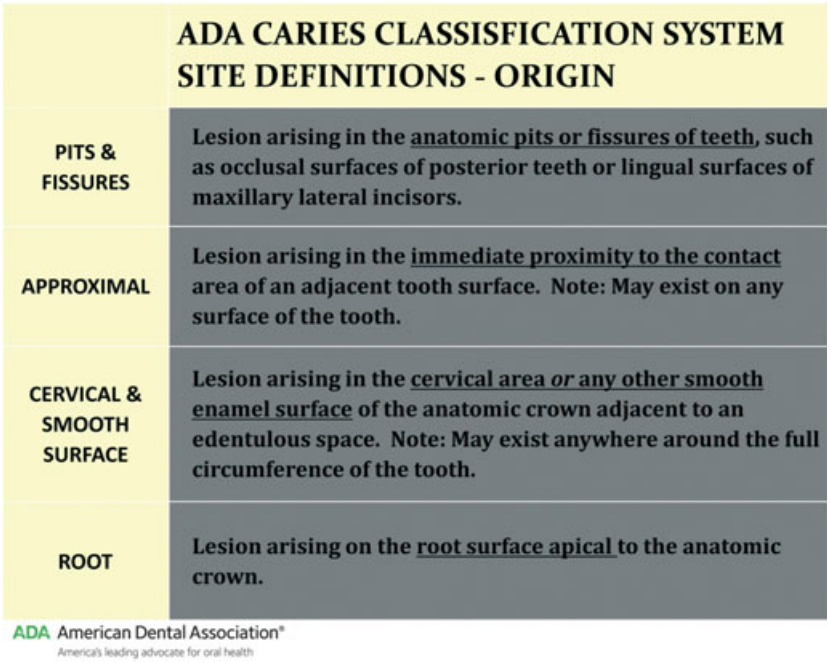
ICDAS code	Description
0	Sound tooth surface
1	First visual change in enamel
2	Distinct visual change in enamel
3	Localized enamel breakdown due to caries with no visible dentin
4	Underlying dark shadow from dentin (with or without enamel breakdown)
5	Distinct cavity with visible dentin
6	Extensive distinct cavity with visible dentin



Appendix 3
ADA CCS stages-extent



Appendix 4
ADA CCS site definitions-origin



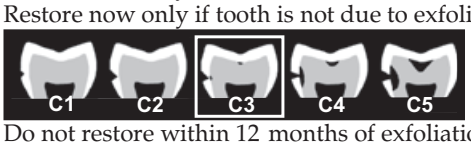
Appendix 5
Caries management system protocol for permanent teeth diagnosed clinically (ICDAS II) or from bitewing radiographic images in relation to children, adolescents, and adults

Lesion code	Management
ICDAS II	
1–2	Apply fluoride varnish to (i) arrest and remineralise active lesions and (ii) maintain arrested lesions
3–4	Restore with UCSR *only if* associated Radiolucency extends deeper than C4 *otherwise* Fissure seal and review in 6 months (bitewings)
5	Restore with UCSR
6	Restore
Bitewing	
Cl (El)	Do not restore – apply topical fluoride and monitor
C2 (E2)	Do not restore – apply topical fluoride and monitor
C3 (Dl.a)	Do not restore – apply topical fluoride and monitor
C4 (Dl.b)	Do not restore *without further consideration*
C5 (D2)	Restore now
	
Further consideration of C4 (Dl.b) surfaces	If possible, separate teeth and restore only if cavitation is revealed Otherwise, do not restore because it is more likely than not that the approximal surface Is not cavitated And lesion progression could be arrested or has already arrested Implement preventive stategy to Arrest active lesions Remineralise lesions Maintain arrested lesions

UCSR, ultra-conservative sealed restoration.
Source: Modified from Evans et al. (12)

Appendix 6

Caries management protocols for primary teeth diagnosed clinically (ICDAS II) or from bitewing radiographic images

Lesion code	Management
ICDAS II	
1–2	Apply fluoride varnish to arrest and remineralise active lesions and to maintain arrested lesions
3	Restore *only if* associated bitewing radiolucency extends deeper than C3 *otherwise* seal or protected with GIC and review in 6 months (bitewings)
4–6	Restore
Bitewings	
Cl (El)	Do not restore – apply topical fluoride and monitor
C2 (E2)	Do not restore – apply topical fluoride and monitor
C3 (Dl.a)	Do not restore *without further consideration*
C4 (Dl.b)	Restore now only if tooth is not due to exfoliate[a]
C5 (D2)	Restore now only if tooth is not due to exfoliate[a]
	
Further consideration of C4 (Dl.a) surfaces	Do not restore within 12 months of exfoliation[a] Restore if shadow is evident below marginal ridge Otherwise separate teeth and restore *only if* cavitation is revealed Implement preventive stategy to Arrest active lesions Remineralise lesions Maintain arrested lesions Preserve first molars (take particular care)

[a]Clue – less than 1/2 of root remains.

Source: Evans & Dennison (13).