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MANAGEMENT OF INITIAL CARIES LESIONS: IOWA SURVEY

by

Amira Elgreatly

A thesis submitted in partial fulfillment
of the requirements for the Master of Science
degree in Oral Science in the
Graduate College of
The University of Iowa

May 2017

Thesis Supervisors: Associate Professor Justine L. Kolker
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Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

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MASTER'S THESIS

_____

This is to certify that the Master's thesis of

Amira Elgreatly

has been approved by the Examining Committee for the thesis requirement for the Master of Science degree in Oral Science at the May 2017 graduation.

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To my dear parents and siblings, for their endless love and support.
To my husband Ahmed Mahrous for his devoted love and encouragement.
To my son Yousef, I love you so much.

ACKNOWLEDGEMENTS

I would like to express my gratitude and appreciation to my thesis mentors Dr. Justine Kolker and Dr. Sandra Guzman-Armstrong for their patience, knowledge, and encouragement during this research project. I would also like to thank Dr. John Warren, it was a great privilege to have him as part of my thesis committee and I am grateful for all his support, advice and knowledge during this entire process. Last but not least, I would like to thank Dr. Fang Qian for her support and sharing her expertise with the study design and statistical analysis.

I also want to thank my special classmates Dr. Tracy D'Antonio and Dr. Watcharaphong Ariyakriangkai. I was so fortunate to have them during the three years of my program I would not have done it without their support.

Finally I would like to thank all the Operative Department for their support during my residency and masters.

ABSTRACT

The purpose of this study was to investigate Iowa dentist agreement with the International Caries Classification and Management System (ICCMS) Guidelines.in the non surgical management of initial caries lesions in low, moderate and high risk patients. Also to explore factors related to Iowa dentists' management of initial caries lesions in the different caries risk levels.

A survey was electronically sent to 916 University of Iowa alumni dentists who were in active practice. Information on dentists' demographics and practice characteristics were collected in the first section of the survey. The second section included three case based scenarios (low, moderate and high-risk) and for each scenario, three initial caries lesions (ooclusal, interproximal and smooth surface) were provided. Dentists were asked what is their most likely diagnosis of the lesions and what treatment would they recommend for each lesion. Descriptive statistics were conducted to profile the variables of interest. Bivariate analyses were performed to assess the factors associated with the management of initial caries lesions for each scenario. Logistic regression analyses were conducted to assess the variables that could predict Iowa dentist agreement with ICCMS.

138 (response rate=15%; male=83 and female=55) practicing dentists in Iowa completed the survey. Of these (mean age= 48.3years, mean years of clinical practice= 21.4), 70% completed a formal post-graduate training program, and 35% were solo practitioners. Agreement with ICCMS guidelines regarding the management of initial caries lesions for low, moderate and high-risk scenarios was approximately 73%, 59%, and 51% respectively. Odds of having agreement with

ICCMS in the low risk scenario for those who frequently dry the tooth was 3.6 times that of those who less frequently dry the tooth for caries detection (p=0.0468). Odds of having agreement with ICCMS in the moderate risk for those who graduated <20 years ago was 6 times that of those who graduated >30 years ago (p=0.0024). Odds of having agreement with ICCMS in the moderate risk scenario for those who practiced in public health setting was 14 times that of those who practiced in solo practice (p=0.0089) and for those who frequently used magnification was 2.9 times that of those who less frequently use magnification (p=0.0225). Odds of having agreement with ICCMS in the high risk scenario for those who frequently performed CRA was 2 times that of those who less frequently perform CRA (p=0.0262).

The majority of Iowa dentists agreed with ICCMS guidelines in the non-surgical management of initial caries lesions regardless of patient risk level. Iowa dentists had the highest agreement with the ICCMS guidelines for low-risk scenario and agreement was associated with routinely drying teeth for caries detection. Evidence based decisions individualized for a patients' risk status are essential for determining the best management of dental caries lesions.

PUBLIC ABSTRACT

Dentistry has changed from its humble beginnings to the present day. One of the areas that have advanced the most in dentistry is the understanding of diseases that affect the teeth as well as the supporting structures. However, despite all of these advancements, some diseases still prove problematic. One of the most prominent examples of these diseases is dental caries. Dental caries is a disease caused by bacteria that leads to the destruction of tooth structure.

Traditional management techniques involved removal of tooth structure that is affected by caries, and even extending further to prevent recurrence, and then replacing the removed tooth structure with restorative material. However one of the most significant issues with the excessive removal of tooth structure is weakening of the structure of the teeth, making it prone to further breakdown. Modern understanding of the disease process has led to the discovery that not all carious lesions require removal and that it is possible to reverse the progression of caries leading to preservation of tooth structure that would traditionally be removed. However, despite the available evidence of such treatment, not all dentists have adopted the modern management strategies.

There is considerable evidence in the literature indicating that a significant amount of dentists still practice traditional caries management techniques, However this data was never recorded for the dentists in Iowa, thus this study aims to investigate the treatment decisions and weather they are in accordance with the modern management standards through a case based survey.

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CHAPTER I: INTRODUCTION

Mankind has come a long way in health care, advancing from holistic medicine and anecdotal remedies to actual evidence based treatment. However despite all the advances in medicine, some diseases remain problematic (1).

According the National Institute of Dental and Craniofacial Research, dental caries remains the most prevalent chronic disease (2). The Centers for Disease Control and Prevention reported that, ninety-one percent of Americans over twenty at some point in their lives have had cavities. Also it was reported that 27 percent of adults over twenty have untreated caries (3). Dental caries is a process involving an imbalance between the tooth surface and the bacteria in the microbial biofilm resulting in demineralization (4). If this imbalance progresses, loss of minerals from the tooth will lead to frank cavitation with subsequent loss of tooth structure. Dental caries is a continuous process (4) beginning as surface lesions and then progressing into cavitated ones. The progression of early non cavitated caries lesions is slower, thus giving more time for their detection. Moreover the initial lesions are also amenable to remineralization and literally reversing the process before its progression (4). Extensive effort has been made to detect, intercept, reverse and treat initial caries lesions. (4, 5) Unfortunately, evidence suggests that in the past 50 years all these efforts have been only partially successful (6). However in recent years of new caries detection and management systems have been developed, and are showing promise.

Several systems have developed over years to help standardize and simplify the diagnosis and management of dental caries. The International Caries Detection and Assessment System (ICDAS) was developed in 2002 (7). Its main concept is that, the use of a standardized system, based on best available evidence for detecting initial and advanced stages of caries, which should lead to the achievement of better quality

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information that could be used to inform decisions about appropriate diagnosis and clinical management of dental caries(8). The International Caries Classification and Management System (ICCMS) is a health outcome focused system that aims to maintain health and preserve tooth structure. The two key aspects of the ICCMS system are Classification (Caries Staging & Activity Assessment) and Management (Personalized Caries Prevention, Control & Tooth Preserving Operative Care). The ICCMS should be able to help in planning, reviewing and monitoring caries in clinical and public practice(5). The application of the combined synergy of the ICDAS and the ICCMS will synergistically provide tools for detection, prevention and management of dental caries.

Caries risk assessment is the determination of the likelihood of the incidence of caries during a certain time period after evaluating individualized risk factors that affect the disease process of the patient (9). Caries risk assessment models involve a combination of factors including caries indicators and protective factors (10, 11). Caries risk indicators are variables that are thought to cause the disease directly or have been shown useful in predicting it and include those variables that may be considered protective factors. Once dental caries is detected, and the risk factors are considered, treatment can then be evidence based.

According to the American Dental Association (ADA), Evidence Based Dentistry (EBD) is " an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences" (12). It is sensible to say that EBD includes dentists making clinical decisions based on the integration of the best available research evidence, their clinical experience and their patient's needs.

In the literature it is noted that a surgical approach to manage initial carious lesions has been dominant in dental practices, despite the availability of sound research

evidence suggesting the contrary (13). This surgical approach is problematic because it does not deal with the underlying causes of dental caries as a disease *per se*, and it creates a lasting need to repair and replace restorations (1). Subsequently repeated restorative care may eventually lead to loss of teeth and then substitution by dentures or implants creating a financial burden for patients. Thus non surgical preventive measures can become a less costly and more effective modality over the long term.

Initial caries lesions can be arrested or reversed before their progression leads to loss of tooth structure (14). Early caries detection and the use of non surgical interventions are important approaches for managing dental caries. Although in a few cases a surgical approach is needed to arrest caries progression, the non surgical approach generally provides potential benefits that include conserving structure by delaying intervention or minimizing surgical procedures.

So what is hindering the transfer of this knowledge into dental practice? The literature suggests potential explanations, such as: characteristics of dentists; characteristics of patients; characteristics of the dental practice environment; characteristics of the health system in place and a lack of active translation of new knowledge into practice (13, 15). Thus guidelines should be put in place for the appropriate management of dental caries as a disease.

There is a wide variation in management decisions among dentists and the decision- making process of how dentists choose the appropriate treatment strategy is not well known. Also, the factors influencing their decision-making process are not clearly understood. Therefore, the dentists' management regarding the choice between surgical and non surgical approaches for initial caries lesions should be explored. Thus, this study aims to describe dentist's caries management decisions based on consideration of patient. Dentists' characteristics that might influence their management will be explored. The

purpose of this study is to assess dentists' management of initial caries lesions in three caries risk levels (low, moderate, and high) and the agreement with the ICCMS guidelines in the non surgical management of initial caries lesions. A survey with hypothetical scenarios will be used to assess the views of dentists' related to caries management of initial caries lesions.

<u>Research questions</u>

Do dentists appropriately recommend treatment for initial caries lesions for low risk patient according to the ICCMS?

Do dentists appropriately recommend treatment for initial caries lesions for moderate risk patient according to the ICCMS?

Do dentists appropriately recommend treatment for initial caries lesions for high risk patient according to the ICCMS?

What factors are associated with an appropriate treatment decision for a low risk patient?

What factors are associated with an appropriate treatment decision for a moderate risk patient?

What factors are associated with an appropriate treatment decision for a high risk patient?

CHAPTER II: LITERATURE REVIEW

Introduction

Dental caries is considered to be the most common chronic disease (16, 17). Due to recent advancements in understanding the disease presentation, management of caries lesions has slowly moved away from the traditional surgical (restorative) approach to a more conservative and tooth preservative methods with emphasis on re-mineralization of initial carious lesions. The development of initial carious lesions seems to be comparatively slow in most patients, allowing the implementation of the preventive strategies when the lesions have the highest probability to be arrested. Classic diagnostic techniques along with a more thorough understanding of caries lesions, will aid in both the diagnosis and the management of dental caries (18).

The notion that caries is identified only when restorative intervention is warranted has changed during the past two decades to one in which caries is viewed as a continuous process that spans the lesions beginning with demineralization all the way to becoming frank caries lesions (19). Dental caries at a basic level is initiated due to an imbalance between remineralization of the tooth surface and the demineralization caused by the acids released by the microbial biofilm (20, 21). If this imbalance progresses, the loss of minerals will progress to frank cavitation. During the early of carious lesion the preventive strategies can arrest the progression of the lesion and promote remineralization. Therapies targeting promotion of remineralization can be applied, however this will be affected by factors such as the stage in the caries process and the rate of progression of the disease (10). Therefore, the assessment of initial carious lesions becomes essential. Over the last years, novel techniques in the identification and management of caries, and especially in the initial stages of the caries have been developed based on a better understanding of the biology of the caries process.

Clinical caries detection measures including detection of initial (non cavitated) lesions have been introduced and described in many clinical studies (22). Numerous caries detection systems have been developed to score initial lesions (23-25). However, some approaches that rely only on detection of cavitated lesion are still used in dental practice. At this point, cavitated lesions are managed by restorative care (25).

The recommendation of the International Consensus Workshop on Caries Clinical Trials (26) was that Caries detection techniques should precisely identify any changes of the tooth structure, be able to observe various stages of mineralization and determine the activity level of caries lesion.

Dental plaque biofilms

Dental plaque on teeth harbor one of the most diverse collections of oral microorganisms (27). The development of these biofilms has been investigated. Within seconds of tooth eruption, and following cleaning, teeth surfaces are covered with a layer of salivary glycoproteins and proteins that is called the "acquired pellicle". Functions of the enamel pellicle include lubrication for effective mastication and protection against demineralization. (28, 29) Initially, only a few bacterial species are able to attach to the acquired pellicle. Cells are held reversibly near to the surface by weak, long-range physicochemical forces. Molecules (adhesins) on these early bacterial colonizers, mainly streptococci (e.g., Streptococcus mitis and S oralis) can bind to complementary receptors in the acquired pellicle to make the attachment irreversible (30) and then these pioneer species start to multiply. The metabolism of the early colonizers adjusts to the local ecosystem, to pave the way for different species of bacteria to subsequently attach, thus diversifying the microbial composition. This process is also known as "microbial succession". (31)The Bacteria that attach start producing the plaque matrix, which is

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composed of extracellular matrix that augments attachment of the biofilm. The matrix is more than a mere scaffold for the biofilm; the matrix can bind and retain molecules, including enzymes, and also retard the penetration of charged molecules into the biofilm. The presence of various types of bacteria living in close proximity yields the opportunity for interactions. (32) Which ultimately produce a more resilient and complex bacterial community.

The composition of the microbial biofilm varies from fissures, approximal surfaces, and gingival crevice (33). Normal fissure microflora is sparse and the organisms present have a saccharolytic metabolism (i.e., their energy is derived from sugar catabolism); the predominant bacteria are streptococci and there are few gram-negative or anaerobic organisms. In contrast, the gingival crevice has a more diverse microflora, including many gram-negative anaerobic and proteolytic species, whereas approximal surfaces have a microflora that is intermediate in composition. The structure of the microflora at any site remains constant, given that there are no severe environmental changes. This is called "microbial homeostasis" which highlights the active state in which the quantities of individual species is balanced due to both synergistic and antagonistic interactions.

Dental caries process

Dental caries is known as a dynamic process where an imbalance leads to mineral loss. This imbalance begins when the bacterial biofilm neutral pH drops from an acidic pH of 7.0 to a pH of less than 5.0. As pH is lowered in the dental plaque and saliva, the super saturation with respect to hydroxyapatite is reduced leading to enamel dissolution (34). However, flourapatite can form instead, given that appropriate conditions are

present, and these conditions are as follows: 1) presence of fluoride at the same time as the hydroxyapatite is dissolving, 2) a pH equal to or higher than 4.5.

If low PH persists the intercrystalline spaces become wider, indicating a partial dissolution of the Hydroxyapatite crystal surfaces. Under in-situ conditions the first clinical enamel changes are visible as opaque changes after air-drying. The porosity is increased and a subsurface lesion is formed after 14 days. After three or four weeks of biofilm retention conditions, the surface shows a complete dissolution of thin perikymata and pits of Tomes' processes, with visual signs of opacity, even without air-drying (35).

As the enamel is a micro-porous solid composed of crystals, and because the caries lesion is the result of acids reacting with individual crystals, it is reasonable to consider the intercrystalline spaces as being the most important pathways for the diffusion of ions into and out of the enamel, particularly at initial stages of lesion formation (35).

Moynihan et al. 2014 (36) performed a systematic review investigating the relationship between the carbohydrate intake and caries development: they also he investigated the effect of restricting sugar intake on caries. The results showed that reduction of sugar intake had a subsequent reduction in caries risk of patients. Long-term plaque retention can lead to the demineralization and destruction of the teeth through caries. Biofilm control is an effective way to prevent dental caries. There is good evidence that tooth brushing with fluoride toothpaste, flossing, and optimal oral hygiene practices prevent dental caries.

Histological studies have shown that initial caries lesions consist of four layers: surface, body, dark, and translucent zones. Being the most superficial, the surface zone is intact and well mineralized; also this surface is relatively immune to caries because it is hypermineralized from the contact with saliva. The second layer is the body zone, is very porous and it is the largest of the four regions in demineralization. The third layer is the dark zone which consists of tiny pores as well as interprismatic areas and cross striations

suggesting the process of demineralization and remineralization. The fourth layer is the translucent zone, which is also the deepest and is tightly packed with more mineralization, with pores formed along the enamel rod boundaries (37). The increase in the internal enamel porosity due to demineralization will appear clinically as loss of translucency producing the characteristic chalky surface of the initial caries lesion. The increased porosity in the initial caries lesion creates a fragile surface that is prone to cavitation. Subsequently, the reduced density of those lesions may be detected radiographically or with transillumination. Initial caries lesions still have potential for re-mineralization (35). Therefore, early clinical detection, monitoring and possible remineralization of initial lesions is an important step in caries management.

Caries detection and severity assessment

Caries lesion diagnosis involves both detection and assessment, such as color, surface and integrity, but most important is to determine whether the lesion is active, progressing rapidly or slowly, or is arrested(26).

Lesion Detection

Visual examination of the tooth surfaces is among the most common methods of caries lesion detection (38). Different caries indices have been developed in order to standardize and quantify the disease.

The DMFT/dmft index:

The DMFT/dmft index was originally described as D for decay referring to frank cavitated lesions, M for teeth that were missing due to caries and F for filled teeth. This index gave equivalent importance to teeth that are missing, untreated, well restored or decayed. It is inapplicable for teeth extracted for non-caries reasons, it can overestimate

the caries experience in teeth with preventive restorations, and it gives little information about treatment needs. The DMF index is a system that can be applied for the whole tooth (DMFT) or for each surface (DMFS), for primary teeth (dmft) and for permanent teeth (DMFT) (39).

Ekstrand criteria:

Ekstrand et al. (1995) suggested a scoring system based on visual assessment of the depth of lesion penetration. The scale described the following scores: (24)
0=No or slight-in-enamel translucency after drying (5 secs)
1=Opacity or discoloration hardly visible on wet surfaces but distinctly visible after drying
2=Opacity or discoloration distinctly visible without drying
3=Localized enamel breakdown in opaque or discolored enamel and/or grey discoloration from the underlying dentine cavitation exposing dentine

This method recognizes the physical phenomenon of the white spot in very early lesions, clinically assessed only after air-drying. One of the most significant advantages of the system is its correlation with histology.

ICDAS

The International Caries Detection and Assessment System (ICDAS) (40). Is a classification concept that aids in the detection of late as well as early caries lesions by using a standardized evidence based system (41). The ICDAS is based on a division of stages of the dental caries process into groups based on histological and clinical visualization (24, 42-45).

The criteria consist of 7 scores: (40)
0=Sound
1= First visual change in enamel (seen after air drying)
2= Distinct visual change in enamel
3= Localized enamel breakdown (without clinical visual signs of dentinal involvement)
4= Underlying dark shadow from dentine
5= Distinct cavity with visible dentine
6= Extensive distinct cavity with visible dentine involving more than half the dentin

Caries detection on dry clean teeth should be aided with a small ball ended explorer (40). Lesion activity should also be assessed in order to apply preventive measures if needed (46). Using ICDAS has shown to be accurate and reproducible in detecting early lesions and lesion changes (47, 48). Recently the International Caries Classification and Management System-ICCMS and the ICDAS have joined forces in order to aid in the management of caries lesions (49) . ICCMS will be discussed in more detail later in this chapter.

American Dental Association Caries Classification System (ADA CCS):

This system integrates the ICDAS with other systems (50) resulting in a more comprehensive classification system that also takes the radiographic appearance of proximal surfaces into account. ADA CCS score caries lesions based on the following: anatomic site of origin, severity of the lesion and the lesion activity (51).

Anatomic site of origin: (50) The caries lesion could originate from the following sites: pit and fissure, approximal cervical and smooth surface as well as root caries.

Lesion severity criteria: Clinically the caries lesion may have the following visual appearance:

Sound: no clinically detectable lesion. Dental hard tissue appears normal in color, translucency and gloss.

Initial: earliest clinically detectable lesion compatible with mild demineralization. Lesion limited to enamel or to shallow demineralization of cementum/ dentin. Mildest forms are detectable only after drying. When established and active lesions may be white or brown and enamel has lost its normal gloss

Moderate: visible signs of enamel breakdown or signs the dentin is moderately demineralized.

Advanced: enamel is fully cavitated and dentin is exposed. Dentin lesion is deeply / severely demineralized.

Radiographically the proximal lesion may present as the following as described by Pitts et al. (8):

Sound: E0 or R0 No translucency

Initial: E1 or RA1 Radiolucency in the outermost half of the enamel
E2 or RA2 Radiolucency in the innermost half of the enamel
D1 or RA3 Radiolucency limited to the outermost third of dentin

Moderate: D2 or RB4 Radiolucency reaching the middle third of dentin

Severe: D3 or RB5 Radiolucency reaching the innermost third of dentin

Lesion activity assessment

Ekstrand et al. (46) Described clinical activity assessment factors to consider when making a clinical determination of lesion activity as presented in Table 1. From the current table it can be concluded that inactive and active lesions differ in many aspects and can be mostly distinguished through a thorough examination.

Table 1 Clinical activity assessment factors

Characteristics of active and inactive caries lesions.		
ACTIVITY ASSESSMENT FACTOR	**CARIES LESION ACTIVITY ASSESSMENT DESCRIPTORS**	
	Inactive/Arrested	Active
Location of the Lesion	In plaque filled area	In plaque filled pit/fissure, proximal, gingival
Plaque over the Lesion	Not thick or sticky	Thick and/or sticky
Surface Appearance	Shiny color: brown/black	Matte/opaque/loss of luster; color: white/yellow
Tactile Feeling	Smooth, hard enamel/ hard dentin	Rough enamel/soft dentin
Gingival Status (If the Lesion Is Located Near the Gingiva)	No inflammation, no bleeding on probing	Inflammation, bleeding on probing

Caries Risk Assessment (CRA)

Risk assessment involves an analysis of the probability (prediction) that a patient will have a change in the number, size (depth or width), or activity of caries lesions(52). The assessment also aims to identify factors associated with the etiology of the disease process (i.e., caries risk factors), factors that are indicators or evidence of the presence of disease as well as factors associated with disease prevention and management (i.e.,

protective factors) (53). Recent studies have determined that the most efficient method of dental caries management is the transforming of the oral biofilm and transforming the oral environment into one that favors health (21). This can be accomplished by decreasing caries promoting factors and increasing caries protective factors as described by Featherstone et al. (11).Caries promoting factors include cariogenic bacteria, frequent ingestion of fermentable carbohydrates, and salivary dysfunction and while caries protective factors include salivary glycoproteins , fluoride, and antibacterial therapy .

To determine the appropriate dental caries management plan it is necessary to perform a Caries risk assessment (CRA) which should also be considered to be the standard of care (51). CRA is important in decision-making, caries diagnosis, caries prognosis and treatment options presented to the patient. CRA provides a more personalized and patient focused treatment compared to the traditional method of using a standard treatment that applies to all patients. When assessing the high caries risk patients, preventive interventions can be implemented in an effort to control the caries disease. On the other hand, identifying the low caries risk patients will prevent unnecessary surgical intervention. Caries risk assessment can be done using various instruments, tests as well as computer-based systems for the assessment of caries risk, ranging from local or national (54).

Caries management by risk assessment (CAMBRA) is an evidence-based method aimed at prevention of early stage dental caries. The main idea of CAMBRA is the customized assessment of each individual patient for caries-risk factors protective factors and disease indicators. (55) Factors increasing caries risk include, but are not limited to (56):

Active caries in previous 12 months
High titers of cariogenic bacteria
Poor oral hygiene
Drug/alcohol abuse
Poor family dental health
Cariogenic diet
Genetic abnormality of teeth
Many multi-surface restorations

Chemo or H/N radiation therapy
Eating disorders
Active orthodontic treatment
Irregular dental care
Suboptimal fluoride exposure
Developmental or acquired enamel defects
Prolonged nursing (bottle or breast)
Presence of exposed root surfaces
Restoration overhangs and open margins
Physical or mental disability with inability or unavailability of performing proper oral health care
Xerostomia (medication, radiation, or disease-induced)

Assessing the risk indicators as well as the current caries risk of a patient is important to the accurate diagnosis of the patient, which is in turn important for the correct management of the caries lesions. Which will differ from initial caries to more advanced caries. Initial caries are usually dealt with by arresting the disease process or remineralization.

Arrest of initial caries lesions

The caries lesion may be arrested at any stage by removing the cariogenic biofilm (57). Remineralization occurs when calcium and phosphates, originating from saliva or other sources, recrystallize and build on existing enamel crystals. In this process, fluorides have a considerable function of speeding up the process. The mineral formed during the remineralization is stronger, especially if fluoride ions are incorporated into the surface. These ions can attract calcium ions, which in turn attract phosphate ions, and finally create a fluorapatite like crystal surface. This also means the demineralization by acid can be markedly inhibited by a sufficient concentration of fluoride ions on the crystal surface (1). This in turn will not only stop the advance of the caries but can potentially cause the lesion to regress. The use of the word remineralization has often been associated with lesion arrest by a chemical agent (57). However, cavitated lesions can still be arrested with plaque removal alone. The dentine pulp complex is not passive

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and can respond to carious attacks by production of tertiary dentine (58).
Remineralization often takes place in the surface layer blocking the diffusion of ions in
and out of the lesion(28).

<center>Preventive and non surgical treatment</center>

Fluoride

Fluoride can defend teeth against caries by either topical or systemic modalities.
Systemic fluorides are components of edible material (59) that are incorporated into tooth
structure during tooth formation prior to eruption. This fluoride converts hydroxyapatite
into fluorapatite and makes the tooth more resistant to decay. Topical fluoride action is
provided by fluoride present in the plaque and saliva. When present, remineralization is
enhanced and the reformed enamel crystals contain more fluoride and have more acid
resistance. While there is evidence of a systemic effect, it is accepted that the systemic
effect is much less than the topical effect. Caries risk can be considerably decreased with
regular contact with small quantities of fluoride (60).

Systemically ingested fluorides come from fluoridated water, and dietary fluoride
supplements. Sources of topical fluorides include:(59), toothpastes, mouth rinses,
professionally applied fluoride foams, gels and varnishes. For optimal dental health water
fluoridation should be adjusted to a concentration of 0.7 parts per million as
recommended by the ADA (61) (59). According to the CDC, in 2010, more than 204
million people in the U.S had access to use community water fluoridation. In Iowa, in
2010, 92.3% of the people who had community water supplies were optimally fluoridated
(62). Community water fluoridation reduces dental caries through two ways: systemically
and topically (59, 61). Additionally, with community water fluoridation, teeth are
exposed to fluoride throughout the day as they drink public water, not just a couple of the

times when people brush their teeth (61) and not just at the times people receive professional topical fluoride application for specific teeth. Therefore, the plaque and saliva receive replenishing of a dilute solution of fluoride on a regular basis, which contributes to caries prevention (61).

According to the Caries Prevention Clinical Practice Guideline (2010) (63)dietary fluoride supplements should only be given to children that are not exposed to fluoridated water and have a high caries risk. In a systematic review by the American Dental Association (ADA) Council on Scientific Affairs (56) on the use of professionally-applied and home-use topical fluoride agents for caries prevention, the recommendation was that fluoride pastes, gels, varnishes, foams, and mouth rinses should be given to patients at a high caries risk. Fluoride agents should be prescribed at the following concentrations: Fluoride varnish 2.26% or acidulated phosphate fluoride (APF) gel1.23% or fluoride mouthrinse 0.09% for children 6 years or older. For children under the age of 6 years old only varnish is recommended.

Pit-and-fissure sealants

Food could be entrapped into grooves, pits, and fissures on occlusal surfaces of teeth, increasing the risk of developing caries lesions by increasing the possibility of accumulating plaque. Thus, when these surfaces are sealed with a pit-and-fissure sealant, plaque accumulation can be minimized. Moreover, it has also been shown that initial caries lesions can be arrested after sealing the pit and fissures.(64) In a systematic review by the American Dental Association (ADA) Council on Scientific Affairs and the American Academy of Pediatric Dentistry (65) regarding the use of sealants compared to fluoride varnishes. The recommendation was that occlusal carious lesions can be prevented and initial caries lesions arrested via the use of pit and fissure sealants.

Others: (Xylitol, antibacterial agents, dietary modification, Plaque control)

According to A review by the American Dental Association (ADA) Council on Scientific Affairs (36) examples of non-fluoride agents are sucrose-free polyol chewing gums, xylitol dentifrices, chlorhexidine, and chlorhexidine in combination with thymol, calcium-containing agents, and phosphate containing agents, casein derivatives, sialogogues, iodine and triclosan. The recommendation of the ADA was that the primary advantage of the use of such products would be among high caries risk children and adults, however they should only be used as adjunct to another caries prevention measures like professional and home fluoride applications. The panel's recommendation was to use the following products xylitol candy or lozenge. Evidence on caries control and prevention show that the caries risk decreases in high caries risk individuals when the rate and amount consumption of carbohydrates is decreased. Which results in decreasing the frequency of acid attack (66).

The International Caries Classification and Management System (ICCMS™)

A workshop by Ismail in 2012 (50) investigated approaches for caries management .The ideal target management was to "preserve the tooth structure, and restore only when necessary." It was discussed that most management techniques are inclined towards "drilling and filling." Caries management should be comprehensive, and not only focused on providing a high quality restoration that will not control or prevent the caries disease, but rather provide comprehensive management through a tailored care plan to be implemented at home or in clinic to prevent and control caries and enable patients to manage their behavioral habits.

ICCMS is an example of a comprehensive caries management pathway. ICCMS encompasses prevention of early as well as management of advanced caries lesions, preservation of tooth structure and patient habitual changes that in achieving a favorable oral health environment. ICCMS is designed to aid in examination and evaluation of

caries clinically (8). It relies on guidelines that have prevention as a priority and minimal surgical intervention is only warranted as a last resort (49). The structure of ICCMS is available as a guide which shows modalities of implementation (7, 49). ICCMS portrays considerable advancement from the classic treatment planning ideals that were most commonly practiced. Four key elements are included within ICCMS. These elements are described in the next section.

ICCMS Element 1- History- Patient-Level Caries Risk Assessment

The following are components that should be gathered during caries risk assessment of patients as they contribute to the patients caries risk (49). The risk factors on the patient level are listed in Table 2. It can be seen that dry mouth and head and neck radiation will always classify an individual as high risk.

Table 2 Patient level risk factors

Patient-level caries risk status	Head and Neck Radiation*
	Dry mouth (conditions, medications/recreational drugs/self-report)*
	Inadequate oral hygiene practices
	Deficient exposure to topical fluoride
	High frequency/ amount of sugary drinks/ snacks
	Symptomatic-driven dental attendance
	Social-economic status/Health access barriers
	For children: high caries experience of mothers or caregivers

*: Risk factors that will always classify an individual as high caries risk.

ICCMS Element 2- Classification: Caries Staging and Lesion Activity with Intraoral Caries Risk Assessments

The following intraoral risk factors are considered to affect the caries risk of patients, (49) the intraoral risk factors are listed below in Table 3.

Table 3 Intraoral Risk factors

Intraoral caries risk factors	Xerostomia *
	Pulp exposure and indications of dental sepsis *
	Caries experience and active lesions
	Thick plaque especially in plaque stagnation areas
	Appliances, restorations and other causes that might lead to increased plaque retention
	Root exposure

*: Risk factors that will always classify an individual as high caries risk.

ICCMS embraces CAMBRA's philosophy for caries-risk assessment. Considering various factors that combine medical and dental health as well as behavior into developing the final caries risk. ICCMS development group defines three levels of caries risk, low, moderate and high risk according to the criteria detailed in Table 4 (49).

Table 4 ICCMS Caries risk criteria

Patient's Risk Status	
Low risk status	Absence of high caries risk factors.
Moderate risk status	Neither Low or High caries risk
High risk status	High caries risk factors associated with very high caries experience or multiple lower risk factors

Clinical staging the coronal caries lesions, the ICCMS categories of lesions merged with ICDAS codes as: (49)

Sound tooth structure (ICDAS code 0): no evidence of caries when examined clean and after drying for 5 seconds.
Initial stage caries (ICDAS codes1 and 2): early visible changes in enamel including loss of translucency or discoloration with no visible breakdown of the enamel or shadowing of dentin.
Moderate stage caries (ICDAS codes 3 and 4): discolored lesion with localized enamel breakdown with no shadowing or exposure of dentin.
Extensive stage caries (ICDAS codes 5 and 6): distinct cavitation in the enamel with exposure of dentin.

Radiographic staging the coronal caries lesions, the ICCMS categories of radiographic lesions merged with ICDAS codes as:(49)

0: No radiolucency

RA (initial stage caries): RA 1 (Radiolucency in the outer half of the enamel), RA 2 (Radiolucency in the inner half of the enamel), RA 3 (Radiolucency in the outer one third of the dentine).
RB (Moderate stage caries): RB 4 (Radiolucency reaching the middle one third of dentine).
RC (Extensive stage caries): RC 5 (Radiolucency reaching the inner one third of dentine and clinically cavitated), RC 6 (Radiolucency into the pulp and clinically cavitated).

ICCMS Element 3: Decision Making: Synthesis and Diagnosis

The aim of this third step is to combine caries risk assessment and the clinical and radiographic assessment to result in the production of a probability of the patient developing new lesions or the progression of new lesions. The lower the current activity of the caries and the lower the caries risk, the slower the caries progression and less likely the person is to develop caries.

ICCMS Element 4: Management: Personalized Caries Prevention, Control & Tooth Preserving Operative Care

ICCMS describes an all-inclusive customized plan that prioritizes preserving tooth structure and prevention of existing caries lesions from progressing. ICCMS guidelines recommend the following actions to be taken. The recommendations are as follows: (49) Home care for moderate and high likelihood patients involves Tooth brushing two times a day with highly fluoridated toothpaste (>1450 ppm) (67-70) General behavior modification in oral health (71) and prescriptions of fluoridate mouth rinse.(72-74). Clinical interventions include motivational engagements for all levels of likelihood (74-78). Moderate and high likelihood patients receive sealants (79) fluoride vanish two times a year (73, 74, 80) , fluoride gel or solution.(73, 74), recall up to every three months(50, 75, 80-82), motivational interviewing (71), one to one dietary intake interventions.(81-83), altering medication induced hyposalivation (84) and reducing the use of recreational drugs (85, 86). Clinical interventions for high likelihood patients involves Increasing fluoride varnish application to four times a year (80), topical fluoride application and counseling for reduction of sugar amount and frequency (72, 82). The

ICCMS evidence based recommendations for managing specific caries lesions According to ICCMS stage and lesion location are shown in Table 5(49).

Table 5 Evidence-based recommendations for managing specific caries lesions According to ICCMS stage and lesion location

ICCMS stage	Occlusal lesion	Proximal lesion	Smooth surface lesion
Sound	Risk based prevention (refer to previous table).		
Initial active	NOC*: Topical fluoride application (80, 87), oral hygiene with fluoridated toothpaste (80, 88), biofilm removal mechanically (75, 89).		
	NOC*: Resin based or glass ionomer sealants (64, 90).	NOC*: Resin based sealants or infiltration (91).	
Initial inactive	No lesion specific treatment.		
Moderate active	NOC*: Resin based sealants (92, 93).	Non caviated lesions: NOC* (94). Caviated lesions: TPOC** (94).	TPOC** (94).
	TPOC** (94)		
Moderate inactive	No treatment or TPOC** for plaque stagnation areas (94).	TPOC** (94).	
Extensive active	TPOC** (94).		
Extensive inactive	TPOC** if lesion in plaque stagnation area or esthetically unacceptable (94).	TPOC** (94).	

*: NOC (Non Operative Care), **: TPOC (Tooth Preserving Operative Care).

Threshold for surgical/restorative treatment

Despite the proven success of non surgical management approaches (95-100), most practitioners have limited understanding and acceptance of preventive and tooth structure saving techniques (4, 13, 17, 95, 100, 101)and are likely to use surgical techniques to treat dental caries (4, 13, 97-100, 102, 103). In a systematic review by Bader et al. in1995 (104) differences in practitioners' management decisions were

assessed. It was found that studies on the degree of variations among dentists' choices are scarce, but even when presented with similar clinical situations, differences in treatment decisions still existed (104).

In another study by Bader et al. in 1997 (105) a theoretical model of dental treatment decision making was suggested. This model proposed the idea that dentists use a so called "caries script" to make decisions. The caries script is a hypothetical – deductive process that results from a culmination of the dentists previous experiences. Thus when a lesion matches what the dentist perceives as caries based on his previous experience, this triggers a cascade of decisions that ultimately result in a quick and often not fully thought out diagnosis of dental caries and its subsequent treatment. Thus this should be taken into account when attempting to influence or improve the dentist's clinical decisions

In a study carried out in western Australia by Riordan et al. 1991 (106) 45 dentists took part in a survey investigating the dentists understanding and diagnosis of proximal caries lesions based on radiographs, it was found that 60% of the participants would not restore a tooth that had only enamel lesions and would surgically intervene only when the lesion has reached the dentin.

In another study done in Ontario by El-Mowafy et al. 1994 (107) 52% of the dentists in Ontario responded to the study a percentage amounting to 1,276 dentists. The study involved a survey with patient scenarios to which the dentist would respond by stating the usual treatment that they would do in their practice. A multivariate analysis was made and the results showed a strong tendency of younger dentists for restore enamel lesions more often than older dentists. There was also significant difference in cavity design based on the dental school attended in which it was found that one school had a more conservative cavity design than the other. One of the more interesting findings included 60% an agreement the participating dentists to restore an enamel lesion on a 12-year-old patient.

A study which took place in Sweden by Mejare et al. 1999 (108) included a questionnaire sent to a sample of 923 dentists from which 70% responded. The questionnaire evaluated the dentists' diagnostic and treatment decisions regarding occlusal and proximal caries lesions. Ninety percent of the dentists stated that they would not restore a tooth unless caries is evident in at least the outer 1/3 of dentin. Contrary to the findings of Al-Mowafy et al. this study found that most of the younger dentists would rather wait and not restore a questionable lesion. It was also found that dentists in private practice were more likely to restore caries earlier than dentists practicing at public health clinics.

A similar study in Norway by Tveit et al. 1999 (109) in which 640 out of 758 with dentists replied to a questionnaire that provided the dentists with radiographs of various teeth with varying degrees of decay. The questionnaire examined the dentist's criteria for treatment, the preparation of choice, design and the restorative material that they would use. Results were that most of the dentist would not restore a tooth before caries lesions reached the dentin, however 19% would still restore the tooth even if it has not yet reached the dentin. The majority of the practitioners chose composite as the material of choice. Fifteen percent of the dentists responded that amalgam was the material of choice.

Another survey distributed among 2000 French dentists by Doméjean-Orliaguet et al. 2004 (110) presented a case of a hypothetical low caries risk patient who was 20 year old. A survey was sent to 2000 dentists with a response rate of 41.4%. The survey included pictures and radiographs of caries lesions on the proximal and occlusal surfaces that were at different depths from (outer/inner ½ of enamel, DEJ, outer 1/3 and ½ of the dentin). It was found that 40% of the included practitioners agreed to restore occlusal caries lesions confined to enamel, and 88% would recommend restoring proximal carious lesions that reached the dentino-enamel junction. The results showed that composite was the material of choice of the included practitioners

A telephone-based survey of 840 Brazilian dentists by Traebert et al. 2005 (111) tested the response of the dentists to the explanation of a hypothetical scenario. The responses showed that 31.5% of the practitioners would restore a lesion in the outer half of the enamel and 79% would restore proximal lesion when it reaches the dentino-enamel junction. Interestingly the study found that dentists who had postgraduate training and those who had graduated within the last 10 years tended to intervene less than older dentists.

A questionnaire was distributed during two national meetings in Iran by Ghasemi et al. 2008 (112), and a total of 1,033 dentists responded. The study found that 77% would restore a enamel lesion contained to enamel for a high risk patient and 32% would restore a lesion in enamel for a low risk patient.

In a recent survey by Gordan et al. (2010) (113), dentists in 5 regions were asked Alabama/Mississippi, Georgia/Florida, Denmark, Norway and Sweden were asked to indicate whether they would intervene surgically in a series of cases involving occlusal caries in patients at low and high risk. A total of 517 practitioners were involved in questionnaire. 3 cases were presented to the participating dentists in the form of a picture of an occlusal surface of a tooth. Case 1 had a white or discolored enamel surface. Case2 had brown discoloration in about one-half of the occlusal surface and case 3 had brown discoloration in most of the fissures in the occlusal surface and had no cavitation. The dentists were then asked to give their treatment decision for each picture under 2 situations, the first situation would be in a low caries risk individual and the second situation would be in a high caries risk individual. The findings are shown in Tables 6-7.

Table 6 Percentage of management options of scenario #1: Low risk Gordan et al. (2010) (113)

TREATMENT OPTION	Percentage		
	Case 1	Case 2	Case 3
No Treatment	69%	24%	7%
Preventive Treatment Only	17%	13%	3%
Surgical Treatment	14%	63%	90%

Table 7 Percentage of management options of scenario #2: High risk Gordan et al. (2010) (113)

TREATMENT OPTION	Percentage		
	Case 1	Case 2	Case 3
No Treatment	40%	10%	3%
Preventive Treatment Only	35%	13%	3%
Surgical Treatment	25%	77%	94%

A survey by Baraba et al. 2010 (114) involved a survey to assess the restorative treatment decision regarding proximal lesions among 307 dentists in Norway and Sweden included in the survey. The results showed that 42% would treat a carious lesion in the enamel, while the rest however would wait until the lesion reaches the dentino-enamel junction.

A study by Gaskin et al. (2010) (115), investigated the knowledge, attitudes, clinical decision-making behavior, and practice behavior concerning minimal intervention. The study compared the responses of civilian versus federal dentists in the United States Air Force, Army, Navy and Public health. The evaluation criteria were tested using key questions. The knowledge was evaluated by the question "how much do you know about minimal intervention dentistry?". The attitudes were tested using the key question "is fluoride an effective remineralizing agent?". The clinical decision making behavior was tested with the question " would you monitor and not restore a proximal carious lesions in high caries risk patient with limited finances? ". The practice behavior was tested with the question " how often do you remineralize non – cavitated carious

lesions? ". A questionnaire was sent with 51 questions to 900 federal service dentists and 600 civilian dentists. The response rate was 41.7% with 512 responses were received. Results show that 15.9% of the federal and 23% of the civilian dentists had little of or no knowledge of minimal intervention dentistry. Federal dentists and females had more knowledge of minimal intervention dentistry. It was also found that the knowledge on minimal intervention dentistry decreased as the age and years since graduation increased. It was also found that federal dentists practiced more minimal intervention dentistry than civilian dentists and that among the federal dentists the public health workers had more knowledge in minimal intervention dentistry than other federal dentists.

An e-mail questionnaire assessing Norwegian dentists' treatment decisions of caries lesions in the proximal region was done by Vidnes-kopperud et al. 2011 (116). In this study 61% of 3,654 dentists replied to the questionnaire and results were that only 7% of the dentists would restore caries in the enamel lesion. However it was seen that older dentists tended to treat enamel lesions more aggressively while more recent graduates were more likely to defer treatment until advancement of the caries lesion to the dentino-enamel junction.

A multicenter study involving 3 universities (Alabama and Florida and Ohio State) was completed by Heaven et al. 2013 (117). Five hundred and fifty-seven practitioners answered questionnaire-involved scenarios including treatment of primary occlusal caries and treatment of primary proximal caries. For the occlusal caries scenario, the practitioners were presented with 5 pictures of a mandibular molar with 5 progressive stages of caries, however the author did not indicate the specific stages of each of the pictures. The proximal caries scenario included 5 radiographs of proximal lesions with the first having minimal enamel surface inclusion (less than ½ of enamel thickness) the second having passed to the DEJ, the third lesion has inclusion of the outer third of the dentin, the fourth case had a carious lesion with more than ½ the thickness of the dentin, and the fifth lesion involved carious lesions that has reached the inner 1/3 of the dentin.

For the " existing restorations" scenario the practitioners were presented with 3 pictures of 3 cases with restorations of varying stages of damage. For all scenarios, practitioners were asked to indicate weather they would provide operative treatment or no operative treatment. For each of the cases presented in the scenarios the dentists were requested to indicate which treatment they would provide if the lesion was in a high caries risk patient or a low caries risk patient. The findings are presented in Table 8.

Table 8 Percentage of operative treatment thresholds by Heaven et al. 2013. (117)

"Threshold stage" Or Depth	Low risk patient Occlusal lesion	High risk patient Occlusal lesion	Low risk patient Proximal lesion	High risk patient Proximal lesion
1 "shallowest"	1%	4%	2%	10%
2	9%	21%	42%	68%
3	34%	40%	54%	21%
4	48%	33%	3%	0%
5 " deepest"	7%	2%	0%	0%

Note: the threshold stages refer to the depth of the caries radiographically with the 1 being the shallowest and the 5 being the deepest.

A survey of 200 dentists by the Ministry of Health in Kuwait was done by Khalaf et al. 2014 (118). The questionnaire investigated the thresholds at which the dentists would surgically intervene in proximal and occlusal carious lesions. The practitioners were presented with an illustration of radiographic appearance of 6 proximal carious lesions with the following depths, 1) outer ½ of enamel, 2) inner half of enamel, 3) DEJ, 4) outer third of dentin, 5) outer half of dentin, and 6) inner half of dentin. The participants were also presented with pictures of 5 occlusal carious lesions on a mandibular molar, with the following description on each lesion a) No radiographic signs of lesions, b) No radiographic signs of lesions, c) Lesions on the outer third of the dentin on the bitewing radiograph, d) Lesions on the middle third of the dentin on the bitewing

radiograph, and e) Lesions on the inner third of the dentin on the bitewing radiograph.

The results are shown in Table 9.

Table 9 Results of the study by Khalaf et al. 2014 (118)

Earliest stage of intervention for proximal carious lesions	Outer half of enamel	2.2%
	Inner half of enamel	8.1%
	DEJ	7.0%
	Outer third of dentin	40.0%
	Outer half of dentin	18.9%
	Inner half f dentin	23.8%
Earliest stage for intervention for occlusal caries	1	0
	2	4.3%
	3	28.1%
	4	43.1%
	5	23.8%
Choice of restorative material	Amalgam	11.4%
	Composite	61.1%
	GIC	7%
	RMGI	7.6%
	Sandwich technique	13%

A recent study by Rechmann et al. 2016 (119) involved a survey of 1922 dentists in California that presented the practitioners with a hypothetical 20 year old patient with low caries risk.. The results show 42 % of the respondents would restore a caries lesion confined to the enamel while 33% would wait until caries has progressed to the dentin. However it was also found that dentists who have recently graduated were more likely to not treat superficial lesions and reserve restorative treatment to deeper lesions.

Summary of findings

Due to the similarity in the study design between many studies that utilizes questionnaires the following Tables 10-13 have been made to represent the findings in the studies.

Table 10 Percentage of dentists surgically intervening in occlusal lesions

Study	LESION GRADE, %				
	1	2	3	4	5
Mejare et al(108)	n/a	6	67	27	n/a
Doméjean-Orliaguet al (110)	2	47	47	3	n/a
Heaven et al(117)	1	9	34	33	2
Khalaf et al (118)	n/a	4	28	43	24
Doméjean et al 2015	2	37	55	6	n/a
Rechmann et al (119)	2	39	50	8	2

Grade 1, white or brownish discoloration in the enamel, no cavitation, no radiographic signs of caries; grade 2, minor loss of tooth substance with a break in the enamel surface or discolored surface or discolored fissures with gray or opaque enamel or caries confined to the enamel, no radiographic signs of caries; grade 3, moderate loss of tooth substance or caries in the outer one-third of the dentin according to the radiograph; grade 4, considerable loss of tooth substance or caries in the middle one-third of the dentin according to the radiograph; and grade 5, considerable loss of tooth substance or caries in the inner one-third of the dentin according to the radiograph

The Table above shows a comparison of the findings related to percentage of dentists surgically intervening in occlusal lesions of varying depths of 1-5 with the following criteria; 1) No radiographic signs of lesions. 2) No radiographic signs of lesions. 3) Lesions on the outer third of the dentin on the bitewing radiograph. 4) Lesions on the middle third of the dentin on the bitewing radiograph and 5) Lesions on the inner third of the dentin on the bitewing radiograph.

Table 11 Percentages of dentists surgically intervening in proximal lesions

	LESION DEPTH, %*					
	Outer One-Half Enamel	Inner One-Half Enamel	DEJ[†]	Outer One-Third Dentin	Middle One-Third Dentin	Inner One-Third Dentin
Riordan et al. (106)	2	9	29	40	11	9
el-Mowafy et al. (107)	1	27	67	5	—	—
Mejare et al. (108)	0	1	4	42	52	1
Tveit et al. (109)	4**	4	15	62	19	1
Doméjean et al. (110)	20	36	32	11	1	—
Traebert et al. (111)	32	23	25	18	3	—
Ghasemi et al. (112)	8	—	23	58	—	11
Baraba et al.(114)	10	32	39	18	1	0
Vidnes-Kopperud et al. (116)	1	6	57	36	—	
Heaven et al. (117)	2	42	54	3	1	—
Khalaf et al. (118)	2	8	7	40	19	49.2
Rechman et al (119)	3	15	43	33	4	2

The above table shows the differences in the percentages of dentists surgically intervening in proximal lesions with different depths in which the dentists were presented with radiographs of illustrations with varying depths of the carious lesions with the following description; 1) outer ½ of enamel, 2) inner half of enamel, 3) DEJ, 4) outer third of dentin, 5) outer half of dentin, and 6) inner half of dentin.

Table 12 Percentage of dentists intervening surgically in lesions confined in enamel for occlusal and proximal lesions of high and low caries risk

Study	High risk proximal lesion	High risk pit and fissure lesion	Low risk proximal lesion	Low risk pit and fissure lesion	Proximal caries CR* not mentioned	Pit and fissure caries CR* not mentioned
Riordan et al. (106)	n/a	n/a	2.2%	n/a	n/a	n/a
Al- Mowafy (107)	n/a	n/a	n/a	n/a	60%	n/a
Mejare et al. (108)	n/a	n/a	67%	90%	n/a	n/a
Tveit et al. (109)	n/a	n/a	18%	n/a	n/a	n/a
Domejean et al. (110)	n/a	n/a	40%	88%	n/a	n/a
Treabert et al. (111)	n/a	n/a	n/a	n/a	n/a	31%
Ghasmi et al. (112)	77%	n/a	32%	n/a	n/a	n/a
Gordan et al. (113)	25%	n/a	39%	14%	n/a	n/a
Baraba et al. (114)	n/a	n/a	42%	n/a	n/a	n/a
Vidness-kopperud et al. (116)	n/a	n/a	28%	n/a	n/a	n/a
Rechmann et al. (119)	n/a	n/a	42%	38%	n/a	n/a

*Caries risk

From the above mentioned studies it can be concluded that there is considerable variation in the approach that dentists take in treating dental caries, which is influenced by multiple factors such as the caries risk of the patient, setting of practice of the dentist, the age of the dentist as well as the number of years since graduation. However a common finding was that dentists that were younger and recently graduated tended to have a more conservative approach. Some studies tested the influence of caries risk on the decisions of dentists, however only high and low risk patients were involved in the scenarios and not involved the moderate risk patient.

CHAPTER III: MATERIALS AND METHODS

Overview

The primary aim of this study was to use a survey to determine whether Iowa dentists' decision regarding the management of initial caries lesions was in agreement with the ICCMS guide for three levels of patients caries risk (low, moderate and high) and the factors associated with the agreement. The survey instrument was a web-based questionnaire. E-mail addresses of participants were obtained from the University of Iowa College of Dentistry Alumni records. All participants were active members of the University of Iowa Alumni Association.

Hypotheses

The following general hypotheses were assessed in this study:

1-The majority of Iowa dentists agree with the International Caries Classification System (ICCMS) in the management of initial caries lesions for low risk patients.

2-The majority of Iowa dentists agree with the International Caries Classification System (ICCMS) in the management of initial caries lesions for moderate risk patients.

3-The majority of Iowa dentists agree with the International Caries Classification System (ICCMS) in the management of initial caries lesions for high risk patients.

<u>Null hypotheses</u>

The following null hypotheses were tested in the study:

1-The Iowa dentists' demographic characteristics are not associated with the dentists' initial caries lesion management agreement in **low risk patients** according to ICCMS.

    a. Agreement is not associated with dentists' age.

    b. Agreement is not associated with dentists' gender.

    c. Agreement is not associated with dentists' year of graduation.

    d. Agreement is not associated with dentists' years of practice.

    e. Agreement is not associated with dentists' postgraduate training.

    f. Agreement is not associated with dentists' practice type.

2-The Iowa dentists' demographic characteristics are not associated with the dentists' initial caries lesion management agreement in **moderate risk** patients according to ICCMS.

    a. Agreement is not associated with dentists' age.

    b. Agreement is not associated with dentists' gender.

    c. Agreement is not associated with dentists' year of graduation.

    d. Agreement is not associated with dentists' years of practice.

    e. Agreement is not associated with dentists' postgraduate training.

    f. Agreement is not associated with dentists' practice type.

3-The Iowa dentists' demographic characteristics are not associated with the dentists' initial caries lesion management agreement in **high risk** patients according to ICCMS.

    a. Agreement is not associated with dentists' age.

    b. Agreement is not associated with dentists' gender.

    c. Agreement is not associated with dentists' year of graduation.

    d. Agreement is not associated with dentists' years of practice.

    e. Agreement is not associated with dentists' postgraduate training.

f. Agreement is not associated with dentists' practice type.

4-The Iowa dentists' knowledge and practicing characteristics are not associated with the dentists' initial caries lesion management agreement in **low risk** patients according to ICCMS.

    a. Agreement is not associated with dentists' practice busyness.

    b. Agreement is not associated with the types of insurance patients have.

    c. Agreement is not associated with the age of the patients.

    d. Agreement is not associated with the dentists' familiarity with ICDAS.

    e. Agreement is not associated with the dentists' familiarity with ICCMS.

    f. Agreement is not associated with the dentists' familiarity with CAMBRA.

    g. Agreement is not associated with the dentists' familiarity with ADA-CCS.

    h. Agreement is not associated with the dentists' use of a caries risk assessment.

    i. Agreement is not associated with the dentists' drying the tooth for caries detection.

    j. Agreement is not associated with the dentists' use of a sharp explorer for caries detection.

    k. Agreement is not associated with the dentists' use of magnification for caries detection.

5-The Iowa dentists' knowledge and practicing characteristics are not associated with the dentists' initial caries lesion management agreement in **moderate risk** patients according to ICCMS.

    a. Agreement is not associated with dentists' practice busyness.

    b. Agreement is not associated with the types of insurance patients have.

    c. Agreement is not associated with the age of the patients.

d. Agreement is not associated with the dentists' familiarity with ICDAS.

e. Agreement is not associated with the dentists' familiarity with ICCMS.

f. Agreement is not associated with the dentists' familiarity with CAMBRA.

g. Agreement is not associated with the dentists' familiarity with ADA-CCS.

h. Agreement is not associated with the dentists' use of a caries risk assessment.

i. Agreement is not associated with the dentists' drying the tooth for caries detection.

j. Agreement is not associated with the dentists' use of a sharp explorer for caries detection.

k. Agreement is not associated with the dentists' use of magnification for caries detection.

6-The Iowa dentists' knowledge and practicing characteristics are not associated with the dentists' initial caries lesion management agreement in **high risk** patients according to ICCMS.

a. Agreement is not associated with dentists' practice busyness.

b. Agreement is not associated with the types of insurance patients have.

c. Agreement is not associated with the age of the patients.

d. Agreement is not associated with the dentists' familiarity with ICDAS.

e. Agreement is not associated with the dentists' familiarity with ICCMS.

f. Agreement is not associated with the dentists' familiarity with CAMBRA.

g. Agreement is not associated with the dentists' familiarity with ADA-CCS.

h. Agreement is not associated with the dentists' use of a caries risk

assessment.

    i. Agreement is not associated with the dentists' drying the tooth for caries detection.

    j. Agreement is not associated with the dentists' use of a sharp explorer for caries detection.

    k. Agreement is not associated with the dentists' use of magnification for caries detection.

Survey

Please find the completed survey at Appendix and the description of the survey instrument in page 41.

Dependent variables

The three dependent variables were the dentists' decision on how to manage initial caries lesions based on the caries risk (low, moderate, and high) and whether the decision was in agreement with ICCMS. Responses that matched the 'non surgical' management were considered agreement with ICCMS.

Independent variables

1. Gender: Self-reported as either 'Male' or 'Female' in response to a question on the survey.

2. Age: Self-reported in years then re-categorized into 4 categories: 26-35, 36-45, 46-55, and >56 years of age.

3. Year received dental degree: Self-reported as actual year (i.e. 1995) dentist graduated from dental school. Then re-calculated by subtracting graduated year from the current year to give the number of years since graduation, which was then re-categorized into 4 categories: <10, 10-19, 20-29, and 30-48 years.

4. Post graduate training: Self-reported as 'Yes' or 'No' based on the question 'Have you ever completed a formal postgraduate training program?' Dentist who responded 'Yes', selected their postgraduate training area(s) from a list that included: advanced program in general dentistry or comprehensive dentistry, dental public health, endodontics, general practice residency, operative, oral and maxillofacial pathology, oral and maxillofacial radiology, oral and maxillofacial surgery, orthodontics, pediatric dentistry, prosthodontics, periodontics, and other.

5. Years of clinical practice: Self-reported in years then re-categorized into 4 categories: <10, 10-19, 20-29, and 30-48 years.

6. Type of practice: Self-reported based on the question 'How would you describe your role in your primary practice?' then re-categorized into three categories: 'Solo practice', 'Group practice', and 'Other'.

7. Busyness in dental practice: Self reported based on the question 'how would you best describe your practice during the past 12 months?' then re-categorized into two categories: 'Busy' versus 'Not busy'.

8. Types of patient dental insurance:

   8.1. Self-pay and private insurance: Dentist reported the percent of their patients who were self-pay or had private insurance and then re-categorized based on the responses into two categories: ≤70% and ≥71%.

   8.2. Medicaid (Title XIX), DWP, and Hawk-I: Dentist reported the percent of their patients who had Medicaid (Title XIX), DWP, or Hawk-I insurances and then re-categorized based on the responses into three categories: 0-10%, 11-30%, and 31-70%.

8.3.Others: Dentist reported the percent of their patients who had other insurances and then re-categorized based on the responses into two categories: 0%, and ≥1%.

9. Patient age groups:

    9.1. ≤18 years of age: Dentist reported the percent of their patients under 18 years then re-categorized based on the responses into three categories: 0-18%, 19-44%, and 45-100% of their patients were less than 18 years of age.

    9.2. 19-65 years of age: Dentist reported the percent of their patients between 19 and 65 years then re-categorized based on the responses into two categories: ≤50% and ≥51% of their patients were between 19 and 65 years of age.

    9.3. >65 years of age: Dentist reported the percent of their patients over 65 years then re-categorized based on the responses into three categories: 0-25%, 30-39%, and 40-70% of their patients were over 65 years of age.

10. Familiarity with ICDAS: Self reported based on the question 'Are you familiar with the ICDAS?' then re-categorized based on the responses into two categories: 'Very familiar/ somewhat familiar' versus 'Not familiar at all'.

11. Familiarity with ICCMS: Self reported based on the question 'Are you familiar with the ICCMS?' then re-categorized based on the responses into two categories: 'Very familiar/ somewhat familiar' versus 'Not familiar at all'.

12. Familiarity with CAMBRA: Self reported based on the question 'Are you familiar with the CAMBRA?' then re-categorized based on the responses into two categories: 'Very familiar/ somewhat familiar' versus 'Not familiar at all'.

13. Familiarity with ADA-CCS: Self reported based on the question 'Are you familiar with the ADA-CCS?' then re-categorized based on the responses into two categories: 'Very familiar/ somewhat familiar' versus 'Not familiar at all'.

14. The use of a caries risk assessment: Self reported based on the question 'How often do you perform CRA for your new and/or recall patients?' then re-

categorized based on the responses into two categories: 'Always/often' versus 'Rarely/never'.

15. Caries detection: Dentists were asked how often they use the following criteria when detecting caries:

 15.1.   Drying the tooth: Self reported based on the question 'How often do you dry the tooth with compressed air?' then re-categorized based on the responses into two categories: 'Always/often' versus 'Rarely/never'.

 15.2.   Use of a sharp explorer: Self reported based on the question 'How often do you use a sharp explorer?' then re-categorized based on the responses into two categories: 'Always/often' versus 'Rarely/never'.

 15.3.   Use of magnification: Self reported based on the question 'How often do you use magnification?' then re-categorized based on the responses into two categories: 'Always/often' versus 'Rarely/never'.

Human Subjects

An application to conduct this study was submitted to and approved by the University of Iowa Human Subject's Office (IRB# 201511749). University of Iowa Institutional Review Board (IRB) approval was granted in November 2015.

Pre-testing the survey

The research instrument was pre-tested, thirty-one-question survey, to obtain feedback about the clarity of the questions, photographs and radiographs. The survey was pre-tested by eleven faculty members from the Department of Family Dentistry, eleven faculty members and five residents from the Department of Prosthodontics, ten faculty members and eleven residents from the Department of Operative Dentistry at the

University Of Iowa College Of Dentistry during December 2015. Changes were made according to the feedback provided, including improvements to the quality and the size of the photographs and the radiographs. There were no substantive, scientific changes made to the survey.

<u>Study population</u>

This study was an observational, cross-sectional study of a sample of general dentists graduated from the University of Iowa College of Dentistry and Dental Clinics. The study sample inclusion criteria were; University of Iowa DDS alumni residing in the state of Iowa, who had a current business address and who had an active primary e-mail address. The e-mail addresses were obtained from The University of Iowa Alumni Association. The director of the University of Iowa Alumni records was provided with a letter from the faculty advisor defining and approving the research project, documentation (official letter) of approval to research project from the University of Iowa Institutional Review Board (IRB), and a final copy of the e-mail letter and the survey that would be sent to alumni. Additionally, an alumni records requisition form was submitted to request alumni e-mail addresses.

The e-mail addresses provided for the University of Iowa College of Dentistry DDS graduates were pulled from the University of Iowa Institutional Advancement Database, more commonly known as the Black and Gold Information (BGI) database. As of August 28th of 2015, 1,665 living University of Iowa College of Dentistry DDS alumni resided in Iowa. Alumni who were excluded from the list were those who requested a preference not to receive any University and/or University of Iowa College of Dentistry correspondence (including those who requested "no e-mail") and those with an Academic Restricted alumni record (Family Educational Rights and Privacy Act (FERPA)), as well as alumni who had requested to be dropped from University of Iowa based "research

survey" e-mails. A total number of 916 living University of Iowa College of Dentistry

D.D.S. alumni with e-mail addresses were included in the study population.

Invitation e-mail was sent with the exempt information sheet from the IRB and

the survey link was attached. The exempt information sheet included the components

required by the IRB to ensure that respondents understood that research participation was

voluntary and any reports filed would not include identifiable information. As a

participation incentive, participants who agreed to take part in the study and complete the

online survey, received one hour of continuing education (CE) credit as compensation.

The University of Iowa continuing education director approved the CE credit.

Participants, who read the exempt information sheet and choose to participate in the

study, accessed the survey though the link contained within the e-mail to complete the

survey.

<center>Survey Instrument</center>

The electronic survey was created and designed using Research Electric Data

Capture (REDCap) (120). REDCap is a secure web application for building and

managing online surveys and database (120). Most survey questions were closed ended,

requesting that participants select a response or specify a value. The survey was divided

in to two sections. The first section asked about dentists' information including

demographics, familiarity with current caries classification and management systems

(knowledge) and practicing characteristics.

Demographic questions included; dentist age, year of graduation, years of

practice, postgraduate training, and practice type (solo, groups, or public health practice).

Dentists' familiarity with the current caries classification and management systems

<center>41</center>

(knowledge) was assessed through questions regarding familiarity with ICDAS, ICCMS, CAMBRA and ADA-CCS.

For better understanding of the patient population that the dentists treat, practice characteristic questions were included in the survey. Practicing characteristics questions included dentists' busyness in dental practice and the percentage of patients that the dentists treat that are covered with self-pay or private insurance, Medicaid, DWP, and Hawk-I or any other insurance. Also, a question that was asked was to provide the percentage of patients that the dentist treated in their practice that were under the age of 18 years, between 19 and 65 years and over 65 years of age.

Four questions were asked about caries risk assessment (CRA) that were: how often did the dentist perform CRA for their new and /or recall patients, did they use a formalized CRA system or instrument, and if yes, were asked to specify which CRA system they used; and whether they re-evaluated the CRA for their patients at recall visits. Seven questions were asked about caries detection and how often the dentists use the following: dry the tooth with compressed air, use a sharp explorer, use a blunt probe, use magnification, use a head light, use recent radiographs according to the ADA guidelines and use an adjunct diagnostic tool(s) for caries detection.

The second section of the survey consisted of three hypothetical patient scenarios. The scenarios were included in the survey to assess the dentists' most likely diagnosis and recommended treatment for the initial caries lesions. For each patient scenario, five questions were asked. The first question asked the dentist to classify the patient caries risk (low, moderate, or high) based on the scenario provided. The second, third and fourth questions included clinical photographs of initial carious lesion; occlusal pit and fissures, smooth surface proximal, and smooth surface free carious lesion. For each carious lesion, dentists were asked to determine the lesions depth and activity and also the recommended treatment for the lesion. Dentists were asked to select their recommended treatment from a list that included both surgical and non surgical options. The last question for each

patient scenario asked dentists' what treatment they would provide for the patient based on their caries risk. Photographs of initial carious lesions were taken from patients seen in the University of Iowa College of Dentistry and Dental Clinics. All carious lesions (a total of nine) were classified as ICDAS scores 1 or 2, as evaluated by two faculty members from the Department of Operative Dentistry. All treatment options and patient recommendations provided were obtained from the ICCMS guidelines recommendations (49).

After the participants submitted their responses to the survey, a following educational section provided an overview of the ICCMS guidelines, and the correct answers for the patient scenarios were provided. This educational section was added following the survey to present an educational component to be able to provide the CE credit to the participants.

Survey Procedures

The survey invitation was e-mailed to each potential subject's e-mail address on file with the University of Iowa Alumni Association. The invitation e-mail contained the exempt information sheet that explained the purpose of the study, the potential participants' rights, and study investigator contact information in case there were questions. The link to the survey was attached to the invitation e-mail. Participants who did not respond to the first e-mail were contacted a week after the initial e-mail. The survey was sent two times in a period of one month.

Strategies to achieve a higher response rates included providing a compensation of one hour of CE credit to motivate participants to complete the survey. Additionally, the e-mail subject line was changed in order to prompt a higher response rate. The initial subject line was 'Survey invitation with one hour of CE credit' and then was changed to 'U of Iowa Cariology survey with one hour of CE credit'. The e-mail with the second

subject line was sent four times in a period of two months. A total of six e-mail reminders were sent in a three months period.

<div align="center">Statistical Analysis</div>

Descriptive statistics were calculated for all of the dependent and independent variables (i.e. using means and frequencies). After descriptive analyses were conducted, some of the variables were re-categorized in order to facilitate additional bivariate and regression analyses. These variables were re-categorized based on the literature or for conceptual reasons to achieve greater statistical power. Independent variables were then categorized into two domains: 1) dentists' demographic characteristics, and 2) dentists knowledge and practicing characteristics.

Bivariate analyses were performed to evaluate difference between the dentists who agreed and those who did not agree with the ICCMS Guidelines for management of initial caries lesions for low, moderate and high risk patients with regard to their demographic characteristics, knowledge, and practicing characteristics. Separate analyses were performed for each risk level. The standard chi-square test, Fisher's exact test, and Cochran-Mantel-Haenszel test were used for categorical variables, and the Wilcoxon rank-sum test was used for quantitative measures. A p-value of less than 0.05 was used as a criterion for statistical significance, and a p-value in $0.05{\leq}p{<}0.10$ was used as a criterion for marginal significance. Statistical analyses were performed using the statistical package SAS® System version 9.4 (SAS Institute Inc., Cary, NC, USA).

Multivariable logistic regression analysis was performed to explore the variables used to predict Iowa dentists' agreement with the ICCMS Guidelines for each scenario. Within each scenario, variables showing significant and marginal significance associations with the agreement with the ICCMS guidelines in bivariate analysis ($p{\leq}0.1$)

were used to develop a final model using forward stepwise logistic regression analysis, and verified using backward elimination.

CHAPTER IV: RESULTS

Overview

The results will be presented in three sections which are; descriptive statistics, bivariate analysis and logistic regression analysis. One hundred-sixty-five participants responded to the survey (response rate 18%), five participants were excluded because they answered "no" to the question "are you currently practicing dentistry". Twenty- two participants' responses were excluded because they had partial responses to the survey. Thus, the final number of participants' was one hundred, thirty-eight (response rate 15%).

Descriptive statistics

These data will be explained in three subsections, dentists' demographic characteristics, dentist familiarity with current caries detection and management systems (knowledge) and dentists practicing characteristics.

Dentists demographic characteristics

Tables 13 and 14 present the dentists demographic characteristics. The mean and standard deviation (SD) of the study participants' age was 48.3 (12.3) years. Of the participants approximately 60% were males and 40%% were females. The mean (SD) number of years since graduation was 21.7 (12.5). The mean (SD) number of years in clinical practice was 21.4 (12.5). Of the included participants about 70% had completed a formal postgraduate training program, while approximately 30% had no formal postgraduate training. The type of dental practice was subdivided into three categories. The first category included solo practices (dentist working alone in their private practice) and accounted for almost 36% of the participants. The second category involved dentists

practicing as part of a group practice including those working as an employee in a

corporate owned practice (e.g. Aspen, Ocean Dental, Apple White Dental), which

accounted for 50% of the participants. The third category included dentists practicing in

public health settings (e.g. community health center), academic institutions, the military

and the other types of practices. This category accounted for about 15% of the

participants.

Table 13 Dentists' demographic characteristics continuous variables (n=138*)

Demographic characteristics	Mean (SD)	Range
Age	48.3±12.3 years	26-72 years
Years since graduation	21.7±12.5 years	1-48 years
Years of practice	21.4±12.5 years	1-48 years

Table 14 Dentists' demographic characteristics categorical variables (n=138*)

Demographic characteristics	Frequency	Valid Percent (%)
Gender Males Females	83 55	60.1% 39.9%
Postgraduate training Yes No	96 42	69.6% 30.4%
Practice type Solo Group Other	49 69 20	35.5% 50% 14.5%

Dentists knowledge and practicing characteristics

Tables 15-18 describe the dentist practicing characteristics and familiarity with

current caries assessment and detection systems. The following characteristics of

participants' dental practice were investigated: the busyness of their practice, and patient

distribution in terms of patient age and insurance coverage. In regard to busyness, about

16% of the participants responded that they are not busy enough and that they would like

to provide treatment to more patients. Half of the participants responded that they provide care to all those who have requested an appointment and they did not feel overworked. However, over 30% responded that they provide treatment to all those who request an appointment and they did feel overworked. Only 3% of the participants responded that they have limited their practice to current patients only and they are not accepting new patients.

Participants were asked to estimate the percentage of their patients who had private insurance or paid out of pocket (self-pay), had government sponsored dental care (Medicaid, DWP, Hawk-I), or had some other method of coverage. The mean percentage (SD) of patients classified as self pay or had private insurance was about 78% (21.1). The mean percentage (SD) of the patients had government sponsored insurance coverage was about 16% (16.1). The mean percentage (SD) of patients covered under other types of insurance was about 7% (18.4).

Participants were given age groups ($\leq$18 years, 19-65 years, >65 years) and asked to report what percentage of their patients were in each age group. A mean of 23% (21) of the patients treated by participants were in the age group of $\leq$18 years old while about 54% (18.1) of the patients treated by participants were in the age group of 19 to 65 years old. Twenty-three percent of the patients treated by practitioners were in the age group that is above 65 years old.

The familiarity of the participating dentists with current caries detection, classification or management methods or systems was investigated. Nearly half of the participants were not familiar with ICDAS while about 9% were very familiar and 42% were somewhat familiar. Over 50% of the participants were not familiar with ICCMS while about 5% were very familiar and 38% were somewhat familiar. However, only 25% of the participants were not familiar with CAMBRA and about 24% were very familiar and 52% were somewhat familiar. Regarding familiarity of participating dentists with ADA-CCS, about 17% of the participants were very familiar with ADA-CCS,

approximately 60% were somewhat familiar and 23% were not familiar at all with ADA-CCS.

Dentists were asked four questions about caries risk assessment (CRA) which included the frequency of which they perform CRA on their patients, if they use a formalized CRA form or system, which system of CRA they use, and if they revaluate CRA for patients on recall visits or not. Approximately 30% of the participants responded that they always perform CRA, about 18% responded that they often perform CRA, 33% claimed they rarely perform CRA, and almost 20% responded that they never perform CRA on their patients. Of the participating dentist about 10% answered that they use a formalized CRA system or instrument while 90% answered that they do not. About 48% answered that they revaluate CRA for patients on recall, while 52% answered that they do not.

The participating dentists were asked about the caries detection methods they used in their daily clinical practice. The first diagnostic aid in question was drying the tooth for caries detection. Approximately 51% answered that they always dry the tooth, 41% answered often, 7% answered rarely, and 1% answered never. The second question was the use of a sharp explorer for caries detection. About 64% answered that they always use a sharp explorer for caries detection, 26% answered often, 7% answered rarely, and 3% answered never. The third question was the use of a blunt probe for caries detection. Approximately 10% answered that they always use a blunt probe for caries detection, 15% answered often, 37% answered rarely, and 38% answered never. The fourth question was the use of magnification (loups or microscope) for caries detection. About 61% answered that they always use magnification, 14% answered often, 10% answered rarely, and 15% answered never. The fifth question was the use of head light for caries detection. About 46% answered that they always use head light, 9% answered often, 12% answered rarely, and 34% answered never. The sixth question was the use of recent radiographs according to the ADA guidelines for caries detection. Approximately

87% answered that they always use recent radiographs according to the ADA guidelines

and 13% answered that they often do. The last question was in regard to the use of an

adjunct diagnostic tool(s) for caries detection. About 4% claimed that the always use

adjunct diagnostic tools, 9% answered often, 27% answered rarely, and 59% answered

never.

Table 15 Dentists practicing characteristics (n=138*)

Practicing characteristics	Frequency	Valid percent (%)
Dentist busyness		
I was not busy enough, and I would have liked to provide care to more patients.	22	15.9
I provided care to all those who have requested an appointment, and I did not feel overworked.	69	50
I provided care to all those who have requested an appointment, but felt I overworked.	43	31.2
I have limited my practice to current patients only, and I am not accepting new patients.	4	2.9
I am too busy and unable to treat new patients requesting appointments.	0	0

Table 16 Dentists practicing characteristics (n=138*)

Practicing characteristics	Mean (SD)	Range
Type of insurance		
Self pay or private insurance.	77.8 ±21.1	0-100%
Medicaid (Title XIX), DWP, and Hawk-I.	16.1 ±16.1	0-70%
Other.	6.7±18.4	0-100%
Age of the patient		
≤18 years.	23±21	0-100%
19-65 years.	53.9±18.1	0-98%
>65 years.	23±13.3	0-70%

Table 17 Dentists familiarity with current caries assessment and detection systems (n=138*)

Familiarity with current caries assessment and detection systems	Frequency	Valid percent (%)
Familiarity with ICDAS		
Very familiar.	12	8.7
Somewhat familiar.	58	42.0
Not at all familiar.	68	49.3
Familiarity with ICCMS		
Very familiar.	7	5.1
Somewhat familiar.	53	38.4
Not at all familiar.	78	56.5
Familiarity with CAMBRA		
Very familiar.	33	23.9
Somewhat familiar.	71	51.5
Not at all familiar.	34	24.6
Familiarity with ADA-CCS		
Very familiar.	24	17.4
Somewhat familiar.	83	60.1
Not at all familiar.	31	22.5

Table 18 Dentist performance of caries risk assessment (CRA) (n=138*)

Caries Risk Assessment (CRA)	Frequency	Valid percent (%)
How often performing CRA		
Always (75-100%)	40	29
Often (50-75%)	25	18.1
Rarely (<50%)	46	33.3
Never (0%)	27	19.6
Use formalized CRA System or Instrument		
Yes	14	10.1
No	124	89.9
Reevaluate the CRA for you patients at recall		
Yes	66	47.8
No	72	52.2

Table 19 Dentist caries detection practice (n=138*)

Caries detection	Frequency	Valid percent (%)
Dry the tooth		
Always (75-100%)	71	51.45
Often (50-75%)	56	40.6
Rarely (<50%)	10	7.25
Never (0%)	1	0.7
Use of sharp explorer		
Always (75-100%)	88	63.8
Often (50-75%)	36	26.1
Rarely (<50%)	10	7.25
Never (0%)	4	2.9
Use of blunt explorer		
Always (75-100%)	14	10.1
Often (50-75%)	21	15.2
Rarely (<50%)	51	37
Never (0%)	52	37.7
Use of magnification		
Always (75-100%)	84	60.9
Often (50-75%)	19	13.8
Rarely (<50%)	14	10.1
Never (0%)	21	15.2
Use of headlight		
Always (75-100%)	63	45.65
Often (50-75%)	12	8.7
Rarely (<50%)	16	11.59
Never (0%)	47	34.06
Use of radiographs according to ADA guidelines		
Always (75-100%)	120	87
Often (50-75%)	18	13.0
Rarely (<50%)	0	0
Never (0%)	0	0
Use of an adjunct diagnostic tools		
Always (75-100%)	6	4.4
Often (50-75%)	12	8.7
Rarely (<50%)	38	27.5
Never (0%)	82	59.4

Responses to the three scenarios

Three scenarios were provided to the participants. Each scenario included radiographs and photographs of three carious lesions obtained from patients who had received treatment in the Department of Operative Dentistry at the University of Iowa, College of Dentistry. The lesions were initial caries of the occlusal pit and fissure,

proximal smooth surface and free-surface (smooth surface) lesions. Each scenario represented a different patient with different caries risk (low, moderate, high); however, it was not stated to the participants what caries risk level was for each scenario was. The participants were given a brief health history, dental history, oral hygiene level and reason for consultation of the patient, as well as the findings of the clinical examination. The practitioners were asked to assess the caries risk level of each scenario. Scenario 1 was the moderate risk patient, scenario 2 was the low risk patient, and scenario 3 was the high risk patient. Tables 20-22 represent the scenario questions included in the survey as well as percentage of answers to each of the questions.

Table 20 Responses to the low risk scenario (S2) (n=138*)

Responses to the low risk scenario	Valid Percent (%)
Caries risk	
Low risk. [+]	92
Moderate risk.	8
High risk.	0
Diagnosis of occlusal lesion	
Sound tooth structure.	37
Enamel caries lesion. [+]	56.5
Dentin caries lesion.	6.5
Activity of Enamel caries lesion*	
Active.	25.6
Arrested. [+]	60.3
Do not know.	14.1
Activity of Dentin caries lesion*	
Active.	33.3
Arrested.	44.4
Do not know.	22.2
Treatment of occlusal lesion	
No lesion specific treatment. [+]	48.6
Resin based sealant without mechanical preparation of the tooth structure.	7.3
Glass ionomer sealant without mechanical preparation of tooth structure.	5.1
Resin based sealant with mechanical preparation of tooth structure (Fissurotomy).	21
Resin modified glass ionomer sealant with mechanical preparation of tooth structure.	4.4
Resin modified glass ionomer restoration.	1.5
Preventive resin restoration.	5.1
Resin based composite restoration.	6.5
Amalgam restoration.	0.7
Diagnosis of proximal lesion	
Sound tooth structure.	23.9
Enamel caries lesion. [+]	47.8
Dentin caries lesion.	28.3
Treatment of proximal lesion	
No lesion specific treatment. [+]	33.3
Clinically applied topical fluoride (Varnish, gel, foam).	33.3
Resin sealant / proximal infiltration (ICON).	2.2
Resin based composite restoration.	29.7
Resin modified glass ionomer.	1.5
Amalgam restoration.	0

Table 20 continued

Diagnosis of smooth surface lesion	
Sound tooth structure.	44.2
Enamel caries lesion. [+]	50.7
Dentin caries lesion.	5.1
Activity of Enamel caries lesion*	
Active.	12.9
Arrested. [+]	82.9
Do not know.	4.3
Activity of Dentin caries lesion*	
Active.	42.9
Arrested.	28.6
Do not know.	28.6
Treatment of smooth surface lesion	
No lesion specific treatment. [+]	44.2
Clinically applied topical fluoride (Varnish, gel, foam).	36.2
Resin infiltration (ICON).	3.6
Resin modified glass ionomer restoration.	5.8
Resin based composite restoration.	10.1
Amalgam restoration.	0
Overall recommendations and management of the low risk patient	
No recommendations.	7.25
Tooth brushing 2/day with over the counter fluoridated toothpaste. [+]	59.4
Tooth brushing 2/day with a 5000ppm fluoridated toothpaste.	31.2
General behavior modification in oral health.	29.7
Prescribed fluoridated mouthrinse.	10.9
Motivational engagement.	46.4
Sealants.	3.6
Fluoride varnish 2 times per year.	36.96
Fluoride varnish 4 times per year.	1.45
Fluoride gels or solution (2%NaF).	2.9
Recalls up to every 3 months.	4.35

*Due to missing data, not all variables add up to the total sample size population of 138
[+] Correct answer based on ICCMS

Table 21 Responses to the moderate risk scenario (S1) (n=138*)

Responses to the moderate risk scenario	Valid Percent (%)
Caries risk	
Low risk.	4.4
Moderate risk. [+]	59.4
High risk.	36.2
Diagnosis of occlusal lesion	
Sound tooth structure.	2.9
Enamel caries lesion. [+]	60.1
Dentin caries lesion.	37
Activity of Enamel caries lesion*	
Active. [+]	66.3
Arrested.	14.5
Do not know.	19.3
Activity of Dentin caries lesion*	
Active.	78.4
Arrested.	5.9
Do not know.	15.7
Treatment of occlusal lesion	
No lesion specific treatment.	5.8
Resin based sealant without mechanical preparation of the tooth structure. [+]	7.3
Glass ionomer sealant without mechanical preparation of tooth structure. [+]	2.9
Resin based sealant with mechanical preparation of tooth structure (Fissurotomy).	19.6
Resin modified glass ionomer sealant with mechanical preparation of tooth structure.	10.1
Resin modified glass ionomer restoration.	5.1
Preventive resin restoration.	10.9
Resin based composite restoration.	31.9
Amalgam restoration.	6.5
Diagnosis of proximal lesion	
Sound tooth structure.	0
Enamel caries lesion. [+]	4.4
Dentin caries lesion.	95.65
Treatment of proximal lesion	
No lesion specific treatment. [+]	2.2
Clinically applied topical fluoride (Varnish, gel, foam).	4.4
Resin sealant / proximal infiltration (ICON).	0.7
Resin based composite restoration.	62
Resin modified glass ionomer.	3.6
Amalgam restoration.	27.5

Table 21 continued

Diagnosis of smooth surface lesion	
Sound tooth structure.	20.3
Enamel caries lesion. [+]	44.9
Dentin caries lesion.	34.8
Activity of Enamel caries lesion*	
Active. [+]	46.8
Arrested.	25.8
Do not know.	27.4
Activity of Dentin caries lesion*	
Active.	79.2
Arrested.	6.3
Do not know.	14.6
Treatment of smooth surface lesion	
No lesion specific treatment.	7.3
Clinically applied topical fluoride (Varnish, gel, foam). [+]	51.5
Resin infiltration (ICON). [+]	2.2
Resin modified glass ionomer restoration.	11.6
Resin based composite restoration.	27.5
Amalgam restoration.	0
Overall recommendations and management of the moderate risk patient	
No recommendations.	0
Tooth brushing 2/day with over the counter fluoridated toothpaste.	37.7
Tooth brushing 2/day with a 5000ppm fluoridated toothpaste. [+]	65.94
General behavior modification in oral health. [+]	76.8
Prescribed fluoridated mouthrinse. [+]	13.8
Motivational engagement. [+]	84.8
Sealants. [+]	15.22
Fluoride varnish 2 times per year. [+]	56.5
Fluoride varnish 4 times per year.	6.5
Fluoride gels or solution (2%NaF). [+]	2.9
Recalls up to every 3 months. [+]	15.9

*Due to missing data, not all variables add up to the total sample size population of 138
[+] Correct answer based on ICCMS

Table 22 Responses to the high risk scenario (S3) (n=138*)

Responses to the high risk scenario	Valid Percent (%)
Caries risk	
Low risk.	0
Moderate risk.	1.5
High risk. [+]	98.5
Diagnosis of occlusal lesion	
Sound tooth structure.	12.3
Enamel caries lesion. [+]	59.4
Dentin caries lesion.	28.3
Activity of Enamel caries lesion*	
Active. [+]	51.9
Arrested.	30.9
Do not know.	17.3
Activity of Dentin caries lesion*	
Active.	84.2
Arrested.	2.6
Do not know.	13.2
Treatment of occlusal lesion	
No lesion specific treatment.	18.9
Resin based sealant without mechanical preparation of the tooth structure. [+]	5.1
Glass ionomer sealant without mechanical preparation of tooth structure. [+]	2.2
Resin based sealant with mechanical preparation of tooth structure (Fissurotomy).	14.5
Resin modified glass ionomer sealant with mechanical preparation of tooth structure.	8
Resin modified glass ionomer restoration.	4.4
Preventive resin restoration.	9.4
Resin based composite restoration.	31.2
Amalgam restoration.	6.5
Diagnosis of proximal lesion	
Sound tooth structure.	0.7
Enamel caries lesion. [+]	38.4
Dentin caries lesion.	60.8
Treatment of proximal lesion	
No lesion specific treatment.	5.1
Clinically applied topical fluoride (Varnish, gel, foam). [+]	19.6
Resin sealant / proximal infiltration (ICON). [+]	0
Resin based composite restoration.	36.2
Resin modified glass ionomer.	8
Amalgam restoration.	31.2

Table 22 continued

Diagnosis of smooth surface lesion	
Sound tooth structure.	20.3
Enamel caries lesion. [+]	59.4
Dentin caries lesion.	20.3
Activity of Enamel caries lesion*	
Active. [+]	63.4
Arrested.	18.3
Do not know.	18.3
Activity of Dentin caries lesion*	
Active.	92.9
Arrested.	0
Do not know.	7.1
Treatment of smooth surface lesion	
No lesion specific treatment.	12.3
Clinically applied topical fluoride (Varnish, gel, foam). [+]	42.8
Resin infiltration (ICON). [+]	2.2
Resin modified glass ionomer restoration.	28.3
Resin based composite restoration.	13.8
Amalgam restoration.	0.7
Overall recommendations and management of the high risk patient	
No recommendations.	0.77
Tooth brushing 2/day with over the counter fluoridated toothpaste.	23.2
Tooth brushing 2/day with a 5000ppm fluoridated toothpaste. [+]	80.4
General behavior modification in oral health. [+]	77.5
Prescribed fluoridated mouthrinse. [+]	23.2
Motivational engagement. [+]	78.3
Sealants. [+]	5.8
Fluoride varnish 2 times per year.	49.3
Fluoride varnish 4 times per year. [+]	20.3
Fluoride gels or solution (2%NaF). [+]	6.5
Recalls up to every 3 months. [+]	48.55

*Due to missing data, not all variables add up to the total sample size population of 138
[+] Correct answer based on ICCMS

Agreement with ICCMS treatment recommendations

As previously explained the survey involved three patient scenarios; low,

moderate and high caries risk. Each scenario contained three initial caries lesions

(occlusal, proximal and smooth surface caries). Table 23 presents the caries management

recommendations according to ICCMS for each lesion per scenario according to the

caries risk level and the lesion activity. In the low risk scenario, the ICCMS recommends

no lesion specific treatment for the initial inactive occlusal pit and fissure, smooth surface

proximal and smooth surface free lesions. In the moderate risk scenario, the ICCMS recommends resin based or glass ionomer sealants for the initial active occlusal pit and fissure caries lesion. For the initial smooth surface proximal lesion in the moderate risk scenario, the ICCMS recommends topical fluoride application, and/or resin based sealants or infiltration. While for the initial active smooth surface caries lesion the ICCMS recommends topical fluoride application and/or resin infiltration. In the high risk scenario, the ICCMS recommends for the initial active occlusal pit and fissure caries lesion, either resin based or glass ionomer sealants. Regarding the initial proximal caries lesion in the high risk scenario the ICCMS recommends topical fluoride application and/or resin sealants or proximal infiltration. For the initial smooth surface caries lesion in the high risk scenario the ICCMS recommends, topical fluoride application and/or resin infiltration.

Table 23 Treatment recommendation by the ICCMS for initial caries lesion

		Treatment recommendation by ICCMS for initial caries lesions according to the risk level and lesion activity
Low risk	Occlusal pit and fissure inactive	No lesion specific treatment.
	Proximal smooth surface inactive	No lesion specific treatment.
	Free Smooth surface inactive	No lesion specific treatment.
Moderate risk	Occlusal pit and fissure active	Resin based/ Glass ionomer sealant without mechanical preparation of the tooth structure..
	Smooth surface Proximal active	Clinically applied topical fluoride (Varnish, gel, foam). Resin sealant / proximal infiltration (ICON).
	Free Smooth surface active	Clinically In-office applied Fluoride application (varnish, gel, foam). Resin infiltration (ICON).
High risk	Occlusal pit and fissure active	Resin based/ Glass ionomer sealant without mechanical preparation of the tooth structure.
	Smooth surface proximal active	Clinically applied topical fluoride (Varnish, gel, foam). Resin sealant / proximal infiltration (ICON).
	Free Smooth surface active	Clinically In-office applied Fluoride application (varnish, gel, foam). Resin infiltration (ICON).

New variables were created to define agreement in the treatment of the initial caries lesions in each scenario. Practitioner responses that agreed with the recommended treatment by ICCMS were reported 'match' while responses that did not agree were reported as 'no match'. Table 24 shows the number and the percentage of dentists agreed with the ICCMS in 1, 2, 3 or none of the three initial caries lesions for each scenario. In the current study for each scenario, dentists were considered to be in agreement with ICCMS guidelines if they had agreed with ICCMS guidelines in the treatment recommendations of at least 1 of the 3 caries lesions per scenario. Dentists were considered not to be in agreement only if they did not agree with the ICCMS treatment guidelines in any of the 3 included caries lesions. The percentage of practitioner agreement per scenario is shown in Table 25.

Table 24 Agreement with ICCMS guidelines

Number of matched treatments	% Agreement in low caries risk scenario (S2)	% Agreement in moderate caries risk scenario (S1)	% Agreement in high caries risk scenario (S3)
0	27.54 (n=38)	41.30 (n=57)	48.55 (n=67)
1	31.88 (n=44)	49.28 (n=68)	34.78 (n=48)
2	27.54 (n=38)	6.52 (n=9)	13.04 (n=18)
3	13.04 (n=18)	2.90 (n=4)	3.62 (n=5)

Table 25 Percentage agreement with ICCMS

Caries risk	Percentage agreement with ICCMS
Low caries risk (n=100)	75.5%
Moderate caries risk (n=81)	58.7%
High caries risk (n=71)	51.4%

<u>Bivariate analysis</u>

Low risk scenario

Bivariate analyses were conducted to explore the factors associated with agreement with ICCMS. Categories were grouped together as explained in Chapter III. The bivariate analysis showed that there was only one variable significantly (p<0.05) associated with the agreement with the ICCMS Guidelines for low risk scenario. The analysis revealed that the subjects who answered always or often that they dry the tooth with compressed air for caries detection were as likely to agree with the ICCMS Guideline compared to those who answered that they rarely or never dry the tooth with compressed air for caries detection (74.8% vs. 45.5%; p=0.0366). The detailed significant results are reported in Table 26 and the non significant factors are reported in Table 27 No significant differences were found with regard to demographics, knowledge and other clinical characteristics that are not reported in Table 26 (p>0.10 in all instances).

Table 26 Significant Factors Associated with Management of Initial Caries Lesions for Low Risk (n=138*)

Variables	Had No Agreement N=38 n (%)	Had Agreement N=100 n (%)	P-value
Frequency of drying the tooth with compressed air			0.0366[a]
Always or often	32 (25.2)	95 (74.8)	
Rarely or never	6 (54.5)	5 (45.5)	

a Statistically significant (p<0.05) using chi-square test

Table 27 Factor Not significantly Associated with Management of Initial Caries Lesions for Low Risk (n=138*)

Variables	Had No Agreement N=38 n (%)	Had Agreement N=100 n (%)	P-value
Gender			0.9550
Male	23 (27.7)	60 (72.3)	
Female	15 (27.3)	40 (72.7)	
Age			0.7457
Mean/Median (years)	48.8/49.0	48.1/49.5	
Age group of practitioner			0.9872
26-35	8 (28.6)	20 (71.4)	
36-45	8 (25.0)	24 (75.0)	
46-55	9 (28.1)	23 (71.9)	
55+	13 (28.3)	33 (71.7)	
Years since graduation			0.8418
Mean/Median (years)	21.9/20.5	21.6/22.0	
Years since graduation			0.9644
1-9 years	8 (26.7)	22 (73.3)	
10-19 years	10 (31.25)	22 (68.75)	
20-29 years	8 (25.8)	23 (74.2)	
30+ years	12 (27.3)	32 (72.7)	
Completed a formal postgraduate training program			0.8149
Yes	11 (26.2)	31 (73.8)	
No	27 (28.1)	69 (71.9)	
Years of clinical practice			0.7392
Mean/Median (years)	21.8/20.5	21.3/21.0	
Years of clinical practice			0.9097
1-10 years	9 (26.5)	25 (73.5)	
11-19 years	9 (32.1)	19 (67.9)	
20-29 years	7 (24.1)	22 (75.9)	
30+ years	13 (29.55)	31 (70.45)	

Table27 continued

Role in primary practice			0.3062
Solo	11 (22.45)	38 (77.55)	
Group practice	23 (33.33)	46 (66.7)	
Public health practice & other	4 (20.0)	16 (80.0)	
Percentage of patients covered by self-pay and private insurance			0.3386
0-70%	13 (33.3)	26 (66.7)	
71-100%	25 (25.25)	74 (74.75)	
Percentage of patients covered by government sponsored			0.8957
0-10%	19 (26.0)	54 (74.0)	
11-30%	14 (28.6)	35 (71.4)	
31-70%	5 (31.25)	11 (68.75)	
Percentage of patients covered by other insurance			0.1129
0%	29 (31.9)	62 (68.1)	
1-100%	9 (19.15)	38 (80.85)	
Percentage of patients less than 18 years old			0.6303
0-19%	13 (23.2)	43 (76.8)	
20-44%	22 (30.1)	51 (69.9)	
80-100%	3 (33.3)	6 (66.7)	
Percentage of patients between 19 and 65 years old			0.3637
0-50%	20 (31.25)	44 (68.75)	
51-100%	18 (24.3)	56 (75.7)	
Percentage of patients over 65 years old			0.8208
0-25%	26 (26.3)	73 (73.7)	
26-39%	6 (28.6)	15 (71.4)	
40-70%	6 (33.3)	12 (66.7)	
Dentist busyness			0.6705
Not busy enough/Not over burdened	24 (26.4)	67 (73.6)	
Overburdened/Too busy to treat	14 (29.8)	33 (70.2)	
Familiarity with ICDAS			0.5109
Very and somewhat familiar	21 (30.0)	49 (70.0)	
Not at all familiar	17 (25.0)	51 (75.0)	
Familiarity with ICCMS			0.3407
Very and somewhat familiar	19 (31.7)	41 (68.3)	
Not at all familiar	19 (24.4)	59 (75.6)	
Familiarity with CAMBRA			0.5468
Very and somewhat familiar	30 (28.85)	74 (71.15)	
Not at all familiar	8 (23.5)	26 (76.5)	
Frequency of Performing CRA for New or Recall Patients			0.6741
Always or often	19 (29.2)	46 (70.8)	
Rarely or never	19 (26.0)	54 (74.0)	

Table 27 continued

			0.9271
Use of a formalized CRA system or instrument			
Yes	34 (27.4)	90 (72.6)	
No	4 (28.6)	10 (71.4)	
Reevaluate CRA for recall patients			0.4069
Yes	22 (30.6)	50 (69.4)	
No	16 (24.2)	50 (75.8)	
Frequency of use of sharp explorer			0.2416
Always or often	36 (29.0)	88 (71.0)	
Rarely or never	2 (14.3)	12 (85.7)	
Frequency of use of a blunt probe			0.8739
Always or often	10 (28.6)	25 (71.4)	
Rarely or never	28 (27.2)	75 (72.8)	
Frequency of use of magnification			0.5507
Always or often	27 (26.2)	76 (73.8)	
Rarely or never	11 (31.4)	24 (68.6)	

Moderate risk scenario

Unlike the low risk scenario, bivariate analyses resulted in many factors being
either significant (p <0.05) or marginally significant (0.05<p<0.10). Bivariate analysis
revealed that female dentists were more likely to agree with ICCMS than male dentists
(p=0.0958). Younger Dentists, in the age group 26-35 years or 36-45 years were more
likely to agree with ICCMS than those who were over 45 years old (p=0.0002). Similarly
dentists who had fewer years since graduation (less than 20 years) were more likely to
agree with ICCMS than those who had over 20 years since graduation (p=0.0002).
Dentists who had post-graduate training were more likely to agree with ICCMs than
those who did not have post-graduate training (p=0.0171). Moreover, the subjects who
practiced in a group practice or in public health settings were more likely to agree with
ICCMS than those in solo practice (p=0.0017). Dentists who had 31-70 % of their
patients covered by government sponsored insurance were more likely to agree with
ICCMS than those who had <30% of their patients covered by government sponsored
insurance (p=0.0991). Dentists who reported that 0-19% or 80-100% of their patients

were less than 18 years old were more like to agree with the ICCMS than those who had 20-44% of their patients under 18 years old (p=0.0587).

Moreover, the subjects who were very or somewhat familiar with the ICDAS, ICCMS, and CAMBRA were more likely to agree with ICCMS (p=0.0168, p=0.0437, and p=0.0169 respectively) than those who answered that they are not familiar. Dentists who reported that they rarely or never dry the tooth with compressed air for caries detection were more likely to agree with ICCMS than those who answered always or often ((p=0.0264). Lastly dentists who answered that they always or often use magnification were more likely to agree with the ICCMS than those who answered rarely or never (p=0.0093). The detailed significant and marginally significant results are reported in Table 28 and the non-significant factors are reported in Table 29.

Table 28 Significant Factors Associated with Management of Initial Caries Lesions for Moderate Risk (S1) (n=138*)

Variables	Had No Agreement N=57 n (%)	Had Agreement N=81 n (%)	P-value*
Gender Male Female	39 (47.0) 18 (32.7)	44 (53.0) 37 (67.3)	0.0958[a]
Age Mean/Median (years)	52.9/56.0	45.0/43.0	0.0002[b]
Age group 26-35 36-45 46-55 55+	5 (17.9) 9 (28.1) 14 (43.8) 29 (63.0)	23 (82.1) 23 (71.9) 18 (56.2) 17 (37.0)	<0.0001[c]
Years since graduation Mean/Median (years)	26.5/29.0	18.3/15.0	0.0002[b]
Years since graduation 1-9 years 10-19 years 20-29 years 30+ years	6 (20.0) 8 (25.0) 15 (48.4) 28 (63.6)	24 (80.0) 24 (75.0) 16 (51.6) 16 (36.4)	<0.0001[c]
Completed a formal postgraduate training program Yes No	11 (26.2) 46 (47.9)	31 (73.6) 50 (52.1)	0.0171[a]
Years of clinical practice Mean/Median (years)	26.3/29.5	18.2/15.0	0.0002[b]
Years of clinical practice 1-10 years 11-19 years 20-29 years 30+ years	8 (23.5) 5 (17.9) 14 (48.3) 27 (61.4)	26 (76.5) 23 (82.1) 15 (51.7) 17 (38.6)	<0.0001[c]
Role in primary practice Solo Group practice Public health practice & other	27 (55.1) 28 (40.6) 2 (10.0)	22 (44.9) 41 (59.4) 18 (90.0)	0.0017[d]
Percentage of patients covered by self-pay and private insurance Mean\median percentage	82.5/85.0	74.5/80.0	0.0763[b]
Percentage of patients covered by Medicaid 0-10% 11-30% 31-70%	30 (41.1) 24 (49.0) 3 (18.7)	43 (58.9) 25 (51.0) 13 (81.3)	0.0991[d]
Percentage of patients covered by other insurance Mean\median percentage	3.2/0.0	9.1/1.0	0.0899[b]

Table 28 continued

Percentage of patients less than 18 years old			0.0587[d]
0-19%	17 (30.4)	39 (69.4)	
20-44%	37 (50.7)	36 (49.3)	
80-100%	3 (33.3)	6 (66.7)	
Familiar with ICDAS			0.0168[a]
Very and somewhat familiar	22 (31.4)	48 (68.6)	
Not at all familiar	35 (51.5)	33 (48.5)	
Familiar with ICCMS			0.0437[a]
Very and somewhat familiar	19 (31.7)	41 (68.3)	
Not at all familiar	38 (48.7)	40 (51.3)	
Familiar with CAMBRA			0.0169[a]
Very and somewhat familiar	37 (35.6)	67 (64.4)	
Not at all familiar	20 (58.8)	14 (41.2)	
Frequency of drying the tooth with compressed air			0.0264[d]
Always or often	56 (44.1)	71 (55.9)	
Rarely or never	1 (9.1)	10 (90.9)	
Frequency of use of magnification			0.0093[a]
Always or often	36 (35.0)	67 (65.0)	
Rarely or never	21 (60.0)	14 (40.0)	

[*] Statistically significant ($p<0.05$) or marginally statistically significant ($0.05 \leq p < 0.10$)

[a] Statistically significant or marginally significant using chi-square test

[b] Statistically significant or marginally significant using the nonparametric Wilcoxon rank-sum test

[c] Statistically significant or marginally significant using Cochran-Mantel-Haenszel test

[d] Statistically significant or marginally significant using Fisher's exact test

Note: Statistical analyses were conducted based on all non-missing values

Table 29 Factors Not Significantly Associated with Management of Initial Caries Lesions for Moderate Risk (S1) (n=138*)

Variables	Had No Agreement N=38 n (%)	Had Agreement N=100 n (%)	P-value
Percentage of patients between 19 and 65 years old 0-50% 51-100%	28 (43.75) 29 (39.2)	36 (56.25) 45 (60.8)	0.5874
Percentage of patients over 65 years old 0-25% 26-39% 40-70%	43 (43.4) 9 (42.9) 5 (27.8)	56 (56.6) 12 (57.1) 13 (72.2)	0.4574
Dentist busyness Not busy enough/Not over burdened Over burdened/Too busy to treat	41 (45.05) 16 (34.0)	50 (54.95) 31 (66.0)	0.2131
Frequency of Performing CRA for New or Recall Patients Always or often Rarely or never	26 (40.0) 31 (42.5)	39 (60.0) 42 (57.5)	0.7690
Use of a formalized CRA system or instrument Yes No	52 (41.9) 5 (35.7)	72 (58.1) 9 (64.3)	0.6541
Reevaluate CRA for recall patients Yes No	30 (41.7) 27 (40.9)	42 (58.3) 39 (59.1)	0.9281
Frequency of use of sharp explorer Always or often Rarely or never	53 (42.7) 4 (28.6)	71 (57.3) 10 (71.4)	0.3074
Frequency of use of a blunt probe Always or often Rarely or never	13 (37.1) 44 (42.7)	22 (62.9) 59 (57.3)	0.5627

High risk scenario

Bivariate analysis revealed that the subjects who completed formal post-graduate training programs were more likely to agree with ICCMS than those who did not have post-graduate training (p=0.046). Dentists who practiced in a group practice or in a public health setting were more likely to agree with ICCMs than those who were in a solo practice (p=0.025). Moreover the bivariate results showed that the dentists who answered

than they were very or somewhat familiar with ICCMS, were more likely to agree with

ICCMS than those who answered that they are not familiar with ICCMS (p=0.0779).

Additionally, dentists who answered that they always or often perform CRA for their new

or recall patients were more likely to agree with ICCMS than those who answered rarely

or never (p=0.0252). The detailed significant results are reported in Table 30. No other

significant differences were found with regard to the demographic characteristics,

knowledge and clinical characteristics (p>0.10 in all instances). The non significant

variables are reported in Table 31.

Table 30 Significant Factors Associated with Management of Initial Caries Lesions for
High Risk (S3) (n=138*)

Variables	Had No Agreement N=67 n (%)	Had Agreement N=71 n (%)	P-value
Completed a formal postgraduate training program			0.0460[a]
Yes	15 (35.7)	27 (64.3)	
No	52 (54.2)	44 (45.8)	
Role in primary practice			0.0250[a]
Solo	30 (61.2)	19 (38.8)	
Group practice	30 (43.5)	39 (56.5)	
Public health practice & other	7 (35.0)	13 (65.0)	
Familiar with ICCMS			0.0779[b]
Very and somewhat familiar	24 (40.0)	36 (60.0)	
Not at all familiar	43 (55.1)	35 (44.9)	
Frequency of Performing CRA for New or Recall Patients			0.0252[a]
Always or often	25 (38.5)	40 (61.5)	
Rarely or never	42 (57.5)	31 (42.5)	

*Statistically significant (p<0.05) or marginally statistically significant (0.05<p<0.10)
a Statistically significant using chi-square test
b Marginally statistically significant using chi-square test
Note: Statistical analyses were conducted based on all non-missing values

Table 31 Non Significant Factors Associated with Management of Initial Caries Lesions for High Risk (S3) (n=138*)

Variables	Had No Agreement N=38 n (%)	Had Agreement N=100 n (%)	P-value
Gender			0.3471
Male	43 (51.8)	40 (48.2)	
Female	24 (43.6)	31 (56.4)	
Age			0.2078
Mean/Median (years)	49.6/51.0	47.1/47.0	
Age group			0.1596
26-35	8 (28.6)	20 (71.4)	
36-45	20 (62.5)	12 (37.5)	
46-55	14 (43.75)	18 (56.25)	
55+	25 (54.35)	21 (45.65)	
Years since graduation			0.1865
Mean/Median (years)	23.1/25.0	20.5/21.0	
Years since graduation			0.9644
1-9 years	8 (26.7)	22 (73.3)	
10-19 years	10 (31.25)	22 (68.75)	
20-29 years	8 (25.8)	23 (74.2)	
30+ years	12 (27.3)	32 (72.7)	
Years of clinical practice			0.2304
Mean/Median (years)	22.6/24.5	20.4/20.0	
Years of clinical practice			0.2262
1-10 years	9 (30.0)	21 (70.0)	
11-19 years	20 (62.5)	12 (37.5)	
20-29 years	14 (45.2)	17 (54.8)	
30+ years	23 (52.3)	21 (47.7)	
Percentage of patients covered by self-pay and private insurance			0.7236
0-70%	18 (4.15)	21 (53.85)	
71-100%	49 (49.5)	50 (50.5)	
Percentage of patients covered by Medicaid			0.8997
0-10%	18 (46.15)	21 (53.85)	
11-30%	23 (51.1)	22 (48.9)	
31-70%	26 (48.15)	28 (51.85)	
Percentage of patients covered by other insurance			0.5133
0%	46 (50.6)	45 (49.4)	
1-100%	21 (44.7)	26 (55.3)	
Percentage of patients less than 18 years old			0.5236
0-19%	26 (46.4)	30 (53.6)	
20-44%	38 (52.1)	35 (47.9)	
80-100%	3 (33.3)	6 (66.7)	

Table 31 continued

Percentage of patients between 19 and 65 years old			0.4790
0-50%	29 (45.3)	35 (54.7)	
51-100%	38 (51.4)	36 (48.6)	
Percentage of patients over 65 years old			0.1669
0-25%	51 (51.5)	48 (48.5)	
26-39%	11 (52.4)	10 (47.6)	
40-70%	5 (27.8)	13 (72.7)	
Dentist busyness			0.7685
Not busy enough/Not over burdened	45 (49.4)	46 (50.6)	
Overburdened/Too busy to treat	22 (46.8)	25 (53.2)	
Familiarity with ICDAS			0.1745
Very and somewhat familiar	30 (42.9)	40 (57.1)	
Not at all familiar	37 (54.4)	31 (45.6)	
Familiarity with CAMBRA			0.8456
Very and somewhat familiar	50 (48.1)	54 (51.9)	
Not at all familiar	17 (50.0)	17 (50.0)	
Use of a formalized CRA system or instrument			0.6530
Yes	61 (49.2)	63 (50.8)	
No	6 (42.9)	8 (57.1)	
Reevaluate CRA for recall patients			0.4860
Yes	37 (51.4)	35 (48.6)	
No	30 (45.4)	36 (54.6)	
Frequency of drying the tooth with compressed air			0.3992
Always or often	63 (49.6)	64 (50.4)	
Rarely or never	4 (36.4)	7 (63.6)	
Frequency of use of sharp explorer			0.3107
Always or often	62 (50.0)	62 (50.0)	
Rarely or never	5 (35.7)	9 (64.3)	
Frequency of use of a blunt probe			0.6975
Always or often	16 (45.7)	19 (54.3)	
Rarely or never	51 (49.5)	52 (50.5)	
Frequency of use of magnification			0.4320
Always or often	48 (46.6)	55 (53.4)	
Rarely or never	19 (54.3)	16 (45.7)	

<u>Multivariable logistic regression analysis</u>

Multivariable logistic regression analysis was performed to explore the variables that can be used to predict Iowa dentists' agreement with the ICCMS Guidelines for each scenario. Within each scenario, variables showing significant associations with the agreement with the ICCMS guidelines in bivariate analysis ($p \leq 0.1$) were used to develop a final model using forward stepwise logistic regression analysis, and verified using backward elimination.

Low risk scenario

The ICCMS recommends no lesion specific treatment for initial inactive occlusal, smooth surface proximal and smooth surface free caries lesions. Dentists were considered to be in agreement with ICCMS if they agreed with ICCMS in the treatment recommendation for at least one out of the three lesions in the low risk scenario. Based on the bivariate analysis, only frequency of drying the tooth with compressed air showed statistically significant association with agreement with ICCMS ($p<0.05$) Table 26, therefore it was used to build the final logistic regression model.

Table 32 Logistic Regression for the Significant Predicator Related to the Agreement with the ICCMS Guidelines for Low Risk Scenario (n=138*)

Variables	Odds Ratio Estimate (95% Wald Confidence Limits)	P-value*
Frequency of drying the tooth with compressed air		0.0468
Always or often	3.56 (1.02, 12.67)	
Rarely or never	1.00	

*P-value from the logistic regression analysis of the variable associated with the agreement with ICCMS Guidelines

The findings from the logistic regression analysis indicated that those who answered that they always or often dry the tooth with compressed air for caries detection were 3.56 times as likely to recommend no lesion specific treatment for initial inactive caries lesions in the low risk scenario than those who answered rarely or never. Stated differently, the odds of having agreement with the ICCMS guidelines for those who always or often dry the tooth with compressed air for caries detection were 3.56 times that of those who answered rarely or never (95% CI: 1.02-12.67; p=0.0468). The results of logistic regression analysis are presented in Table 32.

Moderate risk scenario

The ICCMS treatment recommendation for initial active occlusal pit and fissure caries lesion is sealant application. While for initial active smooth surface proximal and smooth surface free ICCMS recommends topical fluoride application and/or resin infiltration. Dentists were considered to be in agreement with ICCMS if they agreed with ICCMS in the treatment recommendation for at least one out of the three lesions in the moderate risk scenario. The variables that showed statistical and marginal significance (p≤0.10) in the bivariate analysis (Table 28) were admitted into the final stepwise logistic regression procedure. Multiple variables were significantly associated with the agreement with the ICCMS Guidelines for moderate scenario in bivariate analysis, however, only three variables including years since graduation (p=0.0024), type of practice (p=0.0089) and frequency of use of magnification (p=0.0225), were significantly related to the agreement with the ICCMS Guidelines in the final logistic regression model. The results are shown in Table 33.

Table 33 Logistic regression for Significant Predicators Related to the ICCMS Guidelines for Moderate Risk Scenario (n=138*) (final model, giving odds ratio adjusted for other variable in the model)

Variables	Odds Ratio Estimate (95% Wald Confidence Limits)	p-value*
Years since graduation		0.0024
1-9 years	5.94 (1.84, 19.21)	(0.0029)
10-19 years	6.00 (2.03, 17.77)	(0.0012)
20-29 years	2.19 (0.78, 6.12)	(0.1361)
30+ years	1.00	
Type of practice		0.0089
Public health practice	14.45 (2.62, 49.76)	(0.0022)
Group practice	1.62 (0.69, 3.80)	(0.2635)
Solo	1.00	
Frequency of use of magnification		0.0225
Always or often	2.89 (1.16, 7.17)	
Rarely or never	1.00	

*P-value from the logistic regression analysis of the variable associated with the ICCMS Guidelines while controlling other variables constant

This study dentists with less than 20 years since gradation groups and practicing in public health setting, and using magnification always or often for caries detection were the most likely to predict agreement with the ICCMS Guidelines for the moderate risk scenario. Holding all other variables constant, The odds of having agreement with ICCMS for subjects who answered that they always or often use magnification were 2.89 times that of those who answered rarely or never (95% CI: 1.16-7.17; p=0.0225). Additionally, the odds of having agreement with ICCMS for subjects who had graduated either 1-9 years ago or 10-19 years ago were 5.94 (95% CI: 1.84-19.21; p=0.0029) or 6.00 times (95% CI: 2.03-17.77; p=0.0012) that of those who graduated 30 years ago while no difference in odds of the agreement with the ICCMS Guidelines between subjects who graduated 20 to 29 years ago and who graduated over 30 years ago (p=0.2635). Lastly, subjects who were in Public Health Practice had odds that were 14.45 (95% CI: 2.62-49.76; p=0.0022) times as likely as those in solo practice to agree with the ICCMS Guidelines while no difference was noted between subjects who were in group practice and who were in solo practice (p=0.2635).

High risk scenario

The ICCMS treatment recommendation for initial active occlusal pit and fissure caries lesion is sealant application. While for initial active smooth surface proximal and smooth surface free ICCMS recommends topical fluoride application and/or resin infiltration. Dentists were considered to be in agreement with ICCMS if they agreed with ICCMS in the treatment recommendation for at least one out of the three lesions in the high risk scenario. Based on the bivariate analysis, the four significant variables that showed statistical and marginal significance ($p \leq 0.1$) (Table 30) were used to build the final logistic regression model. However, only one variable, frequency of performing CRA for new and/or recall patients, was significantly associated with the agreement with ICCMS Guidelines in the final logistic regression model (Table 34).

Table 34 Logistic Regression for Significant Predicators Related to the Agreement with the ICCMS Guidelines for High Risk Scenario (n=138*)

Variables	Odds Ratio Estimate (95% Wald Confidence Limits)	p-value*
Frequency of Performing CRA for New or Recall Patients		0.0262
Always or often	2.17 (1.10, 4.29)	
Rarely or never	1.00	

*P-value from the logistic regression analysis of the variable related to the agreement with ICCMS Guidelines

The findings from the logistic regression analysis indicated that those who answered that they always or often performed CRA for new and/or recall patients were more likely to agree with ICCMS treatment recommendation than those who answered rarely or never. Odds of having agreement with the ICCMS Guidelines for subjects who always or often performed CRA for new and/or recall patients were 2.17 times that of

those who rarely or never performed CRA for new and/or recall patients (95% CI: 1.10-4.29; p=0.0262).

Further analysis

To further evaluate whether the number of years since graduation was to the agreement with the ICCMS Guidelines for low and high risk scenarios, two additional logistic regression models were conducted. The reason behind forcing years since graduation is that in recent years there were changes in education as well as in clinical practice; also this variable was statistically significant in the moderate risk model. Therefore the variable, number of years since graduation, was forced into the model of low and high risk, and single covariates were added one at a time to that model in a forward stepwise fashion. The forward stepwise logistic regression models then were verified using backward elimination. Years since graduation was not defined as a categorical variable in this additional analysis due to the non significant results obtained for each of the two models.

The findings from the logistic regression analysis indicated that frequency of drying the tooth with compressed air was significantly associated with the agreement with the ICCMS Guidelines for low risk scenario (p=0.0491), adjusted for the number of years since receiving a dental degree. The odds of having agreement with the ICCMS guidelines for those who always or often dried the tooth with compressed air for caries detection were 3.52 (95% CI: 1.01-12.33) times that of those who rarely or never dried the tooth. However, the final logistic regression analysis showed that the number of years since graduation was not significantly associated with agreement with the ICCMS guidelines for low risk scenario. The results of logistic regression analysis are presented

in Table 35. Therefore, it was decided to keep the model (Table 32) described earlier

without years since graduation as the final model to report for low risk scenario.

Table 35 Multivariable Logistic Regression Model for Exploring the Factors Related to
the Agreement with the ICCMS Guidelines for Low Risk Scenario (S2), Adjusted for
Number of Years Since graduation (final model, giving odds ratio adjusted for other
variable in the model).

Variables	Odds Ratio Estimate (95% Wald Confidence Limits)	p-value*
Frequency of drying the tooth with compressed air		0.0491
Always or often	3.52 (1.01, 12.33)	
Rarely or never	1.00	
Number of years since graduation		0.9471
Years	1.00 (0.97, 1.03)	

*P-value from the logistic regression analysis of the variable associated with the
agreement with ICCMS Guidelines

The findings from the logistic regression analysis indicated that frequency of

performing CRA for new or recall patients was associated with the agreement with the

ICCMS Guidelines for high scenario (p=0.0408). The odds of having agreement with the

ICCMS Guidelines for subjects who always or often performed CRA for their new and/or

recall patients were 2.05 (95% CI: 1.03-4.08) times that of those rarely or never

performed CRA for their new and/or recall patients. However, the final logistic

regression analysis showed that the number of years since graduation was not

significantly associated with agreement with the ICCMS guidelines for high risk

scenario. The results of logistic regression analysis are presented in Table 36. Therefore,

it was decided to keep the model (Table 34) described earlier without years since

graduation as the final model to report for high risk scenario.

Table 36 Multivariable Logistic Regression Model for Exploring the Factors Related to the Agreement with the ICCMS Guidelines for High Risk Scenario (S3), Adjusted for Number of Years since graduation (final model, giving odds ratio adjusted for other variable in the model).

Variables	Odds Ratio Estimate (95% Wald Confidence Limits)	p-value*
Frequency of Performing CRA for New or Recall Patients		0.0408
Always or often	2.05 (1.03, 4.08)	
Rarely or never	1.00	
Number of since graduation		0.3079
Years	0.99 (0.96, 1.01)	

*P-value from the logistic regression analysis of the variable related to the agreement with ICCMS Guidelines

CHAPTER V: DISCUSSION

Overview

The purpose of the current cross sectional study was to assess Iowa dentists' agreement with the ICCMS guidelines in the management of initial caries lesions and explore the factors associated with this agreement via an e-mail survey. After obtaining the University of Iowa International Review Board (IRB) approval, the e-mail addresses of graduates from the University of Iowa College of Dentistry were made accessible through the University of Iowa Alumni Association.

A total of 916 surveys were sent via e-mail. Initially the response was only 65 individuals, however, after changing the initial subject line of the e-mail from "Survey invitation with one hour of CE credit" to "U of Iowa cariology survey with one hour of CE credit", another 100 responses were received, yielding a total of 165 responses. However, 5 responses were not usable because dentists had stated that they were not currently practicing. Another 22 responses were also invalid due to the incomplete responses. This resulted in a total of 138 responses used for the current study.

The survey was constructed on the REDCap and composed of three patient scenarios. Each of the three scenarios represented a patient case of different caries risk level (low, moderate and high). The information provided to the dentist in the survey included health and dental history, dental findings and oral hygiene habits of the patient, it also included photographs and dental radiographs of the initial caries lesions.

The method of using scenario based surveys to investigate dentists management of caries lesions was used in multiple previous studies (107-109, 112, 115-117, 121, 122). Most of those studies evaluated the threshold at which dentists intervene surgically in caries of different depths. A study by Heaven et al. (117) investigated dentist's treatment choices (no treatment, operative treatment or preventive) to varying depths of occlusal

and interproximal caries lesions in relationship to the caries risk level (low and high). The current study was focused on the initial carious lesions in three patient scenarios of low, moderate and high caries risk.

<u>Hypothesis acceptance or rejection</u>

In the current study all the participants had more than 50% agreement with ICCMS guidelines in the management of one initial caries lesions out of the three lesions per scenario. Approximately 76% had agreement with ICCMS guidelines in the low caries risk, while 59% had agreement with ICCMS guidelines for the moderate risk scenario and 51% for the high caries risk scenario. Thus we accept the hypothesis that the majority of Iowa dentists agreed with the ICCMS guidelines in the management of initial caries lesions for low, moderate and high caries risk patients.

We accept the hypothesis that Iowa dentists' demographic characteristics are not associated with the dentists' initial caries lesion management agreement in low risk patients according to ICCMS. Similarly, we accepted the hypothesis that the Iowa dentists' demographic characteristics are not associated with the dentists' initial caries lesion management agreement in high risk patients according to ICCMS. However, we reject the Hypothesis that Iowa dentists' demographic characteristics are not associated with the dentists' initial caries lesion management agreement in moderate risk patients according to ICCMS. Since agreement was associated with the number of years since graduation and dentists' practice type. Those who graduated in the last 20 years were more likely to agree than those who graduated over 20 years ago. Dentists who practiced in public health settings were more likely to agree than those who worked in solo or group practice.

We also reject the hypothesis that Iowa dentists' knowledge and practicing characteristics are not associated with the dentists' initial caries lesion management

agreement in low risk patients according to ICCMS. Since agreement was more likely among those who dry the teeth for caries detection. Also, we reject the hypothesis that Iowa dentists' knowledge and practicing characteristics are not associated with the dentists' initial caries lesion management agreement in moderate risk patients according to ICCMS. Since agreement was more likely among those who use magnification for caries detection. We also reject the hypothesis that Iowa dentists' knowledge and practicing characteristics are not associated with the dentists' initial caries lesion management agreement in high risk patients according to ICCMS. Since agreement was more likely among those who perform caries risk assessment.

Study population

Initially the study was going to include all practicing dentists in the state of Iowa and would have been possible by using the Iowa dentist tracking system, that provides mailing addresses of all dentists in Iowa, while this would have been appropriate for a paper based survey, since the survey included color high-resolution photographs and radiographs, using an electronic format was more appropriate. Thus the Iowa dentist tracking system was not used. Therefore the University of Iowa Alumni Association was used to obtain the e-mail addresses of the graduates of the University of Iowa College of Dentistry practicing in the state of Iowa.

Response rate

The number of responses in the current study is low compared to other similar studies (107-109, 112, 115-117, 121, 122). This low response rate might be due to the use of an e-mail survey that is easily disregarded especially among those who receive a large amount of e-mail. Also the study population was relatively small - a total number of 916

living College of Dentistry DDS alumni were included – with only 165 total responses. Incomplete surveys and those from non practicing dentists reduced the effective response to only 138 (15%). In the current study the response rate was on the lower end of the spectrum of response rates found in similar studies (107-109, 112, 115-117, 121, 122), as shown in Table 37.

. Table 37 Response rates of similar studies compared to that of the current study

Study	Response Rate
Riordan et al. (106)	95.1%
El-Mowafy et al. (107)	52.1%
Mejare et al. (108)	70.5%
Tveit et al. (109)	84.4%
Doméjean et al. (110)	39.1%
Traebert et al. (111)	89.4%
Baraba et al.(114)	38.0%
Vidnes-Kopperud et al. (116)	61.0%
Heaven et al. (117)	63.0%
Khalaf et al. (118)	92.5%
Rechman et al (119)	11.3%
Current study	**15%**

It was found that the current study had a response rate that was much lower than the majority of similar studies except that of Rechman et al 2016 (119). One reason behind this might be that both the current study and that of Rechman et al. 2016 (119) were electronic surveys, while most of the other studies were mailed surveys which generally yielded a higher response rate. In the current study efforts were made to increase the sample size such as, providing a compensation of one hour of continuing education to motivate participants to complete the survey, however the response rate remained low.

In the current study the percentage agreement with the ICCMS guidelines regarding the non surgical management of the initial caries lesions was the highest in the low risk scenario, while less agreement was seen in moderate and high risk scenarios as seen in Figure 2. Out of 138 dentists' responses, 100 responses agreed with ICCMS in the non surgical management of the initial caries lesions regarding the low risk scenario. While for the moderate risk scenario 81 responses and for the high risk scenario 71 responses agreed with ICCMS.

Figure 1 Agreement with ICCMS VS. Caries risk
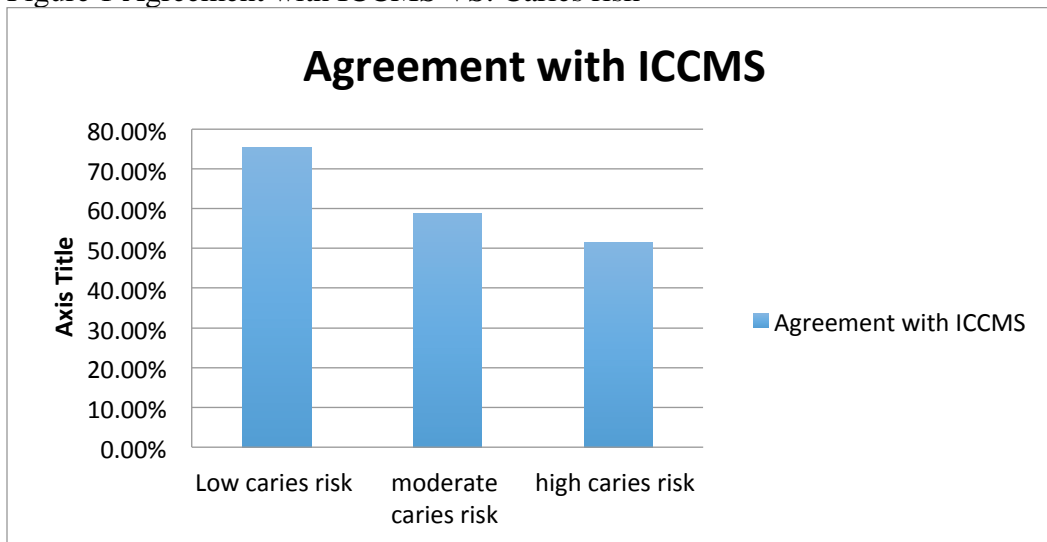
A possible explanation to those findings could be that, with high caries risk there is a higher chance for caries lesion progression and thus, dentists may have a tendency to intervene surgically more often than they would for moderate or for low caries risk. When comparing the current study with the available literature, no study was found that investigated the dentists' agreement with ICCMS guidelines. However, most of the

studies found in the literature did calculate the percentage of dentists who choose surgical intervention for initial pit and fissure and initial inteproximal caries lesions. The available literature also did not include scenarios of moderate risk and free smooth surface initial lesions. Thus to compare the current study to the literature, a comparison of the percentage of dentists who performed surgical intervention for initial pit and fissure and initial interproximal lesions in low and high risk scenarios could be done. Such a comparison is shown in Table 38 and 39.

Table 38 Percentage of dentists recommending surgical intervention for initial pit and fissure lesions in a low risk patient

Study	Low risk initial pit and fissure lesion
Mejare et al. (108)	90%
Domejean et al. (110)	88%
Gordan et al. (113)	14%
Rechmann et al. (119)	41%
Current study	**31%**

Table 39 Percentage of dentists recommending surgical intervention for initial proximal lesions

Study	High risk initial proximal lesion	Low risk initial proximal lesion
Riordan et al. (106)	n/a	2.2%
Mejare et al. (108)	n/a	67%
Tveit et al. (109)	n/a	18%
Domejean et al. (110)	n/a	40%
Ghasmi et al. (112)	77%	32%
Gordan et al. (113)	25%	39%
Baraba et al. (114)	n/a	42%
Vidness- kopperud et al. (116)	n/a	28%
Rechmann et al. (119)	n/a	42%
Current study	**75%**	**31%**

In the current study 31% of the dentists recommended surgical treatment of initial pit and fissure caries lesions in low caries risk scenario. The findings of the current study

are similar to the findings of Rechmann et al., 2016 (119) which reported that 41% of the dentists recommend surgical treatment of initial pit and fissure caries lesions in low risk scenario. On the other hand, for initial pit and fissure caries lesions in high risk scenario the current study findings showed that 75% of the dentists recommended surgical treatment. None of the previous studies reported the percentage of dentists who recommended surgical treatment for initial pit and fissure caries lesions in a high risk scenario.

For the interproximal initial caries lesions in the low risk scenario, the current study findings showed that 31% of the dentists chose surgical treatment which is close to the findings of multiple studies; Ghasmi et al. (112) reported 32%, Gordan et al. (113) reported 39%, and Vidness- kopperud et al. (116) reported 28%. For the interproximal initial caries lesions in high risk scenario, the current study findings showed that 75% of the dentists chose surgical treatment. The findings of the current study are similar to the finding of Ghasmi et al. (112), which showed that 77% of the dentists chose surgical treatment for initial interproximal caries lesions. An explanation to why dentist tend to recommend more surgical treatment to the interproximal caries lesions for high risk patients than for low risk patients could be because of the rate of progression of the interproximal lesion is higher in the high risk patients. Another reason could be that, since radiographs are only covered by the insurance once a year and dentists could not see the progression easily at the patients six months recall, dentists tend to surgically treat those lesions.

Significant factors associated with agreement with ICCMS in each caries risk level

In the section below the factors that showed statistically significance in the logistic regression analyses for each scenario will be discussed.

Significant factors for the Low caries risk scenario

Logistic regression analysis showed that the frequency of drying the tooth with air was a statistically significant factor associated with agreement with ICCMS. The odds of having agreement with the ICCMS guidelines for those who always or often dried the tooth with compressed air for caries detection had odd that were 3.56 times that of those who rarely or never dried the tooth (95% CI: 1.02-12.67; p=0.0468). According to Ekstrand et al. 1987 (42) drying the tooth has been found to facilitate accurate detection of caries. This has been attributed to the fact that when the enamel is dry the refractive index of the enamel is changed from one containing water to air, which facilitates proper visualization of the lesion as described by Fejerskov et al. 2008 (25). Therefore dentists, who dry the teeth for caries detection rather than using an explorer, will be able to detect initial signs of decalcification when the tooth can potentially remineralize. Thus it would seem logical that dentists who frequently dry the tooth would be able to detect initial caries lesions and possibly recommend non surgical treatment. Non surgical approaches aim for arresting, monitoring and/or remineralizing initial caries lesions.

The association between dentists drying the teeth for caries detection and non surgical management for initial caries lesions in low risk patients might be because dentists tend to dry the teeth more than using an explorer for low risk patients, since low risk patients are less likely to have cavitated lesions and restorations where the need of the explorer would be essential.

Significant factors for the Moderate caries risk scenario

Logistic regression found that the number of years since graduation was statistically significant with the agreement of dentists with ICCMS guidelines for the moderate risk category. Subjects who had graduated either 1-9 years ago or 10-19 years ago had odds that were 5.94 or 6.00 times to agree with the ICCMS Guidelines compared

to those who graduated 20 years or more years ago (95% CI: 1.84-19.21; p=0.0029 for 1-9 years or 95% CI: 2.03-17.77; p=0.0012 for 10-19 years). The results are displayed in Figure 2

Figure 2 Agreement with ICCMS VS. Years since graduation
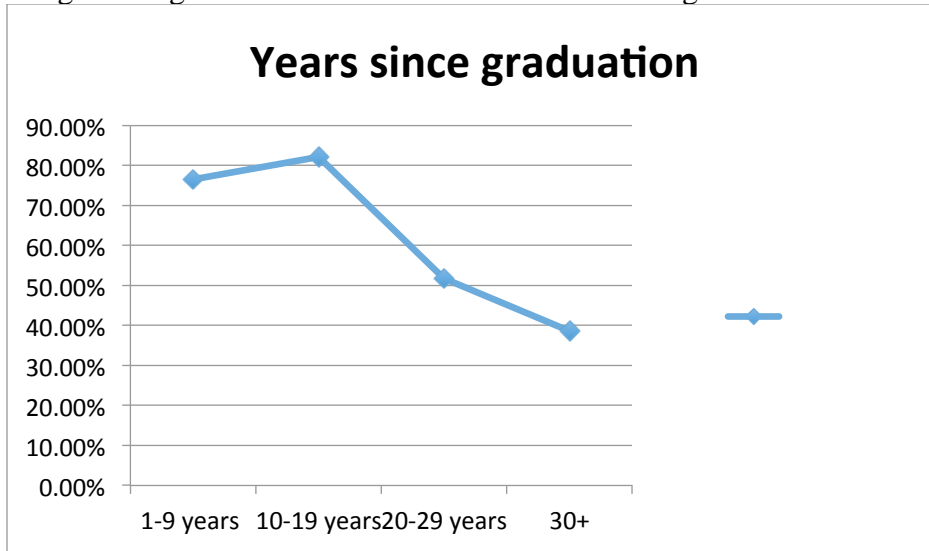
From the Figure 3 it can be seen that agreement with ICCMS guidelines increases slightly from 1-9 years, reaching a peak at 10-19 years and then gradually decreases with increasing time since graduation. These findings might suggest that the recent transformation in knowledge regarding the caries process and the preventive treatment more recently incorporated in the undergraduate dental teaching might be influencing the dentists' treatment approach. This was in agreement with the study by Traebert el al (111) in which dentists with fewer years since graduation performed more conservative and more non surgical treatments. Therefore the association between recent graduates and the non surgical treatment recommendations would be related to the advancement in dental materials and evidence on the effectiveness of current preventive measure in the

past 15 years, allowing the dentists to be more conservative in their treatment of dental caries.

The current study showed that the type of primary practice was statistically significant with agreement with ICCMS for the moderate risk scenario. Subjects who were in public health practice had odds that were 14.45 times to agree with the ICCMS Guidelines compared to those who were in solo practices (95% CI: 2.62-49.76; p=0.0022), while no difference was noted between subjects who were in group practice and who were in solo practice (p=0.2635). The results can be shown in the figure 3.
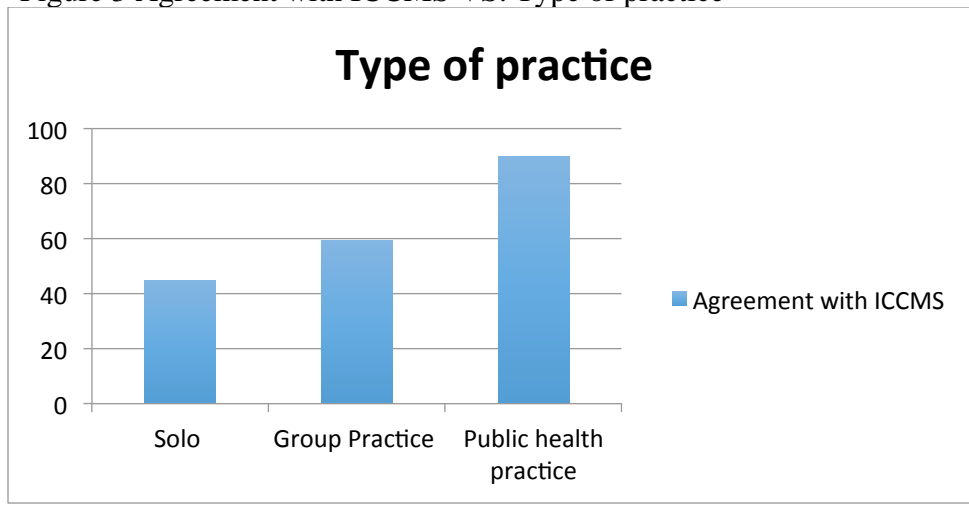
Figure 3 Agreement with ICCMS VS. Type of practice

Figure 4 above shows that those in solo practice had the lowest agreement with ICCMS guidelines, while those in group practice had more agreement with ICCMS and finally the most agreement was among those in public health practices. This is in agreement with a study done by Mejare et al. 1999 (108) where it was found that practitioners working in private practice were more likely to perform surgical treatment than those in public health or academic settings. Also, in another study by Gordan et al.

2009 (121) it was found that practitioners in public health settings did not perform surgical treatment for initial caries lesions while 49% of those in group practice performed surgical treatment in similar lesions. In a study by Baraba et al. (114) no significant difference was found in regard to the percentage of practitioners treating initial caries lesions and the type of institution where they worked. From the findings of these studies and the current study it can be inferred that financial constraints might influence the practitioners decision for treatments. Since the dentists that work in public health settings receive a salary, while dentists in private practice get paid based on their production, private practitioners might tend to perform more surgical treatment. Also, the association between the moderate risk and dentists working in public health setting could be explained by dentists practicing in public health setting being more likely to treat moderate and high risk patients versus low risk patients.

In the current study logistic regression showed that the frequency of using magnification was statistically significant in agreement with ICCMS guidelines. Subjects who always or often used magnification had odds for agreement with ICCMS that were 2.89 times than those who rarely or never used magnification (95% CI: 1.16-7.17; p=0.0225). This could be explained by the fact that magnification allows for a more accurate detection of initial caries lesions resulting in a more accurate treatment. This presents an interesting correlation between the non surgical management of initial caries lesions and the use magnification. At observing the available literature, a study by Neuhaus et al. 2015 (123) found that participants were most in agreement with ICDAS when examiners had natural vision and 2.0x magnification, however the increase in magnification caused a drop in agreement. In another study by Mitropoulos et al. 2012 (124), it was found that there was no difference in the agreement with ICDAS between having magnification and not having magnification. While in the current study there was no question regarding the degree of magnification used by the dentists but it showed that there was a correlation between the general use of magnification and the agreement with

ICCMS regarding the non surgical management of initial caries lesions. Also, younger dentists probably use magnification more often than older dentists.

Significant factors for the high caries risk scenario

In the current study findings showed an increase in the agreement with ICCMS guidelines for dentists that always or often perform CRA for new and/or recall patients. Odds of having agreement with the ICCMS Guidelines for subjects who always or often performed CRA for new and/or recall patients were 2.17 times that of those who rarely or never performed CRA(95% CI: 1.10-4.29; p=0.0262). This would be explained logically by the fact that performing CRA would lead to a risk based treatment allowing the monitoring of initial caries lesions and the possibility of arresting and remineralizing them with non surgical treatments. A study by Gordan et al (121) had similar results, where 69% of dentists who performed caries risk assessment as part of their daily evaluations, were found to be less likely to surgically treat initial caries lesions.

Therefore in the present study, dentists who perform frequently CRA for their patients are able to identify those patients at high risk and consequently modify their risk factors to improve their risk level, which is basically done through non surgical interventions.

Limitations

As a survey, the current study has its limitations, which include; the information gathered was focused on one population and the state of mind of the dentist taking the survey at a certain time of their knowledge and experience. The responses to the survey questions are ideal answers based on the dentist's knowledge and experience. However

the study makes assumptions that the dentists actually apply these management recommendations in their practice. Thus there is no evidence to support whether or not the dentists apply these techniques in their practice.

The study was an e-mail survey, which has proven to be a limitation due to the fact that not all dentists in the University of Iowa Alumni Association agreed to have surveys sent to their e-mail, and also other organizations that could have provided access to dentists for data collection do not have e-mail addresses of participating dentists in Iowa. Thus this limited the number of surveys that were sent. Additionally, there was a low response rate from the dentists that were contacted, and due to time constrains the period over which the surveys were sent was limited, resulting in a low sample size, which is considered a limitation of the study.

The case based scenarios included in the survey provided diagnostic data to the practitioner, however, one of the essential diagnostic features could not be included in the survey, and that is the tactile sensation of the dentist. Due to the study being a survey, testing the participant's tactile sensation was not possible and that is considered a limitation. Also, the low quality radiographs could not be manipulated in the survey. Including more case based scenarios would have increased the utility of the study but it would be too onerous for participants.

Strengths

The study covered a wide array of variables related to the dentist's demographic characteristics, knowledge, and practicing characteristics. The study also included three scenarios one for low, high and moderate caries risks that have not been widely investigated in other studies. The study also compared the dentist's knowledge to caries detection and management guidelines (ICDAS, CAMBRA and ICCMS) and to agreement with the ICCMS guidelines for the provided cases. Another strength is that the

study included both radiographs and photographs of actual teeth, instead of using diagrams or computer generated images that might not mimic the dentist's evaluation of real life scenarios.

An additional strength of the study was the educational value, as the dentists were informed of the evidence based ICCMS guidelines and given CE credit. The participating dentists were also given feedback on their answers. The study was made in an electronic format which made viewing the photographs and radiographs more clear than paper format, and made receiving and analyzing the answers faster, more reliable and less liable to human error.

Generalizing

The study did not have a high response rate, and also the study only focused on dentists in Iowa. For those reasons generalization of the findings should be limited to similar populations.

Future directions

This study has some areas that could be expanded. First and foremost would be increasing the study sample size, this could be done by increasing the number of states in the study, however this might be difficult to obtain a database for dentists e-mail addresses. Another method to increase the response rate would be to use both paper and electronic formats for the study, which should greatly increase both the response rate as well as the number of dentists available as it was found that some dentists would only provide a postal addresses and not an e-mail address. An increase in the study sample would enhance the generalizability of the results.

Further analysis of the data obtained from this study could also be done. For example, it would be interesting to investigate whether there is a relationship between accurate diagnosis of initial caries lesions and the treatment recommendations. In the current study, dentists were considered to be in agreement with ICCMS if they agreed in the non surgical management of at least one out of the three lesions per scenario. For a future study it may be interesting to explore factors associated with agreement with ICCMS in more than one lesion per scenario, so that higher predictors for dentists' agreement could be obtained.

CHAPTER VI: CONCLUSION

Based on the findings of the current study and statistical bivariate and logistic regression analysis, and within the limitations of this study the following conclusions were derived.

It was found that for the low caries risk scenario 73% of the participants had agreement with the ICCMS guidelines regarding the non surgical management of initial caries lesions. For moderate risk patients 58% of the participants had agreed with the ICCMS management guidelines. For the scenario involving the high risk patient 51% of the participants had agreement with the ICCMS guidelines. The factors that were considered to be significant were the following: -

1) Subjects who always or often dried the tooth with compressed air for caries detection during caries detection were the most likely to agree with the ICCMS Guidelines compared to their counterparts for the low risk patient scenario. Odds of having agreement for those who always or often dried the tooth were 3.56 times that of those who responded rarely or never.

2) Frequency of use of magnification, years since graduation, and role in primary practice were significantly related to the agreement with the ICCMS Guidelines for the moderate risk scenario. Odds of having agreement for dentists who always or often used magnification were 2.89 times that of those who responded rarely or never. Subjects who were either 1-9 years or 10-19 years since graduation had odds ratio that were 5.94 or 6.00 times to agree with the ICCMS Guidelines compared to those who were 30 years or more since graduation. Subjects who were in Public Health Practice had odds ratio that were 14.45 times to agree with the ICCMS Guidelines compared to those who were in

Solo Practice, while no difference was noted between subjects who were in Group

Practice and who were in Solo Practice.

3) Subjects who always or often performed CRA were most likely to agree with

the ICCMS Guidelines compared to their counterparts for the high risk patient scenario.

Odds of having agreement for those who always or often performed CRA were 2.17

times that of those who rarely or never performed CRA.

Overall, regardless of the caries risk level, dentists who recently graduated,

practiced in public health settings, used magnification, dried the teeth for caries detection,

and perform CRA for their patients, were more likely to recommend appropriate

treatment as described in the ICCMS guide.

Survey: Management of Initial caries lesions Iowa Survey

Management of initial caries lesions.

Please complete the survey below.

Thank you!

Q:1: Are you currently practicing dentistry?
  ○ Yes
  ○ No

Q:2: Are you male or female?
  ○ Male
  ○ Female

Q:3: What is your age in years?
_____

Q:4: Please provide the Year you received your Dental Degree
_____

Q:5: Have you ever completed a formal postgraduate training program?
(Post-graduate training is a period of one year or longer)
  ○ Yes
  ○ No

Please select your post-graduate training area(s):
(Select all that apply):
  ☐ Advanced Program in General Dentistry (AEGD/ACP, Comprehensive Dentistry)
  ☐ Dental Public Health
  ☐ Endodontics
  ☐ General Practice Residency (GPR)
  ☐ Operative
  ☐ Oral and Maxillofacial Pathology
  ☐ Oral and Maxillofacial Radiology
  ☐ Oral and Maxillofacial Surgery
  ☐ Orthodontics
  ☐ Pediatric Dentistry
  ☐ Prosthodontics
  ☐ Periodontics
  ☐ Other

Other post-graduate training, please specify:
_____

Q:6: How many years of clinical practice do you have, including while in a post-graduate training?
_____

Q:7: How would you describe your role in your primary practice?
  ○ Solo practice (owner).
  ○ Group practice (as an owner, associate, or partner).
  ○ Employee in a corporate owned practice (e.g., Aspen, Ocean Dental, or Applewhite Dental).
  ○ Public health practice (e.g., community health center).
  ○ Academic appointment.
  ○ Military.
  ○ Other.

Q:8: Approximately what percentages of your patients are covered by one of the following types of insurance or self-pay? (Please verify that the numbers sum to 100%)

Self-pay and private insurance: _____

Medicaid (Title XIX), DWP, and Hawk-I: _____

Other: _____

Total= _____

Total Percentage Does Not Equal 100, Please Re-enter: _____

Q:9: Approximately what percentages of your patients are in the following age ranges? (Please verify that the number total to =100%)

< 18 years: _____

19-65 years: _____

>65 years: _____

Total Age = _____

Total Percentage Does Not Equal 100, Please Re-enter: _____

Q:10: How would you best describe your practice during the past 12 months?

○ I was not busy enough, and I would have liked to provide care to more patients.
○ I provided care to all those who have requested an appointment, and I did not feel overworked.
○ I provided care to all those who have requested an appointment, but felt I overworked.
○ I have limited my practice to current patients only, and I am not accepting new patients.
○ I am too busy and unable to treat new patients requesting appointments.

Q:11: Are you familiar with the International Caries Detection and Classification System (ICDAS)?

○ Very familiar.
○ Somewhat familiar.
○ Not at all familiar.

Q:12: Are you familiar with the International Caries Classification and Management System (ICCMS)?

○ Very familiar.
○ Somewhat familiar.
○ Not at all familiar.

Q;13: Are you familiar with the Caries Management by Risk Assessment (CAMBRA)?

○ Very familiar.
○ Somewhat familiar.
○ Not at all familiar.

Q:14: Are you familiar with the ADA's Caries Classification System (ADA-CCS)?

○ Very familiar.
○ Somewhat familiar.
○ Not at all familiar.

Q:15: Caries risk assessment (CRA):

	Always (75-100% of the time)	Often (50-74% of the time)	Rarely (< 50% of the time)	Never (0%)
a. How often do you perform CRA for your new and/or recall patients?	○	○	○	○

b. Do you use a formalized CRA System or Instrument?
○ Yes
○ No

c. Please specify which CRA system you use: _____

d. Do you re-evaluate the CRA for your patients at recall visits?
○ Yes
○ No

Q:16: Caries Detection

For caries detection during an exam how often do you use each of the following:

	Always (75-100% of the time)	Often (50-74% of the time)	Rarely (< 50% of the time)	Never (0%)
a. Dry the tooth with compressed air	○	○	○	○
b. Use of sharp explorer	○	○	○	○
c. Use a blunt probe	○	○	○	○
d. Magnification (Loups or microscope)	○	○	○	○
e. Use a head light	○	○	○	○
f. Use recent radiographs according to the ADA Guidelines	○	○	○	○
g. Use an adjunct diagnostic tool(s) such as DIAGNOdent	○	○	○	○

Patient Scenario

The following section of the survey will include three clinical patient scenarios and you will be asked to answer five questions for each scenario. Clinical photographs and radiographs will be provided for each scenario.

NOTE: For better visualization of photographs and radiographs, please consider taking the survey in a darker room.

Patient Scenario #1:

| Age	22 years old.
General History	No significant medical history, no known allergies, no medications.
Dental History	History of sealants, recall exams and cleaning until the age of 18 years old.
Oral Hygiene	Inadequate oral hygiene practice, patient states that he rarely brushes his teeth more than once a day.
Reason for consultation	He has not been seen by a dentists in 3 years and wants to have a "check up".
Clinical examination	On clinical examination the patient has moderate plaque accumulation at the gingival margins and localized gingival inflammation with bleeding upon probing.

Based on patient scenario #1, please answer the following question:

Q:1: What would you consider the caries risk of this patient?

○ Low risk.
○ Moderate risk.
○ High risk.

Based on patient scenario #1, please answer the following question:

Q:2: The clinical examination revealed the lesion shown on tooth #30 in the picture below. A corresponding Bitewing radiograph is also provided.

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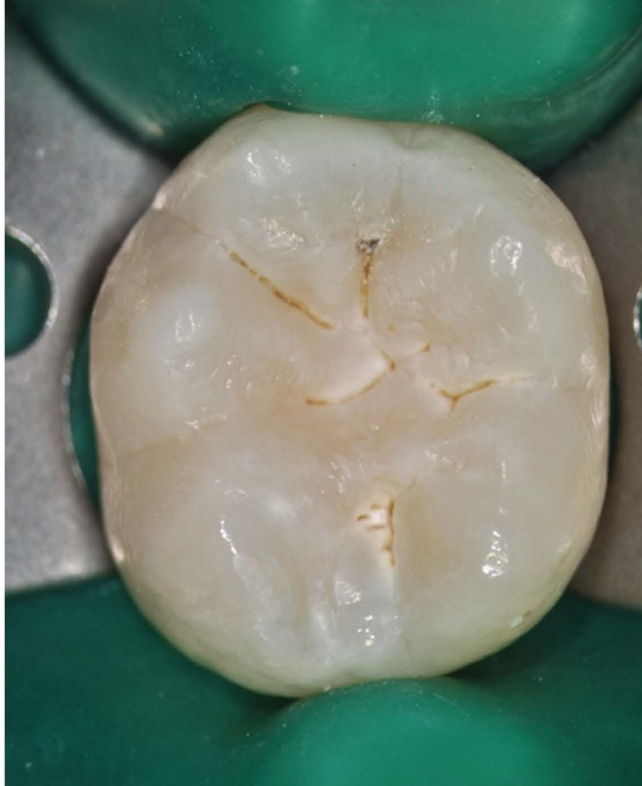
Based on patient scenario #1, please answer the following question:

Q:3: On radiographic examination a lesion is detected on the distal of #19 as shown in the radiograph below . A clinical photograph is also provided.
Upon clinical examination the lesion is non-cavitated.
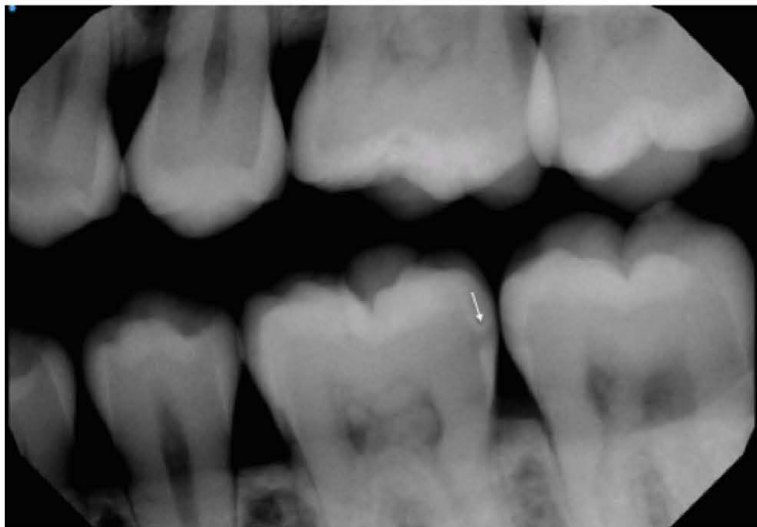
A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #30?

○ Sound tooth structure.
○ Enamel carious lesion.
○ Dentin carious lesion.

What would you consider the activity of this carious lesion?

○ Enamel active carious lesion.
○ Enamel arrested carious lesion.
○ Do not know.

What would you consider the activity of this carious lesion?

○ Dentin active carious lesion.
○ Dentin arrested carious lesion.
○ Do not know.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #30?

○ No lesion specific treatment.
○ Resin based sealant without mechanical preparation of the tooth structure.
○ Glass ionomer sealant without mechanical preparation of tooth structure.
○ Resin based sealant with mechanical preparation of tooth structure (Fissurotomy).
○ Resin modified glass ionomer sealant with mechanical preparation of tooth structure.
○ Resin modified glass ionomer restoration.
○ Preventive resin restoration.
○ Resin based composite restoration.
○ Amalgam restoration.

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #19 Distal?

- ○ Sound tooth structure.
- ○ Enamel caries lesion.
- ○ Dentin carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #19 Distal?

- ○ No lesion specific treatment.
- ○ Clinically applied topical fluoride (Varnish, gel, foam).
- ○ Resin sealant / proximal infiltration (ICON).
- ○ Resin based composite restoration.
- ○ Resin modified glass ionomer.
- ○ Amalgam restoration.

Based on patient scenario #1, please answer the following question:

Q:4: The lesion shown in the picture below was found of tooth #6. A radiograph of tooth #6 is also provided.

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #6?

○ Sound tooth structure.
○ Enamel carious lesion.
○ Dentin carious lesion.

What would you consider the activity of this carious lesion?

○ Enamel active carious lesion.
○ Enamel arrested carious lesion.
○ Do not know.

What would you consider the activity of this carious lesion?

○ Dentin active carious lesion.
○ Dentin arrested carious lesion.
○ Do not know.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #6?

○ No lesion specific treatment.
○ Clinically In-office applied Fluoride application (varnish, gel, foam).
○ Resin infiltration (ICON).
○ Resin modified glass ionomer restoration.
○ Resin based composite restoration.
○ Amalgam restoration.

Based on scenario #1, please answer the following question:

Q:5: What would be your recommendation for this patient? (Select all that apply)

☐ No recommendations.
☐ Tooth brushing 2/day with an over the counter fluoridated toothpaste.
☐ Tooth brushing 2/day with a 5000 ppm fluoridated toothpaste.
☐ General behavior modification in oral health.
☐ Prescribed fluoride mouthrinse.
☐ Motivational engagement (discuss with patients how to improve oral health behaviors), maintain dental visits.
☐ Sealants.
☐ Fluoride varnish 2 times per year.
☐ Fluoride varnish 4 times per year.
☐ Fluoride gels or solution (2% NaF).
☐ Recalls up to every 3 months for professional cleaning & topical Fluoride application on active lesions.

Patient Scenario #2:

Age	45 years old
General History	No significant medical history, no known allergies, no medications.
Dental History	Six month recall exams and professional cleaning.
Oral Hygiene	Good oral hygiene. Patient brushes twice daily with over the counter fluoridated tooth paste.
Reason for consultation	Recall examination.
Clinical examination	Healthy gingival tissue.

Base on patient scenario #2 please answer the following question:

Q:1: What would you consider the caries risk of this patient?

○ Low risk.
○ Moderate risk.
○ High risk.

Based on patient scenario #2, please answer the following question:

Q:2: Upon clinical examination the lesion on the buccal surface of tooth #19 was detected and is shown in the picture below. The buccal surface of #19 feels hard with the side of the explorer and it appears shiny. A bitewing radiograph of the tooth is also provided.

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #19?

○ Sound tooth structure
○ Enamel carious lesion.
○ Dentin carious lesion.

What would you consider the activity of this carious lesion?

○ Enamel active carious lesion.
○ Enamel arrested carious lesion.
○ Do not know.

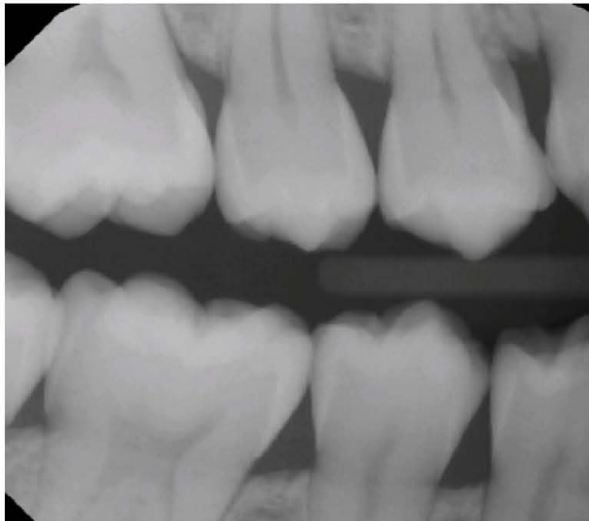What would you consider the activity of this carious lesion?

○ Dentin active carious lesion.
○ Dentin arrested carious lesion.
○ Do not know.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #19?

○ No lesion specifc treatment.
○ Clinically In-office applied Fluoride application (varnish, gel, foam).
○ Resin infiltration (ICON).
○ Resin modified glass ionomer restoration.
○ Resin based composite restoration.
○ Amalgam restoration.

Based on patient scenario #2, please answer the following question:

Q:3: The lesion on the occlusal surface of tooth #4 was detected and is shown in the picture below . A radiograph of tooth #4 is also provided.

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #4?

○ Sound tooth structure.
○ Enamel carious lesion.
○ Dentin carious lesion.

What would you consider the activity of this carious lesion?

○ Enamel active carious lesion.
○ Enamel arrested carious lesion.
○ Do not know.

What would you consider the activity of this carious lesion?

○ Dentin active carious lesion.
○ Dentin arrested carious lesion.
○ Do not know.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #4?

○ No lesion specific treatment.
○ Resin based sealant without mechanical preparation of the tooth structure.
○ Glass ionomer sealant without mechanical preparation of tooth structure.
○ Resin based sealant with mechanical preparation of tooth structure (Fissurotomy).
○ Resin modified glass ionomer sealant with mechanical preparation of tooth structure.
○ Resin modified glass ionomer restoration.
○ Preventive resin restoration.
○ Resin based composite restoration.
○ Amalgam restoration.

Based on patient scenario #2, please answer the following question:

Q:4: Radiographic examination revealed a lesion on the mesial surface of #7 as shown in the radiograph below . A clinical photograph is also provided.
Upon clinical examination the lesion is non-cavitated.

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #7 Mesial?

- ◯ Sound tooth structure.
- ◯ Enamel carious lesion.
- ◯ Dentin carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #7 Mesial?

- ◯ No lesion specific treatment.
- ◯ Clinically applied topical fluoride (Varnish, gel, foam).
- ◯ Resin sealant / proximal infiltration (ICON).
- ◯ Resin based composite restoration.
- ◯ Resin modified glass ionomer.
- ◯ Amalgam restoration.

Based on patient scenario #2, please answer the following question:

Q:5: What would be your recommendation for this patient? (Select all that apply)

- ☐ No recommendations.
- ☐ Tooth brushing 2/day with an over the counter fluoridated toothpaste.
- ☐ Tooth brushing 2/day with a 5000 ppm fluoridated toothpaste.
- ☐ General behavior modification in oral health.
- ☐ Prescribed fluoride mouthrinse.
- ☐ Motivational engagement (discuss with patients how to improve oral health behaviors), maintain dental visits.
- ☐ Sealants.
- ☐ Fluoride varnish 2 times per year.
- ☐ Fluoride varnish 4 times per year.
- ☐ Fluoride gels or solution (2% NaF).
- ☐ Recalls up to every 3 months for professional cleaning & topical Fluoride application on active lesions.

Patient Scenario #3:

| Age	45 years old.
General history	Diabetic, dry mouth.
Dental history	Restorative treatment and extractions due to caries within the past 8 months.
Oral hygiene	Inadequate oral hygiene, patient states that he does not brush his teeth every day.
Reason for consultation	Recall examination
Clinical examination	On clinical examination patient has signs of reduced salivary flow.

Base on patient scenario #3 please answer the following question:

Q:1: What would you consider the caries risk of this patient?

- ◯ Low risk.
- ◯ Moderate risk.
- ◯ High risk.

Based on patient scenario #3, please answer the following question:

Q:2: Radiographic examination revealed a lesion on the distal surface of #30 as shown in the radiograph below. A clinical photograph of tooth #30 is also provided.
Upon clinical examination the lesion is non-cavitated.
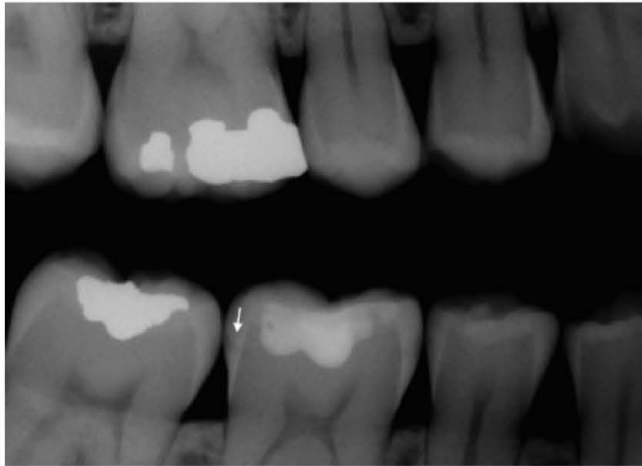
A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #30 Distal?

○ Sound tooth structure.
○ Enamel carious lesion.
○ Dentin carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #30 Distal?

○ No lesion specific treatment.
○ Clinically applied topical fluoride (Varnish, gel, foam).
○ Resin sealant / proximal infiltration (ICON).
○ Resin based composite restoration.
○ Resin modified glass ionomer.
○ Amalgam restoration.

Based on patient scenario #3, please answer the following question:

Q:3: Upon clinical examination a lesion was detected on the occlusal surface of tooth #12 and is shown in the picture below. A radiograph of tooth #12 is also provided.

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #12?

- ◯ Sound tooth structure.
- ◯ Enamel carious lesion.
- ◯ Dentin carious lesion.

What would you consider the activity of this carious lesion?

- ◯ Enamel active carious lesion.
- ◯ Enamel arrested carious lesion.
- ◯ Do not know.

What would you consider the activity of this carious lesion?

- ◯ Dentin active carious lesion.
- ◯ Dentin arrested carious lesion.
- ◯ Do not know.

B) What treatment would you recommend the lesion marked by the arrows on tooth #12?

- ◯ No lesions specific treatment.
- ◯ Resin based sealant without mechanical preparation of the tooth structure.
- ◯ Glass ionomer sealant without mechanical preparation of tooth structure.
- ◯ Resin based sealant with mechanical preparation of tooth structure (Fissurotomy).
- ◯ Resin modified glass ionomer sealant with mechanical preparation of tooth structure.
- ◯ Resin modified glass ionomer restoration.
- ◯ Preventive resin restoration.
- ◯ Resin based composite restoration.
- ◯ Amalgam restoration.

Based on patient scenario #3, please answer the following question:

Q:4: On clinical examination a lesion was identified on the buccal surface of #13, as shown in the picture below. A radiograph of tooth #13 is also provided

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #13?

○ Sound tooth structure.
○ Enamel carious lesion.
○ Dentin carious lesion.

What would you consider the activity of this carious lesion?

○ Enamel active carious lesion.
○ Enamel arrested carious lesion.
○ Do not know.

What would you consider the activity of this carious lesion?

○ Dentin active carious lesion.
○ Dentin arrested carious lesion.
○ Do not know.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #13?

○ No lesion specific treatment.
○ Clinically In-office applied Fluoride application (varnish, gel, foam).
○ Resin infiltration (ICON).
○ Resin modified glass ionomer restoration.
○ Resin based composite restoration.
○ Amalgam restoration.

Based on patient scenario #3, please answer the following question:

Q:5: What would be your recommendation for this patient? (Select all that apply)

☐ No recommendations.
☐ Tooth brushing 2/day with an over the counter fluoridated toothpaste.
☐ Tooth brushing 2/day with a 5000 ppm fluoridated toothpaste.
☐ General behavior modification in oral health.
☐ Prescribed fluoride mouthrinse.
☐ Motivational engagement (discuss with patients how to improve oral health behaviors), maintain dental visits.
☐ Sealants.
☐ Fluoride varnish 2 times per year.
☐ Fluoride varnish 4 times per year.
☐ Fluoride gels or solution (2% NaF).
☐ Recalls up to every 3 months for professional cleaning & topical Fluoride application on active lesions.

Answers

This section of the survey provides the answers for the patient scenario questions.
At the end of this section you will be asked to provide your name and email address to receive a free 1 hour CE (continuing education) credit.

Your responses to the survey will be annonymous to the primary investigator and it will not be possible to link you to your responses on the survey.

The answers to the survey where based on the International Caries Classification and Management System (ICCMS) guide for practitioners and educators. To review the full guide, here is the link to it:
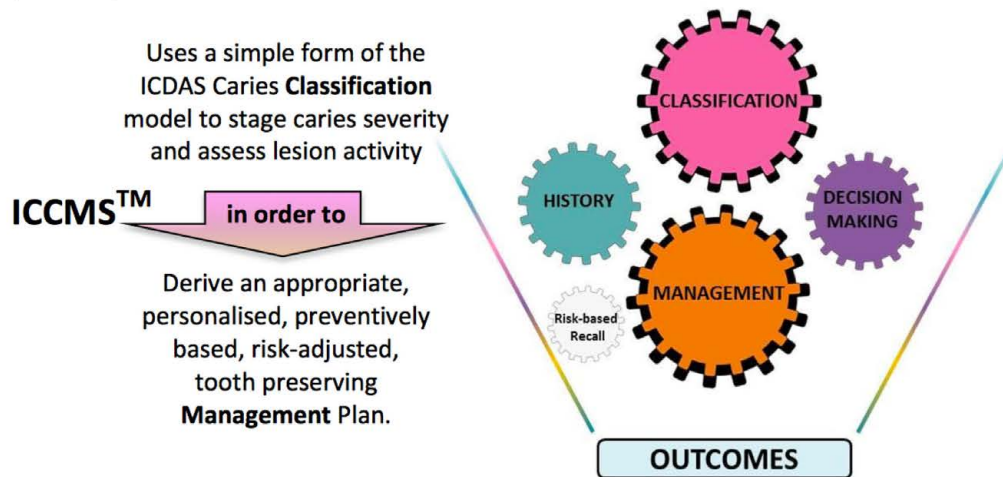
https://www.icdas.org/uploads/ICCMS-Guide_Full_Guide_With_Appendices_US.pdf.

The International Caries Classification and Management System (ICCMS) is a health outcome focused system presents a caries management cycle that aims:

- To prevent new caries lesions from appearing
- To prevent existing caries lesions from advancing further
- To preserve tooth structure with non-operative care at more initial caries stages and conservative operative care at more extensive caries stages

While managing risk factors and recalling patients at appropriate intervals, with periodic monitoring and reviewing.

The ICCMS guide includes a comprehensive set of clinical protocols (drawn up based on the best available evidence) to support history taking, clinical examination, risk assessment and personalised care planning in order to enable improved long-term caries outcomes.

Uses a simple form of the ICDAS Caries **Classification** model to stage caries severity and assess lesion activity

ICCMS™ → in order to →

Derive an appropriate, personalised, preventively based, risk-adjusted, tooth preserving **Management** Plan.

The four ICCMS elements, shown with detailed description of their components and linked by risk-based recall.

Element 1- History: Patient-Level Caries Risk Assessment

Prior to looking into the mouth, and having ensured that there are no urgent pain related issues, patient risk factors for caries are assessed.

Patient level caries risk factors	• **Head and Neck Radiation** • Dry mouth (conditions, medications/recreational drugs/self report) • Inadequate oral hygiene practices • Deficient exposure to topical fluoride • High frequency/ amount of sugary drinks/ snacks • Symptomatic-driven dental attendance • Social-economic status/Health access barriers • For children: high caries experience of mothers or caregivers

Note: Risk factors in red will always classify an individual as high caries risk.

Element 2- Classification: Caries Staging and Lesion Activity with Intraoral Caries Risk Assessments

Plaque is assessed for intraoral caries risk determination, but has to be removed for accurate caries staging and lesion activity assessment.

These risk factors correspond to those with higher association with caries risk status. The calculation of the patient's caries risk status (low, moderate, high) can be done with available tests or computer-based systems, such as CAMBRA and Cariogram.

Intraoral level caries risk factors	• **Hypo-salivation/Gross indicators of dry mouth** • **PUFA (Exposed pulp, Ulceration, Fistula, Absess) – Dental sepsis** • Caries experience • Thick plaque: Evidence of sticky biofilm in plaque stagnation areas • Appliances, restorations and other causes of increased biofilm retention • Exposed root surfaces

Note: Risk factors in red will always classify an individual as high caries risk.

Staging lesions:
The assessment of caries will always be conducted by means of visual examination and when possible, combined with radiographic examination.

Definition of ICCMS™ Caries Merged categories			
Caries categories	Sound surfaces (ICDAS code 0)		**Sound tooth surfaces** show no evidence of visible caries when viewed clean and after prolonged air-drying (5 seconds).
	Initial stage caries (ICDAS codes 1 and 2)		**First or distinct visual changes in enamel** seen as a carious opacity or visible discolouration (white spot lesion and/or brown carious discolouration) not consistent with clinical appearance of sound enamel (ICDAS code 1 or 2).
	Moderate stage caries (ICDAS codes 3 and 4)		A white or brown spot lesion with **localised enamel breakdown,** without visible dentine exposure (ICDAS code 3), **or an underlying dentine shadow** (ICDAS code 4), which obviously originated on the surface being evaluated.
	Extensive stage caries (ICDAS codes 5 and 6)		A **distinct cavity** in opaque or discoloured enamel **with visible dentine** (ICDAS code 5 or 6).

ICCMS Combined Categories: Combining clinical and radiographic information:
Eventually, both the radiographic (when available and for posterior teeth) and the clinical assessment of the lesion severity caries merged categories end up classifying the lesion into the categories of initial, moderate or extensive.

ICCMS™ Combined Categories (C)	Radiographic Categories (R)				
	R_0	RA_{1-2}	RA_3	RB	RC
C_{Sound}	Sound$_{CR}$	Initial$_{CR}$	Initial$_{CR}$	Moderate$_{CR}$	Extensive$_{CR}$
C_{Sound}	Initial$_{CR}$	Initial$_{CR}$	Initial$_{CR}$ or Moderate$_{CR}$	Moderate$_{CR}$	Extensive$_{CR}$
$C_{Moderate}$	Moderate$_{CR}$	Moderate$_{CR}$	Moderate$_{CR}$	Moderate$_{CR}$ or Extensive$_{CR}$	Extensive$_{CR}$
$C_{Extensive}$	Extensive$_{CR}$	Extensive$_{CR}$	Extensive$_{CR}$	Extensive$_{CR}$	Extensive$_{CR}$

R1-2 occlusal cannot be seen on a radiograph due to too much sound enamel around

Lesion activity assessment:
Caries lesions can be detected and assessed at an early stage as initial lesions. These, and also lesions at a further stage of severity, can be progressing at the moment of the clinical examination. Therefore, the next step after the severity assessment of the caries lesions is to judge if these, irrespective of stage, are inactive or active.

ICCMS™ Caries Codes	Characteristics of Lesion	
	Signs of Active Lesions	Signs of Inactive Lesions
ICCMS™ Initial and Moderate Caries Stage	Surface of enamel is whitish/yellowish; opaque with lustre loss, rough. Lesion in a plaque stagnation area. The lesion may be covered by thick plaque prior to cleaning.	Surface of enamel is whitish, brownish or black; enamel may be shiny, hard and smooth. For smooth surfaces, the caries lesion is typically located at some distance from the gingival margin. Lesion may not be initially be covered by thick plaque.
ICCMS™ Extensive Caries Stage	Dentine feels soft or leathery on gentle probing.	Dentine is shiny and hard on gentle probing.

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Element 3- Decision Making: Synthesis and Diagnosis

The third step of the diagnosis process involves the summation and analysis of information from the first two elements, regarding both the patient and the lesion level. The result will be the synthesis and diagnosis of the likelihood of new/progressing lesions in low, moderate or extensive risk status, and of each lesion in terms of whether or not they are active and if they are of initial, moderate or extensive severity.

ICCMS caries diagnosis:
Classification of individual lesions combining information about their stage and activity (e.g. 'initial' active lesion):

ICCMS™ Caries Codes	Activity Status	
	Active Lesions	Inactive Lesions
ICCMS™ Initial	Initial Active	Initial Inactive
ICCMS™ Moderate	Moderate Active	Moderate Inactive
ICCMS™ Severe	Extensive Active	Extensive Inactive

Note: Combined clinical and radiographic (where available) information.

ICCMS caries risk analysis to assess likelihood of new lesions or caries progression:
The consensus view is that risk assessment should be conducted as an integral part of the personalised caries care plan.

ICCMS™ Caries Risk and Likelihood Matrix		Current Caries Activity Status at the Patient Level		
		No active caries lesions*	Initial stage active caries lesions	Moderate or extensive stage active caries lesions
Risk Status	Low risk	Low likelihood	Moderate likelihood	Moderate likelihood*
Risk Status	Moderate risk	Low likelihood	Moderate likelihood	High likelihood
Risk Status	High risk	Moderate likelihood	High likelihood	High likelihood

*Sound surfaces and/or inactive lesions

Element 4- Management: Personalised Caries Prevention, Control & Tooth Preserving Operative Care

It involves and interconnects:
◻ Managing patient's likelihood for new caries and/or progression
◻ Managing individual caries lesions, with caries related treatment when they are active, defining different options according to their severity.

The Management Element Includes:
- Preventing New Caries
- Non-Operative Care of lesions (NOC) (Control)
- Tooth Preserving Operative Care of lesions (TPOC).

Managing a patient's risk factors:

The patient's caries risk factors management plan involves actions to protect sound tooth surfaces from developing new caries lesions, and all current active and inactive lesions from progressing. In addition, it aims to lower the risk status of the patient when moderate or extensive, and to maintain if low. Based on the best available evidence, and depending on the caries risk likelihood status, ICCMS recommends the activities shown below, to choose from. The intensity of the intervention is cumulative.

Note: Local adaptations may be required.
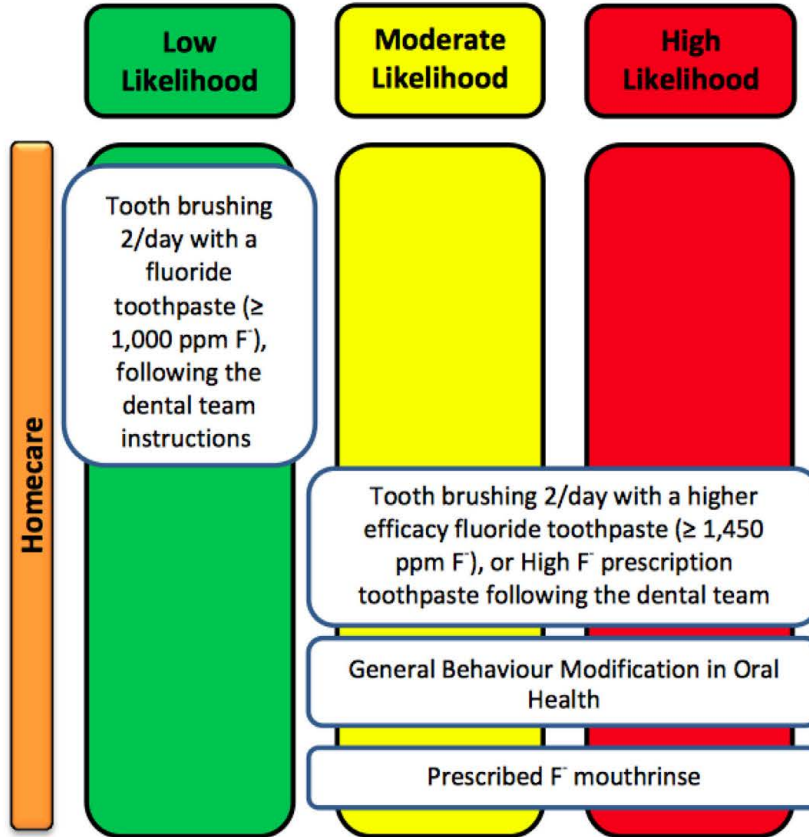
Low Likelihood	Moderate Likelihood	High Likelihood

Homecare

Tooth brushing 2/day with a fluoride toothpaste (≥ 1,000 ppm F⁻), following the dental team instructions

Tooth brushing 2/day with a higher efficacy fluoride toothpaste (≥ 1,450 ppm F⁻), or High F⁻ prescription toothpaste following the dental team
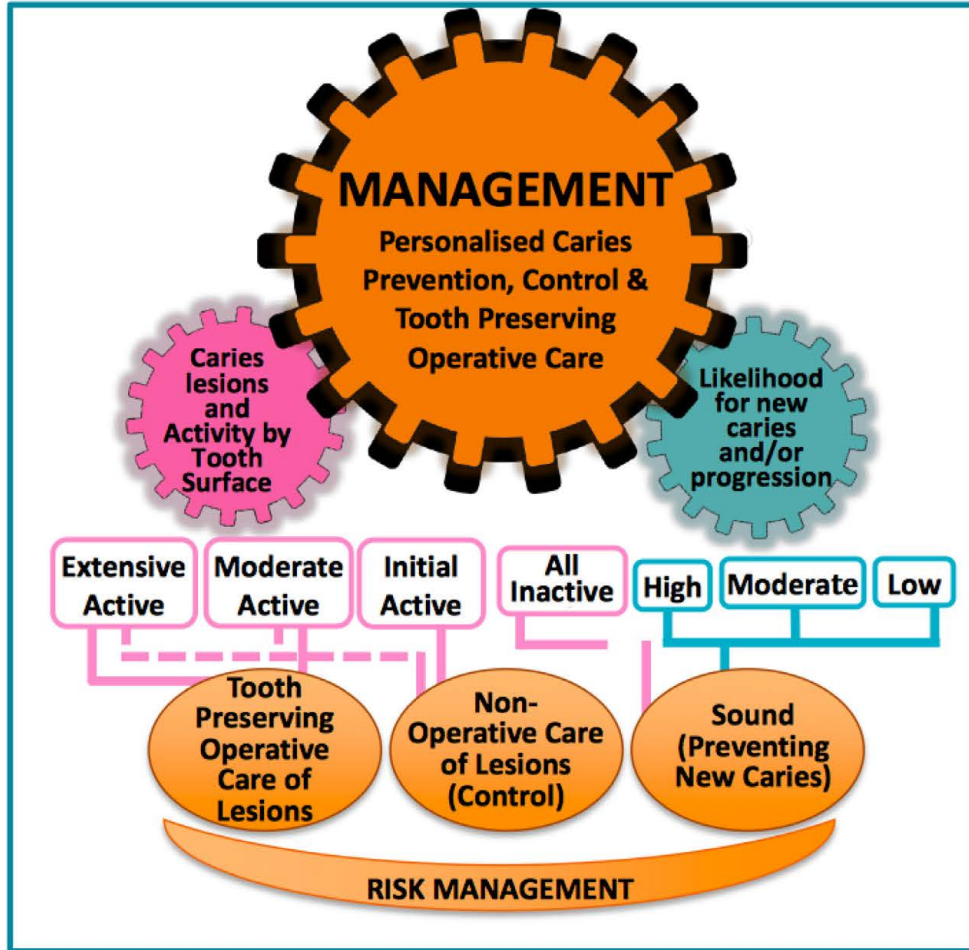
General Behaviour Modification in Oral Health

Prescribed F⁻ mouthrinse

Element 4- Management: Personalised Caries Prevention, Control & Tooth Preserving Operative Care

Managing a patient's risk factors:

Low Likelihood / **Moderate Likelihood** / **High Likelihood**

Clinical Interventions/ approaches

- Motivational engagement (discuss with patients how to improve oral health behaviours - including amount of sugar), maintain dental visits at risk-based intervals
- Sealants
- F⁻ varnish 2 times /year
- F⁻ gel or solution
- Recalls up to every 3 months: professional cleaning & topical F⁻ application on active lesions
- Motivational interviewing
- One-to-one dietary intake interventions
- Altering medication-induced hyposalivation
- Reducing the use of recreational drugs
- Increase F⁻ varnish to 4 times/year
- Topical F⁻ application, counseling: reduce sugar amount & frequency

Managing Individual Lesions:

The 'Managing Individual Caries Lesions' plan is tailored to the lesion level.

The ICCMS Caries Diagnosis table (from Element 3) is applicable to caries management decisions. The level of intervention depends on the clinical caries classification of the surface or tooth and the radiological extent (when information is available) of the lesion in enamel or dentine.

The levels of clinical management recommended for active lesions are defined as follows:
M-Initial: Initial caries management stage: Non-Operative Care (NOC) - Control.

M-Moderate:Moderate caries management stage: Non-Operative Care of lesions (NOC), or more frequently, Tooth Preserving Operative Care of lesions (TPOC).

M-Extensive: Extensive caries management stage: in general Tooth Preserving Operative Care of lesions (TPOC).

ICCMS™ Stage	INDIVIDUAL CARIES LESIONS MANAGEMENT
M$_{Sound}$	**Risk-based Prevention** (Refer to Previous Section)
M$_{Initial}$ Active	**NOC** • Clinically applied topical F⁻ (for ≤ 6-yr. old children particularly, F⁻ varnish is recommended) • Oral hygiene with F⁻ dentifrice (≥1000 ppm) from first tooth eruption • Mechanical removal of biofilm. Supervision is recommended at least until the age of 8 years • Resin-based sealants / glass ionomer sealants (In interproximal surfaces: Resin-based sealants / infiltrants)
M$_{Initial}$ Inactive	**No lesion-specific treatment**
M$_{Moderate}$ Active	**NOC** • Resin-based sealants** • If sealant not feasible (teeth isolation difficulties) an option for primary teeth is a non-tooth preparation preformed metal/strip crown **TPOC** • Including (for primary teeth) placement of preformed metal or strip crowns In interproximal surfaces: Determine cavitation presence by tooth separation: • No cavitation: **NOC** • Cavitation: **TPOC** (+ preformed metal/strip crowns in primary teeth)
M$_{Moderate}$ Inactive	**TPOC** if the lesion is a PSA or the area is aesthetically unacceptable
M$_{Extensive}$ Active	**TPOC:** Including (for primary teeth) placement of preformed metal or strip crowns In primary teeth: If standard **TPOC** is not possible, consider the Hall Technique or extraction
M$_{Extensive}$ Inactive	**TPOC** if the lesion is a PSA or the area is aesthetically unacceptable

Review and monitoring visits (or recalls):

The duration of personalised intervals between visits to review and monitor a patient's caries status should be considered. The Recall interval is based on age (eruption pattern and other milestones) and risk (based on lesion level as well as overall patient level). ICCMS differentiates between recall intervals set for overall risk management, for assessing preventive interventions and the monitoring of initial lesions (to check their progression status) and reviews of behavioural and oral hygiene change plans.
For coronal caries in the primary dentition, caries management recommendations are dependent on the cooperation level of a child and time to exfoliation.

Answers to the patient scenario questions

Patient Scenario #1:

Age	22 years old.
General History	No significant medical history, no known allergies, no medications.
Dental History	History of sealants, recall exams and cleaning until the age of 18 years old.
Oral Hygiene	Inadequate oral hygiene practice, patient states that he rarely brushes his teeth more than once a day.
Reason for consultation	He has not been seen by a dentists in 3 years and wants to have a "check up".
Clinical examination	On clinical examination the patient has moderate plaque accumulation at the gingival margins and localized gingival inflammation with bleeding upon probing.

Q:1: What would you consider the caries risk of this patient?
Answer: Moderate risk

Q:2:
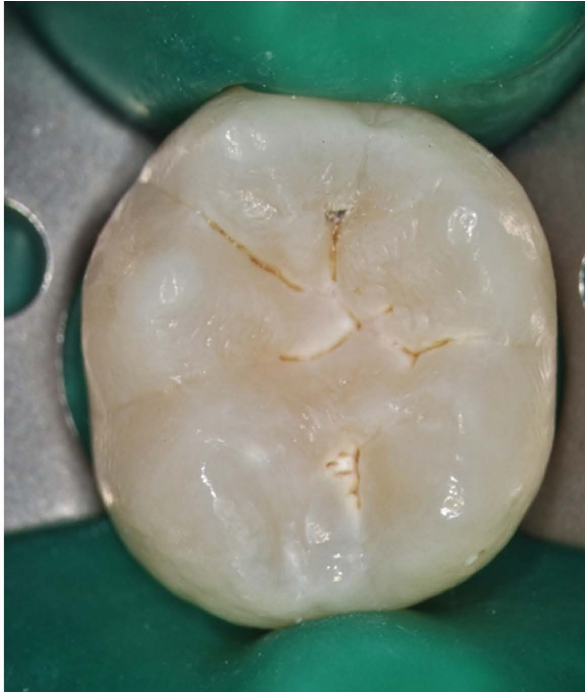
A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #30?
Answer: Enamel active carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #30?
Answers:
-Resin based sealant without mechanical preparation of the tooth structure.
-Glass ionomer sealant without mechanical preparation of tooth structure.

Q:3:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #19 Distal?
Answer: Enamel carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #19 Distal?
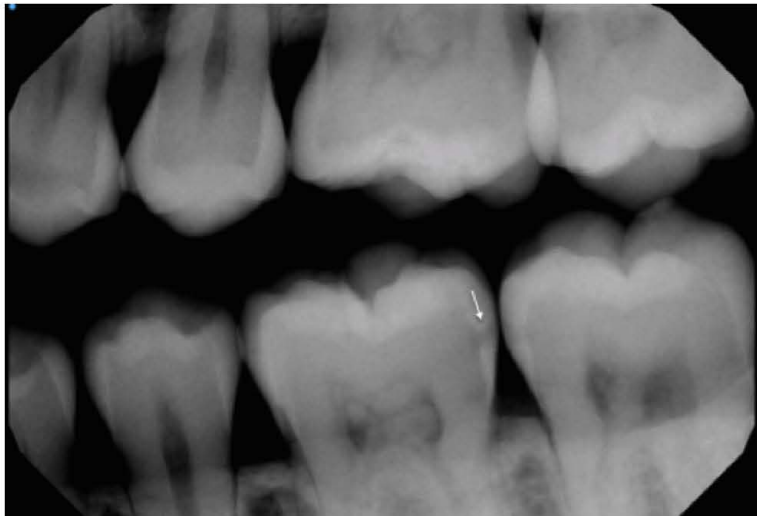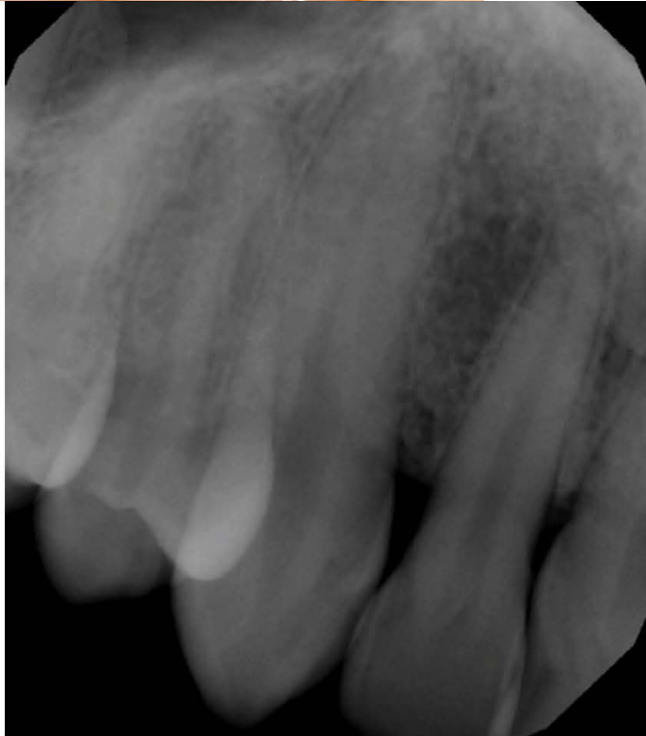Answers: No lesion specific treatment.

Q:4:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #6?
Answer: Enamel active carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #6?
Answers:
-Clinically In-office applied Fluoride application (varnish, gel, foam).
-Resin infiltration (ICON).

Q:5: What would be your recommendation for this patient? (Select all that apply)
Answers:
-Tooth brushing 2/day with a 5000 ppm fluoridated toothpaste.
-General behavior modification in oral health.
-Prescribed fluoride mouthrinse.
-Motivational engagement (discuss with patients how to improve oral health behaviors), maintain dental visits.
-Sealants.
-Fluoride varnish 2 times per year.
-Fluoride gels or solution (2% NaF).
-Recalls up to every 3 months for professional cleaning & topical Fluoride application on active lesions.

Patient Scenario #2:

Age	45 years old
General History	No significant medical history, no known allergies, no medications.
Dental History	Six month recall exams and professional cleaning.
Oral Hygiene	Good oral hygiene. Patient brushes twice daily with over the counter fluoridated tooth paste.
Reason for consultation	Recall examination.
Clinical examination	Healthy gingival tissue.

Q:1: What would you consider the caries risk of this patient?
Answer: Low risk.

Q:2:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #19?
Answer: Enamel arrested carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #19?
Answer: No lesion specific treatment.

Q:3:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #4?
Answer: Enamel arrested carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #4?
Answer: No lesion specific treatment.

Q:4:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #7 Mesial?
Answer: Enamel carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #7 Mesial?
Answer: No lesion specific treatment.

Q:5: What would be your recommendation for this patient?
Answer:
Tooth brushing 2/day with an over the counter fluoridated toothpaste.

Patient Scenario #3:

Age	45 years old.
General history	Diabetic, dry mouth.
Dental history	Restorative treatment and extractions due to caries within the past 8 months.
Oral hygiene	Inadequate oral hygiene, patient states that he does not brush his teeth every day.
Reason for consultation	Recall examination
Clinical examination	On clinical examination patient has signs of reduced salivary flow.

Q:1: What would you consider the caries risk of this patient?
Answer: High risk.

Q:2:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #30 Distal?
Answer: Enamel carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #30 Distal?
Answers:
-Clinically applied topical fluoride (Varnish, gel, foam).
-Resin sealant / proximal infiltration (ICON).

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Q:3:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #12?
Answer: Enamel active carious lesion.

The lesion activity was diagnosed as active because the lesion looks dull and opaque with enamel demineralization.

B) What treatment would you recommend the lesion marked by the arrows on tooth #12?
Answers:
-Resin based sealant without mechanical preparation of the tooth structure.
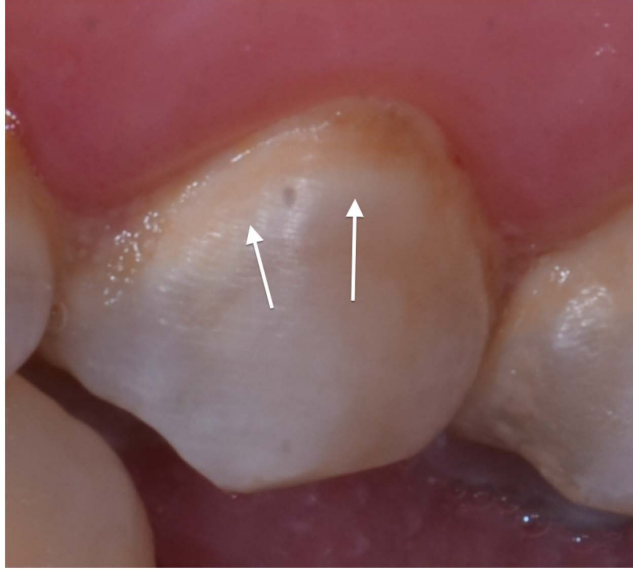-Glass ionomer sealant without mechanical preparation of tooth structure.

Q:4:

A) What is the most likely diagnosis of the lesion marked by the arrows on tooth #13?
Answer: Enamel active carious lesion.

B) What treatment would you recommend for the lesion marked by the arrows on tooth #13?
Answers:
-Clinically In-office applied Fluoride application (varnish, gel, foam).
-Resin infiltration (ICON).

Q:5: What would be your recommendation for this patient?
Answers:
-Tooth brushing 2/day with a 5000 ppm fluoridated toothpaste.
-General behavior modification in oral health.
-Prescribed fluoride mouthrinse.
-Motivational engagement (discuss with patients how to improve oral health behaviors), maintain dental visits.
-Sealants.
-Fluoride varnish 4 times per year.
-Fluoride gels or solution (2% NaF).
-Recalls up to every 3 months for professional cleaning & topical Fluoride application on active lesions.

To receive a 1 hour CE credit

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NOTE: The survey will remain anonymous to the primary
investigator and providing your name will not be
linked to the survey.

Your name is needed to receive the 1 hour CE credit.

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REFERENCES

1.	Featherstone JD. Remineralization, the natural caries repair process--the need for new approaches. Advances in dental research. 2009;21(1):4-7.
2.	research niodac. dental caries national institute of dental and crainiofacial research 2015 [cited 2015]. Available from:
http://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/DentalCaries/.
3.	(ADA) ADA. Available from: http://www.ada.org/en/press-room/news-releases/2015-archive/may/new-cdc-data-on-adult-cavities.
4.	Featherstone JD. Dental caries: a dynamic disease process. Australian dental journal. 2008;53(3):286-91.
5.	Fisher J, Glick M. A new model for caries classification and management: the FDI World Dental Federation caries matrix. Journal of the American Dental Association (1939). 2012;143(6):546-51.
6.	Widstrom E. Prevention and dental health services. Oral health & preventive dentistry. 2004;2 Suppl 1:255-8.
7.	website IF. ICDAS Foundation 2015. Available from:
https://http://www.icdas.org/what-is-icdas.
8.	Pitts NB, Ekstrand KR, The IF. International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS) – methods for staging of the caries process and enabling dentists to manage caries.
9.	Reich E, Lussi A, Newbrun E. Caries-risk assessment. International dental journal. 1999;49(1):15-26.
10.	Featherstone JD. The caries balance: the basis for caries management by risk assessment. Oral health & preventive dentistry. 2004;2 Suppl 1:259-64.
11.	Featherstone JD. The caries balance: contributing factors and early detection. Journal of the California Dental Association. 2003;31(2):129-33.
12.	trans. ADA policy statement on Evidence -based dentistry 2001 [cited 2015]. Available from: http://www.ada.org/en/about-the-ada/ada-positions-policies-and-statements/policy-on-evidence-based-dentistry.
13.	Pitts NB. Are we ready to move from operative to non-operative/preventive treatment of dental caries in clinical practice? Caries research. 2004;38(3):294-304.
14.	Cochrane NJ, Cai F, Huq NL, Burrow MF, Reynolds EC. New approaches to enhanced remineralization of tooth enamel. Journal of dental research. 2010;89(11):1187-97.
15.	Domejean-Orliaguet S, Leger S, Auclair C, Gerbaud L, Tubert-Jeannin S. Caries management decision: influence of dentist and patient factors in the provision of dental services. Journal of dentistry. 2009;37(11):827-34.
16.	Petersen PE, Ogawa H. The global burden of periodontal disease: towards integration with chronic disease prevention and control. Periodontology 2000. 2012;60(1):15-39.
17.	Selwitz RH, Ismail AI, Pitts NB. Dental caries. Lancet. 2007;369(9555):51-9.
18.	Ellwood RP, Gomez J, Pretty IA. Caries clinical trial methods for the assessment of oral care products in the 21st century. Advances in dental research. 2012;24(2):32-5.

19.   Pitts NB. Modern perspectives on caries activity and control. Journal of the American Dental Association (1939). 2011;142(7):790-2.

20.   Marsh PD. Microbial ecology of dental plaque and its significance in health and disease. Advances in dental research. 1994;8(2):263-71.

21.   Marsh PD. Dental plaque: biological significance of a biofilm and community life-style. Journal of clinical periodontology. 2005;32 Suppl 6:7-15.

22.   TM. M. THE CARIES-INHIBITING EFFECT OF AMINE FLUORIDE DENTIFRICES IN CHILDREN DURING THREE YEARS OF UNSUPERVISED USE. British dental journal. 1965 119(Aug 17 1965):153-63.

23.   Pitts NB, Fyffe HE. The effect of varying diagnostic thresholds upon clinical caries data for a low prevalence group. Journal of dental research. 1988;67(3):592-6.

24.   Ekstrand KR, Kuzmina I, Bjorndal L, Thylstrup A. Relationship between external and histologic features of progressive stages of caries in the occlusal fossa. Caries research. 1995;29(4):243-50.

25.   Ole Fejerskov EK, editor. Dental Caries: The Disease and Its Clinical Management. 2nd Edition ed: Blackwell; April 2008.

26.   Pitts NB, Stamm JW. International Consensus Workshop on Caries Clinical Trials (ICW-CCT)--final consensus statements: agreeing where the evidence leads. Journal of dental research. 2004;83 Spec No C:C125-8.

27.   Aas JA, Paster BJ, Stokes LN, Olsen I, Dewhirst FE. Defining the normal bacterial flora of the oral cavity. Journal of clinical microbiology. 2005;43(11):5721-32.

28.   Fejerskov O CB. Dynamics of caries lesion formation. Copenhagen: Munksgaard; 1996 1996.

29.   Hannig C, Hannig M, Attin T. Enzymes in the acquired enamel pellicle. European journal of oral sciences. 2005;113(1):2-13.

30.   Whittaker CJ, Klier CM, Kolenbrander PE. Mechanisms of adhesion by oral bacteria. Annual review of microbiology. 1996;50:513-52.

31.   Kolenbrander PE, Palmer RJ, Jr., Rickard AH, Jakubovics NS, Chalmers NI, Diaz PI. Bacterial interactions and successions during plaque development. Periodontology 2000. 2006;42:47-79.

32.   Hojo K, Nagaoka S, Ohshima T, Maeda N. Bacterial interactions in dental biofilm development. Journal of dental research. 2009;88(11):982-90.

33.   Xu X, He J, Xue J, Wang Y, Li K, Zhang K, et al. Oral cavity contains distinct niches with dynamic microbial communities. Environmental microbiology. 2015;17(3):699-710.

34.   ten Cate JM, Buijs MJ, Miller CC, Exterkate RA. Elevated fluoride products enhance remineralization of advanced enamel lesions. Journal of dental research. 2008;87(10):943-7.

35.   Holmen L, Thylstrup A, Artun J. Clinical and histological features observed during arrestment of active enamel carious lesions in vivo. Caries research. 1987;21(6):546-54.

36.   Rethman MP, Beltran-Aguilar ED, Billings RJ, Hujoel PP, Katz BP, Milgrom P, et al. Nonfluoride caries-preventive agents: executive summary of evidence-based clinical recommendations. Journal of the American Dental Association (1939). 2011;142(9):1065-71.

37.	Holmen L, Thylstrup A, Ogaard B, Kragh F. A scanning electron microscopic study of progressive stages of enamel caries in vivo. Caries research. 1985;19(4):355-67.
38.	Baelum V, Hintze H, Wenzel A, Danielsen B, Nyvad B. Implications of caries diagnostic strategies for clinical management decisions. Community dentistry and oral epidemiology. 2012;40(3):257-66.
39.	Spencer AJ. Skewed distributions--new outcome measures. Community dentistry and oral epidemiology. 1997;25(1):52-9.
40.	Ismail AI, Sohn W, Tellez M, Amaya A, Sen A, Hasson H, et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Community dentistry and oral epidemiology. 2007;35(3):170-8.
41.	Fyffe HE, Deery C, Nugent ZJ, Nuttall NM, Pitts NB. Effect of diagnostic threshold on the validity and reliability of epidemiological caries diagnosis using the Dundee Selectable Threshold Method for caries diagnosis (DSTM). Community dentistry and oral epidemiology. 2000;28(1):42-51.
42.	Ekstrand KR, Ricketts DN, Kidd EA. Reproducibility and accuracy of three methods for assessment of demineralization depth of the occlusal surface: an in vitro examination. Caries research. 1997;31(3):224-31.
43.	Ismail AI. Visual and visuo-tactile detection of dental caries. Journal of dental research. 2004;83 Spec No C:C56-66.
44.	Ekstrand KR, Ricketts DN, Kidd EA, Qvist V, Schou S. Detection, diagnosing, monitoring and logical treatment of occlusal caries in relation to lesion activity and severity: an in vivo examination with histological validation. Caries research. 1998;32(4):247-54.
45.	Ekstrand KR, Ricketts DN, Longbottom C, Pitts NB. Visual and tactile assessment of arrested initial enamel carious lesions: an in vivo pilot study. Caries research. 2005;39(3):173-7.
46.	Ekstrand KR, Zero DT, Martignon S, Pitts NB. Lesion activity assessment. Monographs in oral science. 2009;21:63-90.
47.	Jablonski-Momeni A, Stachniss V, Ricketts DN, Heinzel-Gutenbrunner M, Pieper K. Reproducibility and accuracy of the ICDAS-II for detection of occlusal caries in vitro. Caries research. 2008;42(2):79-87.
48.	Ferreira Zandona A, Santiago E, Eckert G, Fontana M, Ando M, Zero DT. Use of ICDAS combined with quantitative light-induced fluorescence as a caries detection method. Caries research. 2010;44(3):317-22.
49.	Pitts NBi, A.I. Martignon, S. Douglas, G.V.A. Longbottom, C. ICCMS guide for practitioners and educators 2014. Available from: https://http://www.icdas.org/uploads/ICCMS-Guide_Full_Guide_UK.pdf.
50.	Ismail AI, Tellez M, Pitts NB, Ekstrand KR, Ricketts D, Longbottom C, et al. Caries management pathways preserve dental tissues and promote oral health. Community dentistry and oral epidemiology. 2013;41(1):e12-40.
51.	Young DA, Novy BB, Zeller GG, Hale R, Hart TC, Truelove EL. The American Dental Association Caries Classification System for clinical practice: a report of the American Dental Association Council on Scientific Affairs. Journal of the American Dental Association (1939). 2015;146(2):79-86.

52.   Abernathy JR, Graves RC, Bohannan HM, Stamm JW, Greenberg BG, Disney JA. Development and application of a prediction model for dental caries. Community dentistry and oral epidemiology. 1987;15(1):24-8.

53.   Helfenstein U, Steiner M, Marthaler TM. Caries prediction on the basis of past caries including precavity lesions. Caries research. 1991;25(5):372-6.

54.   Hurlbutt M, Young DA. A best practices approach to caries management. The journal of evidence-based dental practice. 2014;14 Suppl:77-86.

55.   Young DA, Featherstone JD, Roth JR, Anderson M, Autio-Gold J, Christensen GJ, et al. Caries management by risk assessment: implementation guidelines. Journal of the California Dental Association. 2007;35(11):799-805.

56.   Weyant RJ, Tracy SL, Anselmo TT, Beltran-Aguilar ED, Donly KJ, Frese WA, et al. Topical fluoride for caries prevention: executive summary of the updated clinical recommendations and supporting systematic review. Journal of the American Dental Association (1939). 2013;144(11):1279-91.

57.   Fejerskov O KE, Nyvad B, Baelum V. Defining the disease: an introduction. Fejerskov O KE Dental Caries: The Disease and its Clinical Management. 2nd edition ed. London: Blackwell Munksgaard; 2008.

58.   Deery C. Caries detection and diagnosis, sealants and management of the possibly carious fissure. British dental journal. 2013;214(11):551-7.

59.   American Dental Association (ADA), Fluoridation Facts. http://www.ada.org/~/media/ADA/Member Center/FIles/fluoridation_facts.ashx.

60.   Recommendations for using fluoride to prevent and control dental caries in the United States. Centers for Disease Control and Prevention. MMWR Recommendations and reports : Morbidity and mortality weekly report Recommendations and reports / Centers for Disease Control. 2001;50(Rr-14):1-42.

61.   Norman OH, Franklin Garcia-Godoy, Christine, N. Nathe. Primary Preventive Dentistry 7th edition. . 7th edition ed2008.

62.   Center for Disease Control and Prevention (CDC), 2010 Water Fluoridation Statistics. . http://www.cdc.gov/fluoridation/statistics/2010stats.htm.

63.   Rozier RG, Adair S, Graham F, Iafolla T, Kingman A, Kohn W, et al. Evidence-based clinical recommendations on the prescription of dietary fluoride supplements for caries prevention: a report of the American Dental Association Council on Scientific Affairs. Journal of the American Dental Association (1939). 2010;141(12):1480-9.

64.   Ahovuo-Saloranta A, Forss H, Walsh T, Hiiri A, Nordblad A, Makela M, et al. Sealants for preventing dental decay in the permanent teeth. The Cochrane database of systematic reviews. 2013;3:Cd001830.

65.   Wright JT, Crall JJ, Fontana M, Gillette EJ, Novy BB, Dhar V, et al. Evidence-based clinical practice guideline for the use of pit-and-fissure sealants: A report of the American Dental Association and the American Academy of Pediatric Dentistry. Journal of the American Dental Association (1939). 2016;147(8):672-82.e12.

66.   Maheswari SU, Raja J, Kumar A, Seelan RG. Caries management by risk assessment: A review on current strategies for caries prevention and management. Journal of pharmacy & bioallied sciences. 2015;7(Suppl 2):S320-4.

67.   Ekstrand K, Martignon S, Holm-Pedersen P. Development and evaluation of two root caries controlling programmes for home-based frail people older than 75 years. Gerodontology. 2008;25(2):67-75.

68.   Nordstrom A, Birkhed D. Preventive effect of high-fluoride dentifrice (5,000 ppm) in caries-active adolescents: a 2-year clinical trial. Caries research. 2010;44(3):323-31.

69.   Baysan A, Lynch E, Ellwood R, Davies R, Petersson L, Borsboom P. Reversal of primary root caries using dentifrices containing 5,000 and 1,100 ppm fluoride. Caries research. 2001;35(1):41-6.

70.   Ekstrand KR, Poulsen JE, Hede B, Twetman S, Qvist V, Ellwood RP. A randomized clinical trial of the anti-caries efficacy of 5,000 compared to 1,450 ppm fluoridated toothpaste on root caries lesions in elderly disabled nursing home residents. Caries research. 2013;47(5):391-8.

71.   Yevlahova D, Satur J. Models for individual oral health promotion and their effectiveness: a systematic review. Australian dental journal. 2009;54(3):190-7.

72.   Bratthall D, Hansel Petersson G. Cariogram--a multifactorial risk assessment model for a multifactorial disease. Community dentistry and oral epidemiology. 2005;33(4):256-64.

73.   Marinho VC, Higgins JP, Sheiham A, Logan S. One topical fluoride (toothpastes, or mouthrinses, or gels, or varnishes) versus another for preventing dental caries in children and adolescents. The Cochrane database of systematic reviews. 2004(1):Cd002780.

74.   Marinho VC, Higgins JP, Logan S, Sheiham A. Topical fluoride (toothpastes, mouthrinses, gels or varnishes) for preventing dental caries in children and adolescents. The Cochrane database of systematic reviews. 2003(4):Cd002782.

75.   Andlaw RJ. Oral hygiene and dental caries--a review. International dental journal. 1978;28(1):1-6.

76.   Ismail AI, Ondersma S, Jedele JM, Little RJ, Lepkowski JM. Evaluation of a brief tailored motivational intervention to prevent early childhood caries. Community dentistry and oral epidemiology. 2011;39(5):433-48.

77.   Cooper AM, O'Malley LA, Elison SN, Armstrong R, Burnside G, Adair P, et al. Primary school-based behavioural interventions for preventing caries. The Cochrane database of systematic reviews. 2013(5):Cd009378.

78.   Weinstein P, Harrison R, Benton T. Motivating parents to prevent caries in their young children: one-year findings. Journal of the American Dental Association (1939). 2004;135(6):731-8.

79.   Ahovuo-Saloranta A, Forss H, Walsh T, Hiiri A, Nordblad A, Makela M, et al. Sealants for preventing dental decay in the permanent teeth. The Cochrane database of systematic reviews. 2013(3):Cd001830.

80.   Marinho VC, Worthington HV, Walsh T, Clarkson JE. Fluoride varnishes for preventing dental caries in children and adolescents. The Cochrane database of systematic reviews. 2013(7):Cd002279.

81.   Beirne P, Clarkson JE, Worthington HV. Recall intervals for oral health in primary care patients. The Cochrane database of systematic reviews. 2007(4):Cd004346.

82.   Harris R, Gamboa A, Dailey Y, Ashcroft A. One-to-one dietary interventions undertaken in a dental setting to change dietary behaviour. The Cochrane database of systematic reviews. 2012(3):Cd006540.

83.   Jenson L, Budenz AW, Featherstone JD, Ramos-Gomez FJ, Spolsky VW, Young DA. Clinical protocols for caries management by risk assessment. Journal of the California Dental Association. 2007;35(10):714-23.

84.   Sreebny LM, Schwartz SS. A reference guide to drugs and dry mouth--2nd edition. Gerodontology. 1997;14(1):33-47.

85.   Klasser GD, Epstein J. Methamphetamine and its impact on dental care. Journal (Canadian Dental Association). 2005;71(10):759-62.

86.   Madinier I, Harrosch J, Dugourd M, Giraud-Morin C, Fosse T. [The buccal-dental health of drug addicts treated in the University hospital centre in Nice]. Presse medicale (Paris, France : 1983). 2003;32(20):919-23.

87.   Tellez M, Gomez J, Kaur S, Pretty IA, Ellwood R, Ismail AI. Non-surgical management methods of noncavitated carious lesions. Community dentistry and oral epidemiology. 2013;41(1):79-96.

88.   Wong MC, Clarkson J, Glenny AM, Lo EC, Marinho VC, Tsang BW, et al. Cochrane reviews on the benefits/risks of fluoride toothpastes. Journal of dental research. 2011;90(5):573-9.

89.   Bellini HT, Arneberg P, von der Fehr FR. Oral hygiene and caries. A review. Acta odontologica Scandinavica. 1981;39(5):257-65.

90.   Holmgren CJ, Lo EC, Hu D. Glass ionomer ART sealants in Chinese school children-6-year results. Journal of dentistry. 2013;41(9):764-70.

91.   Martignon S, Ekstrand KR, Gomez J, Lara JS, Cortes A. Infiltrating/sealing proximal caries lesions: a 3-year randomized clinical trial. Journal of dental research. 2012;91(3):288-92.

92.   Griffin SO, Oong E, Kohn W, Vidakovic B, Gooch BF, Bader J, et al. The effectiveness of sealants in managing caries lesions. Journal of dental research. 2008;87(2):169-74.

93.   Bakhshandeh A, Qvist V, Ekstrand KR. Sealing occlusal caries lesions in adults referred for restorative treatment: 2-3 years of follow-up. Clinical oral investigations. 2012;16(2):521-9.

94.   Ricketts D, Lamont T, Innes NP, Kidd E, Clarkson JE. Operative caries management in adults and children. The Cochrane database of systematic reviews. 2013(3):Cd003808.

95.   Pitts NB. Monitoring of caries progression in permanent and primary posterior approximal enamel by bitewing radiography. Community dentistry and oral epidemiology. 1983;11(4):228-35.

96.   Pitts NB. The use of bitewing radiographs in the management of dental caries: scientific and practical considerations. Dento maxillo facial radiology. 1996;25(1):5-16.

97.   Bader JD, Shugars DA. The evidence supporting alternative management strategies for early occlusal caries and suspected occlusal dentinal caries. The journal of evidence-based dental practice. 2006;6(1):91-100.

98.   Bader JD, Shugars DA, Bonito AJ. A systematic review of selected caries prevention and management methods. Community dentistry and oral epidemiology. 2001;29(6):399-411.

99.   Beauchamp J, Caufield PW, Crall JJ, Donly KJ, Feigal R, Gooch B, et al. Evidence-based clinical recommendations for the use of pit-and-fissure sealants: a report of the American Dental Association Council on Scientific Affairs. Dental clinics of North America. 2009;53(1):131-47, x.

100.   Griffin SO, Regnier E, Griffin PM, Huntley V. Effectiveness of fluoride in preventing caries in adults. Journal of dental research. 2007;86(5):410-5.

101.   Winston AE, Bhaskar SN. Caries prevention in the 21st century. Journal of the American Dental Association (1939). 1998;129(11):1579-87.

102.   Bader JD, Shugars DA. Variation, treatment outcomes, and practice guidelines in dental practice. Journal of dental education. 1995;59(1):61-95.

103.   Thylstrup A. Mechanical vs. disease-oriented treatment of dental caries: educational aspects. Journal of dental research. 1989;68(6):1135.

104.   Bader JD, Shugars DA. Variation in dentists' clinical decisions. Journal of public health dentistry. 1995;55(3):181-8.

105.   Bader JD, Shugars DA. What do we know about how dentists make caries-related treatment decisions? Community dentistry and oral epidemiology. 1997;25(1):97-103.

106.   Riordan PJ, Espelid I, Tveit AB. Radiographic interpretation and treatment decisions among dental therapists and dentists in Western Australia. Community dentistry and oral epidemiology. 1991;19(5):268-71.

107.   el-Mowafy OM, Lewis DW. Restorative decision making by Ontario dentists. Journal (Canadian Dental Association). 1994;60(4):305-10, 13-6.

108.   Mejare I, Sundberg H, Espelid I, Tveit B. Caries assessment and restorative treatment thresholds reported by Swedish dentists. Acta odontologica Scandinavica. 1999;57(3):149-54.

109.   Tveit AB, Espelid I, Skodje F. Restorative treatment decisions on approximal caries in Norway. International dental journal. 1999;49(3):165-72.

110.   Domejean-Orliaguet S, Tubert-Jeannin S, Riordan PJ, Espelid I, Tveit AB. French dentists' restorative treatment decisions. Oral health & preventive dentistry. 2004;2(2):125-31.

111.   Traebert J, Marcenes W, Kreutz JV, Oliveira R, Piazza CH, Peres MA. Brazilian dentists' restorative treatment decisions. Oral health & preventive dentistry. 2005;3(1):53-60.

112.   Ghasemi H, Murtomaa H, Torabzadeh H, Vehkalahti MM. Restorative treatment threshold reported by Iranian dentists. Community dental health. 2008;25(3):185-90.

113.   Gordan VV, Bader JD, Garvan CW, Richman JS, Qvist V, Fellows JL, et al. Restorative treatment thresholds for occlusal primary caries among dentists in the dental practice-based research network. Journal of the American Dental Association (1939). 2010;141(2):171-84.

114.   Baraba A, Domejean-Orliaguet S, Espelid I, Tveit AB, Miletic I. Survey of Croatian dentists' restorative treatment decisions on approximal caries lesions. Croatian medical journal. 2010;51(6):509-14.

115.   Gaskin EB, Levy S, Guzman-Armstrong S, Dawson D, Chalmers J. Knowledge, attitudes, and behaviors of federal service and civilian dentists concerning minimal intervention dentistry. Military medicine. 2010;175(2):115-21.

116.   Vidnes-Kopperud S, Tveit AB, Espelid I. Changes in the treatment concept for approximal caries from 1983 to 2009 in Norway. Caries research. 2011;45(2):113-20.

117.   Heaven TJ, Gordan VV, Litaker MS, Fellows JL, Brad Rindal D, Firestone AR, et al. Agreement among dentists' restorative treatment planning thresholds for primary occlusal caries, primary proximal caries, and existing restorations: findings from The National Dental Practice-Based Research Network. Journal of dentistry. 2013;41(8):718-25.

118.   Khalaf ME, Alomari QD, Ngo H, Domejean S. Restorative treatment thresholds: factors influencing the treatment thresholds and modalities of general dentists in Kuwait. Medical principles and practice : international journal of the Kuwait University, Health Science Centre. 2014;23(4):357-62.

119.   Rechmann P, Domejean S, Rechmann BM, Kinsel R, Featherstone JD. Approximal and occlusal carious lesions: Restorative treatment decisions by California dentists. Journal of the American Dental Association (1939). 2016;147(5):328-38.

120.   https://redcap.icts.uiowa.edu/redcap/.

121.   Gordan VV, Garvan CW, Heft MW, Fellows JL, Qvist V, Rindal DB, et al. Restorative treatment thresholds for interproximal primary caries based on radiographic images: findings from the Dental Practice-Based Research Network. General dentistry. 2009;57(6):654-63; quiz 64-6, 595, 680.

122.   Tellez M, Gomez J, Pretty I, Ellwood R, Ismail AI. Evidence on existing caries risk assessment systems: are they predictive of future caries? Community dentistry and oral epidemiology. 2013;41(1):67-78.

123.   Neuhaus KW, Jost F, Perrin P, Lussi A. Impact of different magnification levels on visual caries detection with ICDAS. Journal of dentistry. 2015;43(12):1559-64.

124.   Mitropoulos P, Rahiotis C, Kakaboura A, Vougiouklakis G. The impact of magnification on occlusal caries diagnosis with implementation of the ICDAS II criteria. Caries research. 2012;46(1):82-6.