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Knowledge, Attitudes and Practice Behaviors About Caries Risk Assessment and Management

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KNOWLEDGE, ATTITUDES AND PRACTICE BEHAVIORS ABOUT CARIES RISK ASSESSMENT AND MANAGEMENT

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A Thesis Presented to the Faculty of the College of Dental Medicine of Nova Southeastern University in Partial Fulfillment of the Requirements for the Degree of

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By

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I certify that I am the sole author of this thesis, and that any assistance I received in its preparation has been fully acknowledged and disclosed in the thesis. I have cited any sources from which I used ideas, data, or words, and labeled as quotations any directly quoted phrases or passages, as well as providing proper documentation and citations. This thesis was prepared by me, specifically for the M.Sc. degree and for this assignment.

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DEDICATION

I would like to dedicate this thesis to my family who has supported me and stood by me the past years. Their unyielding support and dedication to my comfort has been exemplary. I would not be here without them.

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Abstract

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Abstract

Brief Background: The World Health Organization (WHO), the International Association for Dental Research (IADR) and the World Dental Federation (FDI) in 1981 established the first global oral health goals and promoted the development of oral health objectives targeting reduction in key oral health indicators by 2020. Among the oral health indicators identified in this initiative was the reduction of caries. While there is evidence to suggest that from a global perspective the prevalence of caries is decreasing, there are geographical locations, like Saudi Arabia, where the prevalence of caries is exceeding worldwide statistics. Hence, dental professional, research, and educational associations have promoted caries risk assessment and management as a key approach to mitigate the prevalence of

caries. One of the most recognized comprehensive caries risk assessment and management approach is known as the Caries Management by Risk Assessment (CAMBRA

Objectives: To investigate the CAMBRA knowledge, attitudes and practice behaviors of dentists in Saudi Arabia.

Methods: The proposed investigation is a cross-sectional study that employed a survey using REDCap to solicit responses from dentists in Saudi Arabia about their knowledge, attitudes and practice behaviors of the CAMBRA.

Results: 130 individuals responded to the survey. The majority of the dentists were male (n=72, 56.3%), while 43.7% were female. Most of the participants selected an age range between 25 to 34 years old (n=121, 94.5%), the remaining selected ages older than 34 years old. Furthermore, 68% of the dentists (n=87) reported that they worked in a governmental hospital or clinic. In regards to level of education, 68.8%(n=88) stated their highest level of education was a dental degree, while 31.3% (n=40) stated their highest level of education was a postgraduate degree in dentistry. Most of the dentists 60.9% (n=78) had less than five years of experience. The majority of the dentists 71.6% reported (n=73) that they were using CAMBRA. The participants were asked to select their level of agreement with nine caries risk assessment statements about the importance or relevance of caries risk assessment in dental practice. For example, approximately 96% (n=113,) of the respondents agreed with the following statement "Performing caries risk assessment is an integral part of dental practice". Nine items measured knowledge about carious lesions, caries pathology and potential risk for individuals who have caries. Correct responses for these items ranged from 64% to 100%. Three cases were employed to measure skills about the application of

CAMBRA. Most respondents selected correctly the risk level for the low risk patient; however, for the moderate and high risk patient scenarios over 50% of the respondents selected the wrong answer. Additionally, a 4-point Likert-type scale was used to select the frequency of specific caries management recommendations. For example, 68% of the participants selected always for "Fluoridated over the counter toothpaste" and "Individualized oral hygiene instructions". Also, 4% selected always for "Calcium phosphate products". Results from the Multivariable Logistic Regression analysis indicated that workplace and specialty were significant predictors of total knowledge. Dentists who worked in a governmental hospital or clinic were 2.46 times more likely to obtain higher total knowledge scores than dentists who worked in other sectors while general dentists were 2.3 times more likely to obtain higher total knowledge scores. Our study did not point to any of the demographical variables as significant determinants of CAMBRA attitudes, however, practice behaviors were significant determinants of attitudes and vice versa (AOR= 0.30, CI 95% 0.11, 0.79). Additionally, gender and specialty were significant predictors of practice behaviors. For instance, males were less likely than females to obtain high practice behavior scores and general dentists were three times more likely to score higher than dentists with a specialty.

Conclusion: The outcomes from this study are consistent with other studies in the literature pointing to the need for educational interventions for dentists aimed at improving knowledge about CAMBRA and to influence their practice behaviors. These educational interventions should cover information and strategies to change attitudes that prevent dentists from practicing CAMBRA.

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1.1. Caries Risk Assessment and Management

1.1.1 Overview

The World Health Organization (WHO), the International Association for Dental Research (IADR) and the World Dental Federation (FDI) in 1981determined the first global oral health goals and promoted the development of oral health objectives targeting reduction in key oral health indicators by 2020.[1] These goals include specific targets aiming at reducing the amount of caries in children, a reduction of DMFT in children by age 12 and a decrease in the number of extracted teeth due to caries in the population of adults. As such, globally and at the national level countries have been encourage to designate targets accordingly.[1] In spite of these oral health global initiatives, the Global Burden of Disease Study published in 2013, estimated the prevalence of dental caries worldwide at approximately 35% making it the most prevalent oral condition among 291 conditions.[2] Moreover, this study reported that oral conditions affected 3.9 billion people and untreated caries in permanent teeth was the most prevalent oral health condition across all ages.[2] Furthermore, in specific geographic regions, such as the African Middle-Eastern Region, the prevalence of dental caries increased from 2000 to 2010. In particular, in Saudi Arabia, caries was identified as the most common cause of extraction of permanent teeth.[3, 4] The prevalence of dental caries in Saudi Arabia, was reported as 74.8% in Riyadh[5], 75.4% in Jeddah[6], 73.3% in Eastern Province[7], 66.4% in Abha[8] and has been linked to the changes in the lifestyles of Saudis such as the consumption of great quantities of sugary food, carbonated drinks and lack of awareness concerning appropriate oral health maintenance.[9] Reports from the WHO and studies like the Global Burden of Disease Study call for worldwide attention to the consequences, health and to the problem of dental caries. For instance, The Global Burden of Disease Study reported that the worldwide

burden of oral health conditions is shifting from severe tooth loss to severe periodontitis and untreated caries.[2]

As world health organizations continue to emphasize oral health beyond the treatment of caries, noted is a shift in the manner that dental associations and dental professionals are approaching the problem of dental caries. For instance, "in the past, the dental profession has adhered to a rigid tenet: remove decay from a tooth and then restore"[10] however, dental caries is now recognized as multifactorial infectious disease that can be prevented if correctly assessed; therefore, the approach to treat caries has gone beyond the "drill and fill method" to a comprehensive diagnostic approach that considers disease indicators, risk factors and protective factors to assess the propensity of an individual to acquire caries.[10] One of the most recognized comprehensive caries risk assessment and management protocols is the Caries Management by Risk Assessment (CAMBRA).[10]

In 1995, the *Journal of the American Dental Association* published a landmark supplement highlighting the concept of caries risk assessment and management and the need for dentists to discern treatment approaches according to the patient caries risk level.[11] In this report two approaches to caries risk assessment and management were discussed. One approach stemmed from the quantification of epidemiological and public health factors that can compromise the oral health of the local population. The second approach focused on the determination of individual factors that have been associated with the carious process, such as biological characteristics, medical history, personal habits and life style. "These variables inserted into statistical decision models predict the person's risk of disease over some future period."[12] Dentists were trying to find a method(s) to foresee patients' risk of acquiring dental caries and develop treatment plans that would consider both the causative and protective

factors in order to mitigate the development of dental caries.[13, 14] The optimal synergy between the pathological and protective factors results in the appropriate balance for the process of demineralizing and remineralizing of the tooth structure known as the "caries balance".[15-17] Based on the caries balance concept, a system for caries risk assessment and management was developed by consensus in California following two conferences attended by experts in dental caries resulting in the "Caries Management by Risk Assessment" protocol known as CAMBRA.[18, 19]

An article published in the *Journal of the California Dental Association* in 2011 reported findings from a study that aimed at establishing the predictive validity of the CAMBRA protocol. The validation study was a retrospective investigation conducted in 2006 by the school of dentistry in the University of California in San Francisco (UCSF). The study examined records from patients who had baseline data from an initial caries risk assessment conducted between 2003 and 2009 (N=12,954). A follow-up caries risk assessment was performed on 2,571 patients between 12 to 16 months from baseline. Results from the comparison between patients who had either refused the use of protective factors and/or did not want to purchase the preventive products and those who did follow the recommended use of protective factors such as fluoride toothpaste, mouthwash, water, Xylitol gum and Chlorhexidine determined that there were differences in the amount of first follow-up cavitations, interproximal lesions and white spots between favoring the group that followed the preventive oral health measures. Findings from this study indicated that the risk factors and the preventive measures outlined in the CAMBRA protocol, for the most part, correctly discerned between individuals who were most likely to develop caries lesions versus those who did not.[12]

In response to the concern about the prevalence of dental caries, international dental associations have highlighted the need for research to examine the adequacy of the methods employed by the oral health professionals to assess the risk level of their patients for acquiring caries.[20-23] For example, in response to the high prevalence of dental caries in Saudi Arabia, the Saudi Dental Society (SDS) has organized and unveiled campaigns to prevent dental caries.[23]

Furthermore, several studies of dental caries and caries risk management highlight the importance for the dental professionals to accurately determine and include patients' caries susceptibility, restorative treatment, and a preventive routine that the patient should follow in order to arrest the probability of developing caries in the future in patient treatment plans.[10, 19, 24] The outcomes from these studies point to a need for educational interventions for dental professionals aimed at improving knowledge about CAMBRA and to influence their practice behaviors.

In addition to knowledge and attitudes, theoretical frameworks and studies about transfer of training into practice, have identified age, gender, place of employment, educational level, culture and work culture as variables that influence the transfer of knowledge into practice behaviors.[25-30] Therefore, the purpose of this proposed study is to examine the knowledge, attitudes and practice behaviors of the caries risk assessment and management protocol, CAMBRA, among dentists in Saudi Arabia. The intent of this study is to identify whether knowledge gaps and attitudinal barriers to the practice behaviors of CAMBRA are associated with key demographic variables such as age, place of employment, nationality and gender. This study may potentially permit identification of gaps in knowledge and practice behaviors that may inform targeted educational initiatives.

1.1.2 Epidemiology

Caries prevalence has been declining in the majority of developed countries, while in developing countries the change has been slow.[31-33] Marcenes et al, reported dental caries was the most prevalent oral condition with (35%) and accounted for 15 million Disability-Adjusted Life-Years (DALYs). and contribute to a significant of burden of disease Untreated caries was the leading cause of DALY in Oceania, South Asia, North Africa/ Middle East and West, Central and Southern Sub-Saharan.[2]

Epidemiological studies in economically developing countries report that the prevalence and severity of dental caries have increased with industrialization and exposure to Western diets.[34] The mean Decayed (D), Missing (M), and Filled (F) Teeth (T) or (DMFT) of 12 year olds in low-income countries was 1.9 with 3.3 DMFT for middle-income countries and 2.1 DMFT for high-income countries. In most countries, more than 90% of caries remain untreated.[35] The prevalence of dental caries is increasing in most African Middle-Eastern Region countries.[3] A study was conducted in the urban and rural areas of Lahore, Pakistan to determine whether urbanization and family income were related to dental caries reported caries prevalence of 40.5%, and DMFT score of 1.85 ± 3.26 in children aged 3-5 years.[36] While another study performed in Chikar, Pakistan with 311 schoolchildren revealed an overall DMFT score of 3.3 in 5-20-year-olds. [37] Whereas, according to reports from the World Health Organization (WHO), caries prevalence among the 12-year-old children from many European Union countries (EU) has decreased considerably in the past 35 years due to an increased awareness of oral hygiene maintenance and use of fluoridated toothpaste.[38, 39]

The most common cause of extraction of permanent teeth in Saudi Arabia is dental caries.[4] In the past few decades, the change in lifestyle of Saudis, involving increased consumption of sugary food, carbonated drinks, and lack of awareness towards proper oral

health maintenance attributed to an increase in the prevalence of dental caries.[9, 40] Numerous studies have been conducted in different parts of Saudi Arabia to report the prevalence of dental caries in schoolchildren. Farsi et al, conducted a study to develop an association between enamel defects and caries occurrence in Jeddah, KSA, by examining 510 children and reported a DMFT score of 3.9 and a strong association between enamel defects and caries prevalence among 4-5-year-olds in which caries was found in 75.4% of teeth with enamel defects.[6] Another study performed in Riyadh, KSA reported a DMFT score of 6.1, and no significant difference in the prevalence of caries in relation to gender among 789 pre-school children.[5] In 2012, caries prevalence in the maxillary and mandibular first molar in the age group of 7-10 years schoolchildren was determined to be higher than the recommended standards of the WHO in Abha, KSA and a mean DMFT of 2.74 was reported.[8] In Eastern KSA the overall prevalence of dental caries in primary and permanent teeth was 73.3% among 397 children examined. Among the 6-9 year-old, the prevalence of caries was 77.8%, whereas among the 10-12 year-old, it was approximately 68%.[7]

1.1.3 Etiology

Numerous studies indicated that one specific method that incorporates all factors to assess caries does not exist and emphasized caries as a multifactorial disease.[41] Some of these factors are the level of sugar consumption, the presence of plaque, high counts of Streptococcus mutans, and the individual's behavior towards oral health.[42-46] Family demographical characteristics such as financial status, education level, and occupation have been found to be associated with children's oral health.[47-50] However, it has been concluded that the most important caries risk factors are poor oral hygiene which includes tooth brushing inconsistencies and a caries-producing diet.[51]

Streptococcus mutans (SM) is the most widely recognized microorganism related to the development of caries. SM aids in the demineralization of the tooth by processing sugars to produce acids. Lactobacilli on the other hand does not start the caries process, but plays an essential part in lesion's progression. Moreover, Lactobacilli can be transmitted from mother to child. Furthermore, studies have shown that a mother with poor oral hygiene and recurrent sugar consumption increases the odds of caries development in the child..[52] SM is acquired from the mother during first 12–24 months after birth. Individuals are five times more susceptible to have dental caries with high SM counts.[53]

Also, Actinomyces species were related with caries initiation, whereas Bifidobacterium species were linked with deep caries lesions.[54, 55] In conclusion, there are other oral bacteria that could be involved in the initiation and progression of the development of caries; however, SM is recognized as the leading bacteria that leads to the development of dental caries.

Furthermore, dietary habits with high levels of fermentable carbohydrates are essential in the spread of caries.[56] The chances of developing caries may happen due to improper feeding habits such as prolonged exposure of teeth to fermentable carbohydrates.[57] Enamel and dentin are demineralized by the conversion of fermentable carbohydrates into acids using SM.[58] Due to its mineral content and low lactose level, it has been revealed that cow milk has low cariogenicity.[59-61] The prevalence of dental caries might increase with breast feeding for more than a year and at night.[62] SM colonization and formation of high SM counts are influenced by having a sugar diet, frequent snacking, poor oral hygiene and dietary habits.[56]

Poor oral hygiene causes dental caries. Children should start oral hygiene care as soon as the first primary tooth erupts.[63] Individuals with low financial status are two times more prone to have dental caries.[64] There are many benefits of saliva in the oral cavity, it's flow rate, the

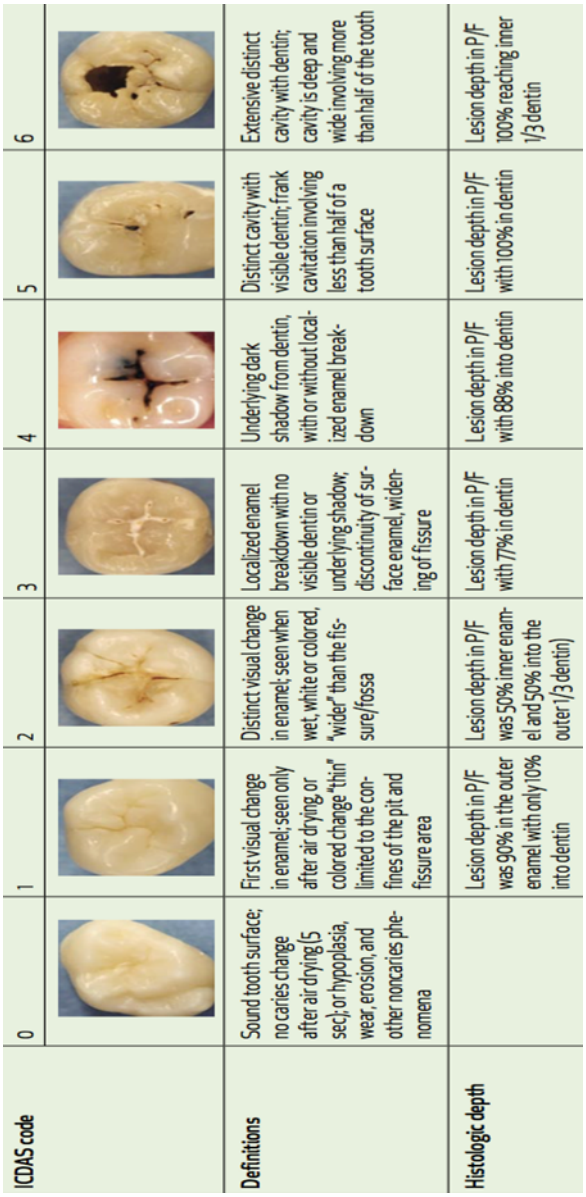
buffering capacity, antimicrobial properties, , and removal of debris, These protective factors are significant in decreasing dental caries.[65] A study showed that parents who smoke affect caries found in children.[66]

1.1.4 Caries Diagnosis

The term "Lesion detection" is an impartial way of deciding whether or not the disease exists by identifying the signs and symptoms. "Lesion assessment" means to describe the lesion after detection and "Caries diagnosis" infers a professional dentist's summarization of all obtainable information and has been defined as "the art or act of identifying a disease from its signs and symptoms".[67, 68] Dental caries disease presentation has changed, the development of non-cavitated lesions seems to be slower, permitting preventive approaches to be applied when the lesions have the best chance to arrest their progression. A combination of methods whether they were traditional or more advanced may improve caries diagnosis and also aid the clinician in monitoring non-invasive treatments.[69, 70] In order for caries detecting methods to be reliable they should correctly detect and monitor caries at any time. The most used and accepted way to diagnose caries is by visual diagnosis, although the use of additional methods should be explored more.[67]

A team of international researchers formed the International Caries Detection and Assessment System (ICDAS) that has been broadly used with substantial research. The system is supposed to merge all new detection systems into one standard system.[71] According to Ekstrand, visual and tactile assessment are not reliable and reproducible. Thus, the ICDAS classifies the system by the level the lesion reached within the tooth on a histological level and is it is represented in discrete and predictable numbers based on the stages of dental caries.[72, 73] Based on the clinical visual examination of caries using a blunt-ended instrument

after cleaning and drying the tooth, ICDAS categorizes caries lesions as seen in (Figure 1).[24, 71]



ICDAS code	0	1	2	3	4	5	6
Definitions	Sound tooth surface; no caries change after air drying [5 sec]; or hypoplasia, wear, erosion, and other noncaries phenomena	First visual change in enamel; seen only after air drying or colored change "thin" limited to the confines of the pit and fissure area	Distinct visual change in enamel; seen when wet, white or colored, "wider" than the fissure/fossa	Localized enamel breakdown with no visible dentin or underlying shadow; discontinuity of surface enamel, widening of fissure	Underlying dark shadow from dentin, with or without localized enamel breakdown	Distinct cavity with visible dentin; frank cavitation involving less than half of a tooth surface	Extensive distinct cavity with dentin; cavity is deep and wide involving more than half of the tooth
Histologic depth		Lesion depth in P/F was 90% in the outer enamel with only 10% into dentin	Lesion depth in P/F was 50% inner enamel and 50% into the outer 1/3 dentin)	Lesion depth in P/F with 77% in dentin	Lesion depth in P/F with 88% into dentin	Lesion depth in P/F with 100% in dentin	Lesion depth in P/F 100% reaching inner 1/3 dentin

Figure 1. ICDAS Classification[24]

Lesion activity assessment is important when using ICDAS and will aid throughout treatment decisions, especially when preventive measures should be applied.[74] Early lesions can be detected through using ICDAS and has proven to be precise and consistent. Also detection of changes in future follow-ups and supplemental methods are helpful in detection of early lesions. [75, 76]

Bitewing radiographs are commonly used as an aid in dental caries diagnosis and their objective is to detect proximal caries lesions that cannot be detected in the visual examination. Studies have shown radiographs are more accurate than clinical examination for detecting proximal caries, occlusal caries reaching dentin, estimating depth of the lesion and for monitoring them. [67, 77, 78] However, when it comes to occlusal surfaces, radiographs seem to be slightly insignificant.[79] When occlusal caries are detected on bitewing radiographs, the lesion probably reached the middle third of dentine and consequently remineralization methods cannot be used.[80] Additionally, radiographs cannot differentiate between active and arrested lesions.[81] Another technique that has been recommended is temporary tooth separation. It can help clinicians to determine if the lesion is active/inactive or cavitated/non-cavitated in proximal areas.[82] ICDAS offered these classifications to evaluate proximal caries lesions (Table 1). Radiographs should be inspected during preliminary examinations and to monitor lesion progression with time.[81]

Table 1. Scores for Radiographical Classification of Lesion Severity

Score	Criteria
0	No Radiolucency
1	Radiolucency in Outer ½ of the Enamel
2	Radiolucency in Inner ½ of the Enamel+- EDJ
3	Radiolucency Limited to the Outer 1/3 of Dentine
4	Radiolucency Reaching the Middle 1/3 of Dentine
5	Radiolucency Reaching the Inner 1/3 of Dentine, Clinically Cavitated
6	Radiolucency Into the Pulp, Clinically Cavitated

Transillumination can aid in caries diagnosis and be utilized to detect proximal dental caries by differentiating between normal and carious enamel using light. Normal enamel appears to be nearly clear which allows the dentine carious lesions to be revealed in multiple colors below the enamel. The development of the ICDAS system can help visual examinations, however it cannot monitor dental caries lesions progression.[83, 84]

All caries detection methods can produce errors. Diagnosing a sound tooth with a carious lesion can result in unnecessary aggressive procedures. It is suggested that sound tooth surfaces should be identified first, before detecting carious lesions that would require restorative treatment. [85]

1.2 Caries Risk Assessment

Conventional dentistry's main focus is performing surgical restorative care on dental caries without knowing that the disease process itself cannot be eradicated by tooth repair alone. Dental caries is the main reason behind restorative dental treatment in both adults and children. For over a century dental specialists have been treating cavities by repairing any destruction caused by dental caries rather than treating the cause of the disease first. Current

evidence suggests an approach that effectively reverse and manages the disease process by targeting infectious agents, alongside the change of the patient's attitude and behavior before any harm is done. This approach is done by indicating the risk that a particular individual is likely to develop caries in the future and is called caries management by risk assessment (CAMBRA). While this risk-based approach is not new to medicine, it signifies a huge change in perspective in dentistry. Conventionally, the practice of dentistry is based on the knowledge, skill, and good clinical judgment of the dental practitioner.[86] This knowledge is frequently passed down from one dental practitioner then onto the next. The impact of new scientific ideas is mostly slow, regardless of whether the change has a huge impact over existing treatment. Evidence-based dentistry chooses the best available scientific evidence instead of traditional approach.[87]

1.3 Caries Disease Management

If we are to treat every patient the same, there is no reason to assess the caries risk level for patients. Certainly, if everyone has dental caries, they would be at high risk and there would be no point in risk assessment. Practitioners can use dental history to foresee if patients will acquire the disease. Every patient at high risk would be managed the same. Nevertheless, not everyone has dental caries; numerous individuals basically do not have dental caries, so why should we treat all patients alike? Is there a better way to manage patients with different risk levels? According to Featherstone et al. managing patients for dental caries by allocating risk levels helps significantly.[88]

1.4 Caries Management by Risk Assessment (CAMBRA)

Caries Management by Risk Assessment (CAMBRA) is different than conventional dentistry where the practitioner not only treats the tooth when it reached a point of no return

and being cavitated, but rather prevents dental caries using evidence based methods. [89] According to Anderson et al, in medicine, evidence was shown that physicians should treat patients according to their risk level rather than treating all patients with the same methods. [90] For example a physician would identify risk factors for heart disease (e.g. high cholesterol, high blood pressure, smoking, etc.) in a patient and treat those risk factors accordingly rather than treating all patients alike whether they had the risk factors or not. Featherstone illustrated an evidence-based strategy called the caries balance method to measure the risk of acquiring dental caries and decide on efficient treatment choices. Figure 2 represents the "balance" and is used to portray the interrelationship of the factors causing dental caries compared with the factors protecting against dental caries.[17, 19]

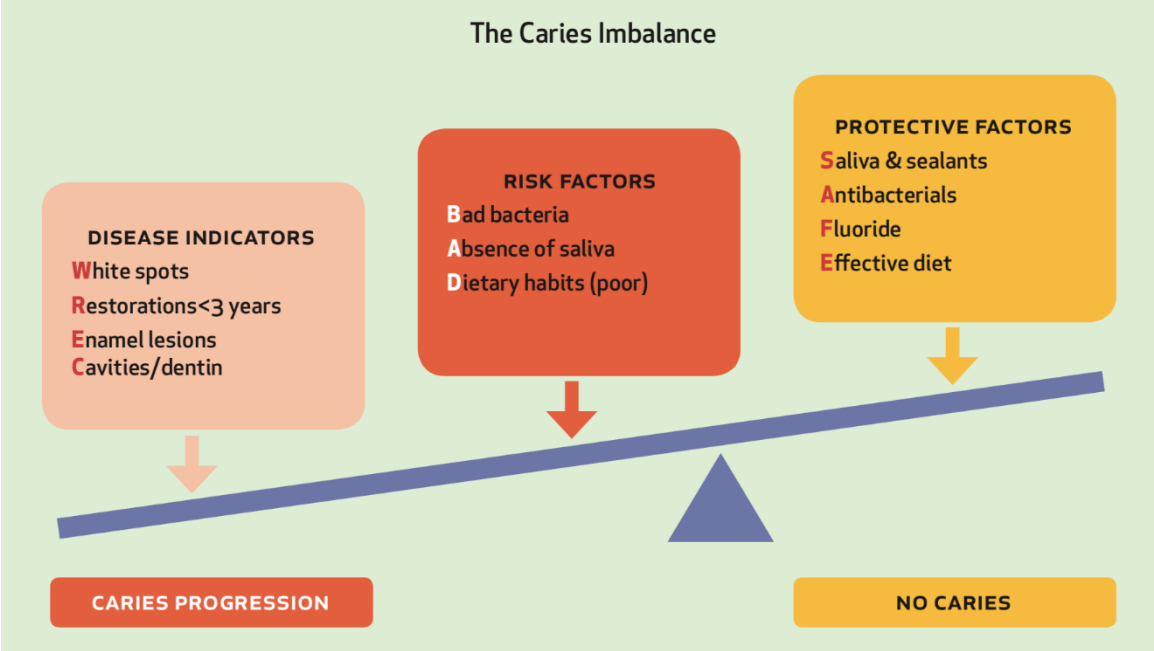


Figure 2. The Caries Imbalance[19]

An intelligent practitioner can foresee the probability of patients acquiring dental caries by assessing the caries balance and assess their risk which will propose a better treatment and prevention from caries. [91] The clinician's focus is to modify the Caries Imbalance in the

patient based on the evidence acquired from the patient by utilizing treatment options such as behavioral, chemical and minimally invasive procedures.[19] The Caries Imbalance is a model in which pathological factors combats protective factors. [92]

1.5. CAMBRA Treatment Recommendations.

Jensen et al recommends four risk level groups (low, moderate, high, and extreme) and the recommendation of caries management procedures for each level as clinical guidelines for managing patients in different caries risk assessment levels for age 6 and older. (Figure 3) These recommendations are not set in stone and are liable to clinical judgment and are made to be used as a guide and help manage dental caries for each individual patient depending on their needs and wishes. Research in caries management is still coming out and will surely change treatment modalities throughout the years. These recommendations are based upon the latest evidence at the time of writing and is considered sensible for managing dental caries.[24]

1.5.1 Risk Factor Management Procedures

These are risk factor management procedures that have shown clinical success which can be shown in details.[24] (Figure 3)

Caries Management by Risk Assessment
Clinical Guidelines for Patients Age 6 and Older

Risk Level ### ***	Frequency of Radiographs	Frequency of Caries Recall Exams	Saliva Test (Saliva Flow & Bacterial Culture)	Antibacterials Chlorhexidine Xylitol ****	Fluoride	pH Control	Calcium Phosphate Topical Supplements	Sealants (Resin-based or Glass Ionomer)
Low risk	Bitewing radiographs every 24-36 months	Every 6-12 months to re-evaluate caries risk	May be done as a base line reference for new patients	Per saliva test if done	OTC fluoride-containing toothpaste twice daily, after breakfast and at bedtime. Optional: NaF varnish if excessive root exposure or sensitivity	Not required	Not required Optional: for excessive root exposure or sensitivity	Optional or as per ICDAS sealant protocol (TABLE 2)
Moderate risk	Bitewing radiographs every 18-24 months	Every 4-6 months to re-evaluate caries risk	May be done as a base line reference for new patients or if there is suspicion of high bacterial challenge and to assess efficacy and patient cooperation	Per saliva test if done Xylitol (6-10 grams/day) gum or candies. Two tabs of gum or two candies four times daily	OTC fluoride-containing toothpaste twice daily plus: 0.05% NaF rinse daily. Initially, 1-2 app of NaF varnish; 1 app at 4-6 month recall	Not required	Not required Optional: for excessive root exposure or sensitivity	As per ICDAS sealant protocol (TABLE 2)
High risk*	Bitewing radiographs every 6-18 months or until no cavitated lesions are evident	Every 3-4 months to re-evaluate caries risk and apply fluoride varnish	Saliva flow test and bacterial culture initially and at every caries recall appt. to assess efficacy and patient cooperation	Chlorhexidine gluconate 0.12% 10 ml rinse for one minute daily for one week each month. Xylitol (6-10 grams/day) gum or candies. Two tabs of gum or two candies four times daily	1.1% NaF toothpaste twice daily instead of regular fluoride toothpaste. Optional: 0.2% NaF rinse daily (1 bottle) then OTC 0.05% NaF rinse 2X daily. Initially, 1-3 app of NaF varnish; 1 app at 3-4 month recall	Not required	Optional: Apply calcium/ phosphate paste several times daily	As per ICDAS sealant protocol (TABLE 2)
Extreme risk** (High risk plus dry mouth or special needs)	Bitewing radiographs every 6 months or until no cavitated lesions are evident	Every 3 months to re-evaluate caries risk and apply fluoride varnish.	Saliva flow test and bacterial culture initially and at every caries recall appt. to assess efficacy and patient cooperation	Chlorhexidine 0.12% (preferably CHX in water base rinse) 10 ml rinse for one minute daily for one week each month. Xylitol (6-10 grams/day) gum or candies. Two tabs of gum or two candies four times daily	1.1% NaF toothpaste twice daily instead of regular fluoride toothpaste. OTC 0.05% NaF rinse when mouth feels dry, after snacking, breakfast, and lunch. Initially, 1-3 app. NaF varnish; 1 app at 3 month recall.	Acid-neutralizing rinses as needed if mouth feels dry, after snacking, bedtime and after breakfast. Baking soda gum as needed	Required Apply calcium/ phosphate paste twice daily	As per ICDAS sealant protocol (TABLE 2)

* Patients with one (or more) cavitated lesion(s) are high-risk patients. ** Patients with one (or more) cavitated lesion(s) and severe hyposalivation are extreme-risk patients. *** All restorative work to be done with the minimally invasive philosophy in mind. Existing smooth surface lesions that do not penetrate the DEJ and are not cavitated should be treated chemically, not surgically. For extreme-risk patients, use holding care with glass ionomer materials until caries progression is controlled. Patients with appliances (RPDs, prosthodontics) require excellent oral hygiene together with intensive fluoride therapy e.g., high fluoride toothpaste and fluoride varnish every three months. Where indicated, antibacterial therapy to be done in conjunction with restorative work. ### For all risk levels: Patients must maintain good oral hygiene and a diet low in frequency of fermentable carbohydrates. **** Xylitol is not good for pets (especially dogs).

Figure 3. Caries Management by Risk Assessment Clinical Guidelines[24]

1.5.2 Low-Risk Patients

Low-risk patients have been protected and will probably still be protected from dental caries by a combination of multiple protective factors. Nevertheless, if any alterations in the oral environment happens, the individual will be prone to the development of dental caries.[24] These patients had minor dental caries experience, fillings, or extractions.[18] Individuals who had a history of caries resulting in restorations and loss of teeth can be low-risk patients by successfully controlling their risk factors. Their protocol should be preserving the balance of protective factors they already possess. They should be informed that the balance they have could be altered in the future and if the patient changes their protective factors, a caries risk assessment should be done at the periodic oral exam.[24] According to the ADA's guidelines, radiographic examinations is less frequent in low-risk patients and it is recommended to have a bitewing radiograph every 24 to 36 months.[93]

1.5.3 Moderate-Risk Patients

It is difficult to identify moderate-risk patients in comparison to low and high-risk patients. They do not have dental caries or risk factors that would classify them as high-risk patients, but they have more risk factors than low-risk patients and high possibility to move to high-risk. Risk factor interventions and professional supervision are more recommended in this risk category. Preventive measures such as fluoride application are recommended to help stop the progression of the disease.[24] Sealants could be used as a preventive aid as well in this risk category.[94] According to the ADA, depending on the risk factors that are shown and the dentist's clinical judgment, radiographic examinations are more frequent than in low-risk patients, with bitewing radiographs approximately every 18 to 24 months.[93]

1.5.4 High-Risk Patients

In this category, patients suffer from current dental caries, and they are most commonly dictated by cavitated lesions and that is a strong indicator that the disease will produce more cavities. unless remineralization is initiated.[18] Patients with high-risk factors and without cavitated lesions could be classified as high-risk. Their treatment must eradicate or reduce the opportunity of developing new or recurrent caries.[24] Prevention and intervention measures should be used for patients in this category such as bacterial testing, antimicrobial treatments, fluoridated toothpaste, fluoride varnish, and xylitol gum.[17, 95, 96] According to the ADA, the frequency of radiographic examinations and periodic oral evaluations increases in this category and it is recommended to take bitewing radiographs every 6 to 12 months.[93]

1.5.5 Extreme-Risk Patients

Extreme-risk patients are defined as high-risk patients who suffer from severe hyposalivation that need special attention. They must be managed and seen more frequently than high-risk patients and require buffering rinses to replace buffering functions of normal saliva and calcium and phosphate pastes for remineralization.[24]

1.6 Purpose of the study

The purpose of this study was to investigate the knowledge, attitudes and practice behaviors of the caries risk assessment and management protocol, CAMBRA, among dentists who currently practice in Saudi Arabia. The intent was to identify knowledge gaps and attitudinal barriers to the use of CAMBRA among dentists in Saudi Arabia and to determine if key demographical variables such as age, place of employment, nationality, and gender were determinants of knowledge and attitudes. Findings from this study could potentially inform targeted educational initiatives.

1.7 Specific aims and hypotheses

The study was guided by the following aims:

Specific Aim 1: To describe the knowledge, attitudes and practice behaviors of the caries management by risk assessment (CAMBRA) protocol of dentists in Saudi Arabia.

Specific Aim 2: To examine the association between gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned, and years of experience in clinical dentistry with knowledge scores of CAMBRA of dentists in Saudi Arabia.

Null Hypothesis 2: There are no significant associations between the knowledge scores of CAMBRA of dentists in Saudi Arabia and gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry.

Alternate Hypothesis 2: There are significant associations between the knowledge scores of the CAMBRA of Dentists in Saudi Arabia and gender, age, nationality, place of employment,

level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry.

Specific Aim 3: To examine the association between gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry with attitudinal scores towards CAMBRA of dentists in Saudi Arabia

Null Hypothesis 3: There are no significant associations between the attitudinal scores of dentists in Saudi Arabia towards the CAMBRA system and gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry.

Alternate Hypothesis 3: There are significant associations between the attitudinal scores of dentists in Saudi Arabia towards the CAMBRA system and gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry.

Specific Aim 4: To examine the association between gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry with the CAMBRA practice behaviors scores of Dentists in Saudi Arabia.

Null Hypothesis 4: There are no significant associations between the CAMBRA practice behaviors scores from dentists in Saudi Arabia and gender, age, nationality, place of

employment, level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry.

Alternate Hypothesis 4: There are significant associations between the CAMBRA practice behaviors scores from dentists in Saudi Arabia and gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned from and years of experience in clinical dentistry.

Chapter 2: Materials and Methods

2.1 Research Design

This investigation is a cross-sectional study that employed a survey to solicit responses from dentists in Saudi Arabia about their knowledge, attitudes and practice behaviors of caries management by risk assessment (CAMBRA).

2.2 Survey Development

An extensive search of the literature was performed to find instruments that had been used in studies about dentists' knowledge, attitudes and practice behaviors of caries risk assessment and management. Searches were conducted in Medline, PubMed and Proquest. The results of the literature searches rendered no instruments that had been published to measure dentists' knowledge, attitudes and practice behaviors of caries risk assessment and management. However, a 2013 study was found that measured knowledge, attitudes and practice behaviors of caries risk assessment and management among dental hygienists. In this study, the authors employed a questionnaire that measured knowledge, attitudes and practice behaviors of CAMBRA. The knowledge section included 10 true/false items, the attitudes section included 11, Agree/Disagree items and 8, practice behaviors items which employed a 4-point Likert-type scale (1=Never, 2=Sometimes, 3=Frequently and 4=Always items). [20] To determine the reliability and validity of the original instrument, the survey was administered to the dental hygiene faculty (n=8) at the University of the Pacific Arthur A. Dugoni School of Dentistry.

A decision was made to employ a modified version of the Dental Hygienists' Knowledge, Attitudes and Practice Behaviors Regarding Caries Risk Assessment and Management in order to make the instrument more appropriate for dentists. (Copy of the modified survey instrument is presented in Appendix D). First, permission was obtained from the authors to modify and use the survey for our study. Once the permission was obtained, three additional knowledge items were added to the survey testing CAMBRA skills. The additional knowledge-based items were patient cases that were published in an article authored by Jensen, et al.[24] These cases were developed by a group of dental professionals, among them JD Featherstone, who is internationally recognized for developing the CAMBRA. The cases were crafted as items that measure knowledge aspects of CAMBRA, specifically, the determination by a dentist of the caries risk level of the patient presented in the case, as, low, moderate or high and the management of the patient.

An initial section was added to the instrument to collect data on the professional characteristics and demographics of the dentist participants. Specifically, the items were added to collect information about the gender, age, nationality, place of employment, level of education, dental specialty, institution where they earned their dental degree, institution where they earned their advanced dental degree and years of experience. Furthermore, two attitudinal items were dropped from the original survey because these items did not apply to dentists. The final version of the modified instrument was titled KAPBCRA.

The responses from the specific KAPBCRA survey items were employed as follows to create knowledge, attitudes and practice behaviors variables. For Specific Aim 2, there were two dependent variables. One variable was total scores from the knowledge section of the KAPBCRA and the second was scores from the cases items (Skills). The total knowledge

variable was created from the sum of the correct answers from nine knowledge true or false items and three skills case-based items with four questions each. The maximum total skills score possible was 21 points. Total knowledge scores where transformed to percent correct from total number of items. A skills variable was calculated from the sum of the correct responses of the three case-based items. Each case-based item had four questions for a maximum total score of 12 points.

For Specific Aim 3, the dependent variable was a total score from the attitudes section of the KAPBCRA. There were nine attitudinal items and for each item that the respondents selected agree, from a scale that provided agree and disagree options, they received a point for each "agree" selected.

For Specific Aim 4 the dependent variable were outcomes from the practice behaviors section. A point was given for every item were respondents selected "Always" as a practice behavior from a scale that provided the following response options, always, frequently, sometimes and never.

The explanatory variables for this study were the following self-reported demographic variables, specifically, gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned, and years of experience in clinical dentistry. These variables were investigated to identify determinants of knowledge, skills, attitudes and practice behaviors of caries risk assessment and management.

The modified instrument KAPBCRA was pilot tested with residents from the Operative Dentistry Program at the College of Dental Medicine in Nova Southeastern University. From the pilot test administration an internal coefficient of reliability, Cronbach's alpha, was calculated overall and by domain, that is, knowledge, attitudes and practice behaviors.

Seventeen residents participated in the pilot test. The obtained Cronbach alpha was .450 for the knowledge items. Since the calculated Cronbach's alpha was below .7, a delete by item analysis was performed to omit, if needed, items that were dissonant.[97] Furthermore, feedback was requested from the pilot test participants about the instrument in general and the readability of the items. One item was changed to permit the participant to select multiple options. Furthermore, the thesis committee decided to keep the three case-based items published by Jensen, et al to assess skills.[24]

2.3 Sample – Participants and Eligibility

The sampling strategy that was employed in this study was a purposive snowball sampling method. Snowball sampling is defined as "yielding a study through referrals made among people who share or know of others who possess some characteristics that are of research interest".[98] The PI sent a survey invitation to known colleagues, specifically, dentists in Saudi Arabia who have an online account in several social media platforms, such as, WhatsApp, Instagram, and Facebook. In the invitation to participate in the study, participants were also asked to forward the invitation to their colleagues, specifically, to other dentists in Saudi Arabia.

2.4 Survey Administration

REDCap, a secure web application for the administration of online surveys was used to administer the survey to dentists in Saudi Arabia who agreed to participate in the study and hosted all the data collected from the survey responses. The online survey forms included an introduction explaining the purpose of the study, indicating that participation was voluntary, instructions for the completion of the survey and a statement indicating that all data collected for the study was confidential and was going to be securely stored. Also, the online

survey forms included the participant consent form that stated that by completing the survey the participant was consenting to participate in the study.

The survey administration window was 10 weeks from the day that this study received IRB approval. A ten-week administration window has been highlighted in studies by Dillman and Nulty as a period that is optimal for acquiring an adequate survey response rate.[99, 100] As recommended by both authors, survey reminder notices were sent on the third and seventh weeks of the survey administration window. After sending the second reminder notice, by the end of that week the amount of participants plateaued, so the data collection period was stopped. A total of 130 individuals responded to the survey. REDCap allows a data set to be downloaded in Excel format that can be exported for statistical analysis.

2.5 Statistical Analysis

Preliminary and Descriptive Analysis

A missing data analysis was employed to determine the extent to which data was missing and to determine if the data was missing completely at random (MCAR). The missing data analysis identifies patterns/reasons for missing data and analyzes distribution of missing data. The missing data analysis revealed no skipped patterns. A listwise deletion method was employed in the analysis of the data as the best strategy for obtaining the least biased estimates.[101]

Considering REDCap survey construction logic, there were a total of 70 items. That included the item logic employed by REDCap for constructing items where the respondent could select all that applied. Of the 70 items, the knowledge, skills, attitudinal and practice behaviors employed a continuous scale. For these items, measures of central tendency and dispersion were reported. Scores were rounded-off to the nearest whole number. The

remaining items, mainly the demographical variables, employed categorical scales. For the nominal items, descriptive statistics were reported in the form of frequencies and percentages by item. (Presented in Appendix A)

The distribution of scores for each continuous variable (total knowledge, skills, attitudes and practice behavior) were examined to determine the binary or dichotomous scale that was going to be employed in the binary logistic regression analysis. In many instances in the literature when the distributions of scores approximate normality, the median is used as a point of reference to construct categories. [102] To check for normality, the mean, median, mode and skewness of each distribution was calculated. After checking for normality, the continuous variables were dichotomized using the median as a reference score. The higher performing category for all the continuous variables in this study included the median scores and all the scores above the median. The second category included all the scores below the median. Since the median was included in the upper category, the distribution of scores were not equal halves of the distribution.[103] (Presented in table 11 in Appendix A)

The analysis of the distribution of scores revealed that for both variables (Total knowledge and skills) the distribution of scores was normal. The mean, median and mode for total knowledge was approximately 63, hence, the median score was employed to dichotomized the scale.[102] The resulting scale for percent correct total knowledge split the distribution of scores into high and low categories as follows: 62 and below was the low category and 63 and above was the high category. The mean, median and mode for the skills scores was 6, therefore, the resulting dichotomized scale was designated as 5 and below, and (6 and above). (Presented in table 11, 12 in Appendix A)

Likewise, the distribution of the attitudinal and the practice behaviors scores were analyzed to determine if the distributions met the properties of a normal distribution. The frequency distribution of the attitudinal scores showed similar scores for the mean, median and mode. However, the skeweness was -1.16; therefore, there were more individuals scoring at and above the median. A skeweness value of 2 above and below are acceptable values for a normal distribution.[104] The median for the attitude scores was 6. The attitudinal scores were dichotomized into two categories; 5 and below, and 6 and above. (Presented in table 11, 12 in Appendix A)

The distribution of practice behaviors scores approximated a normal distribution, that is, the mean, median and mode were of equal values. The median score was 3 and scores were dichotomized and the resulting scales were (2 and below), and (3 and above). (Presented in table 11, 12 in Appendix A)

Inferential Statistics

A bivariate analysis was employed to determine the magnitude and the significance of the unadjusted associations between the dependent(s) and each independent variable, followed by a binomial logistic regression analysis. A multivariable logistic regression analysis was employed to predict, from the explanatory variables, the dependent variables. The explanatory variables for this study were the following self-reported demographic variables, gender, age, nationality, place of employment, level of education, dental specialty, institution where dental degree was earned, and years of experience in clinical dentistry. The initial models included all the explanatory variables, specifically, the demographical and the control variables.

The stepwise regression analysis employed in this study was a modification of the backward selection technique. All candidate variables, that is the control/confounding and the demographic variables were added to the model based on the findings from the literature reviewed in this study.[20, 105, 106] For instance, there is evidence to support that attitudes and practice behaviors mediate knowledge; hence, attitudes and practice behavior were included as control variables in the models predicting total knowledge and skills.[107] For the model predicting attitude, skills and practice behaviors were used as control variables and for the model predicting practice behaviors, skills and attitudes were the control variables. Nonsignificant variables were removed from the model starting with the variable with the highest p value. The cutoff probability for removing variables was a p value of .05 or greater.

Chapter 3: Results

In total, 130 individuals responded to the survey. However, four participants were omitted from the analysis because they selected "other" as nationality and this was not an adequate sample size to use nationality as an explanatory variable. Furthermore, individual items were dropped if there was a missing item response in each of the variables knowledge, attitudes and practice behavior (Listwise) to capture data from individuals who provided partial responses to the survey items. Listwise deletion (complete-case analysis) removes a case for analysis when the case has a missing value in a specific variable. Listwise deletion is recommended when the missing data meets the MCAR assumption.[101]

3.1 Descriptive Statistics

Following are highlights from the descriptive statistics analysis (Presented in tables 2-6 in Appendix A). The majority of the dentists were male (n=72, 56.3%). Most of the participants selected an age range between 25 to 34 years old (n=121, 94.5%), the remaining selected ages older than 34 years old.

Approximately (n=87, 68%) of the dentists reported that they worked in a governmental hospital or clinic. In regards to level of education, (n=88, 68.8%) of dentists stated their highest level of education was a dental degree while (n=40, 31.3%) of dentists stated their highest level of education was a postgraduate degree in dentistry. Most of the dentists (n=78, 60.9%) had less than five years of experience and the remaining had more than five years. The majority of the dentists reported (n=73, 71.6%) that they were using CAMBRA.

The majority of the respondents, 71.6% (n=73) reported using CAMBRA. Participants were asked to select the reasons for not using CAMBRA and were given the opportunity to select more than one answer. Most respondents 72.9% (n=5) reported lack of time as the main reason,

followed by uncooperative patients (n=36, 54.5%), lack of material (n=35, 52.2%), work place regulations (n=33, 51.6%), and lack of knowledge (n=20, 30.3%).

Participants were asked to select where they first acquired information about CAMBRA and to select all the options that applied. The majority of participants stated that they first acquired information about CAMBRA in a dental school (n=84, 82.4%), followed by continuing education classes (n=7, 6.9%), scientific articles (n=5, 4.9%), professional meetings and conferences (n=4, 3.9%), books (n=1, 1%) and internet (n=1, 1%). Furthermore, participants were asked to select where they continued to acquire information about CAMBRA and to select all the options that applied. Respondents indicated that they continued to get information related to CAMBRA from, scientific articles (n=69, 79.3%), followed by the internet (n=67, 76.1%), dental school (n=63, 70%), continuing education classes (n=42, 51.2%), professional meetings and conferences (n=37, 44.6%) and books (n=34, 42%).

Approximately 53% (n=51) of the respondents indicated that in the last five years they participated in 1-4 hours of continuing education on caries risk assessment. 1 to 4 hours was the smallest period of continuing education presented on the survey whereas 11.1% answered that they received 9 or more hours of continuing education in the topic, which was the highest range of continuing education hours on the survey.

Participants were asked which of the following methods do you use to assess caries and they were given the chance to pick more than one choice. The majority of the respondents (n=121, 98.3%) selected radiographs and visual inspection followed by a blunt instrument (n=95, 81.3%). Approximately 39% (n=44) of the respondents indicated that they used a sharp explorer to assess caries.

To assess attitudes about caries risk assessment, the participants were asked to select their

level of agreement with nine caries risk assessment statements about the importance or relevance of caries risk assessment in dental practice. For example, the participants were asked to select their level of agreement with the following statement: "Performing caries risk assessment is an integral part of dental practice". Approximately 96% (n=113) of the respondents agreed with this statement. The mean attitudinal score was 6.5. (Presented in table 13 in Appendix A)

A true and false item format was employed to measure caries risk assessment and management knowledge. Nine items measured knowledge about carious lesions, caries pathology and potential risk for individuals who have caries. Correct responses ranged from 64% to 100%. Specifically, all respondents answered correctly that dental caries is a multifactorial disease while the option false was selected for the following statement "White spot lesions are considered carious lesions" making this the highest incorrect statement. (Presented in table 7 in Appendix A)

Three cases were employed to measure knowledge about the application of CAMBRA. Each case consisted of a scenario with four multiple choice questions. The cases were designed to represent each from a low to a high caries risk patient. The first item asked the participant to identify the patient risk level. Most respondents selected correctly the risk level for the low risk patient; however, for the moderate and high risk patient scenarios over 50% of the respondents selected the wrong answer. Specifically, 64% (n=81) of the respondents selected the wrong response for the identification of a moderate risk patient and 53% (n=67) selected the wrong answer for the high risk level patient. The item that asked about the time for a recall appointment for a patient with a high risk, the majority (n=110, 86%) of the respondents selected the wrong answers (Every 3 months, 5 to 6 months, 7 to 12 months). Approximately 47% (n=60) of the respondents selected the wrong answer (No) when asked about providing another caries risk

assessment during a recall appointment for a low caries risk patient. (Presented in table 8-10 in Appendix A)

A 4-point Likert-type scale (1=Never, 2=Sometimes, 3=Frequently and 4=Always) was used to select how often caries management recommendations were used for patients with moderate or high risk levels. Approximately, 68% of the participants selected Always for "Fluoridated over the counter toothpaste" and "Individualized oral hygiene instructions", 4% selected Always for "Calcium phosphate products". (Presented in table 14 in Appendix A)

3.2 Bivariate Analysis

Bivariate analysis examined crude associations between the dependent variable, knowledge (total knowledge and skills scores), attitude, practice behaviors and the demographic variables. Notably, except for the association between knowledge and specialty, the associations between the demographical variables with knowledge, specifically, total scores and skills scores were not statistically significant. The association between knowledge and specialty was significant (OR= 2.55, CI 95%, 1.15. 5.66). Specifically, participants with a dental degree were 2.5 times more likely to obtain higher knowledge scores than dentists with a postgraduate degree. (Presented in table 15,16 in Appendix B). A significant association was found between attitudes scores and gender. Specifically, males were found to be 2.3 times (95% CI, 1.09, 4.83) more likely to obtain higher attitudinal scores. (Presented in table 17 in Appendix B)

Dichotomized outcomes, below and above the median, on the practice behaviors items were significantly associated to gender, level of education and specialty. Specifically, males were less likely than females to obtain high practice behaviors scores (OR 0.33, 95% CI, 0.16, 0.71), participants with a dental degree were more likely to score higher than dentists with a post graduate degree (OR 3.00, 95% CI, 1.36, 6.60), and general dentists were more likely to score

higher than dentists with a specialty (OR 3.11, 95% CI, 1.49, 6.49). (Presented in table 18 in Appendix B)

Before proceeding with the multivariable logistic regression, the results of the bivariate analysis of the demographical variables were examined to determine problems with multicollinearity. Multicollinearity is a case of multiple regression in which the predictor variables are themselves highly correlated. [108] If there is no linear relationship between the predictors, they are said to be orthogonal. Significant associations were found between level of education and specialty, level of education and years of experience. The highest level of association was between level of education and specialty resulting in a correlation of .7 ($p<.000$). A decision was made to omit from the model level of education and retain specialty.

Furthermore, in the logistic regression models age and nationality were excluded as explanatory variables because they were asked to report one category, therefore, there was no variability across categories. Specifically, the demographical profile of the respondents rendered age and nationality as unusable variables in this study since only four respondents selected "other" for nationality and approximately 95% selected the age range of 25 to 34.

3.3. Multivariable Logistic Regression

Multivariable logistic regression was used was used to examine the demographical variable determinants of CAMBRA total knowledge and skills scores, attitudinal scores on caries risk assessment and management and CAMBRA related practice behaviors (Presented in table 17-24 in Appendix C) by computing adjusted odds ratios (AOR).[109] The initial models included all the explanatory variables, specifically, the demographical and the control variables. All candidate variables, that is the control and the demographic variables, were added to the model based on the findings from the literature reviewed in this study. Model

building then proceeded with stepwise deletion of non-significant variables, resulting in the most parsimonious and explanatory model following method of Hosmer and Lemeshow.[110] Following are the multivariable logistic regression analysis by aim.

3.3.1 Specific Aim 2

Specific aim 2 examined the association between gender, workplace, dental specialty and years of experience in clinical dentistry with knowledge scores of CAMBRA of dentists in Saudi Arabia. Dichotomized scores on practice behaviors and attitudes were used as control variables. Separate models were built for total knowledge scores and skills scores.

To examine the demographical determinants of total knowledge outcomes, attitudes, practice behaviors, gender, workplace, specialty, and years of experience went into the initial model. In the initial model, workplace was a significant determinant of total knowledge scores. From the stepwise elimination of variables that were not significant determinants of total knowledge outcomes, the final model revealed two significant predictors of total knowledge, specifically, workplace and specialty. The models are presented in tables 19-21 in Appendix C. According to the final model, dentists who worked in a governmental hospital or clinic were 2.46 times more likely to obtain higher total knowledge scores (AOR = 2.46, 95% CI, 1.07, 5.62) than dentists who work in other sectors, for example, private clinics, universities or unemployed. General dentists were 2.3 times more likely to obtain higher total knowledge scores (AOR = 2.30, 95% CI, 1.03, 5.14) than specialists.

To examine the demographical determinants of skills outcomes, attitudes, practice behaviors, gender, workplace, specialty, and years of experience went into the initial model. Results of the logistic regression revealed that none of the explanatory variable were significant predictors of skill.

3.3.2 Specific Aim 3

Specific aim 3 examined the association between gender, workplace, dental specialty and years of experience in clinical dentistry with attitudinal scores towards CAMBRA from dentists in Saudi Arabia. This model used skills and practice behaviors as control variables. The resulting model did not point to any of the demographical variables as significant determinants of attitude. Whereas there were no significant demographical determinants, the model indicated that dentists who scored lower in practice behaviors were less likely to score high on attitudes scores (AOR = 0.30, 95% CI, 0.11, 0.79). (Presented in table 22 in Appendix C)

3.3.3 Specific Aim 4

Specific aim 4 examined the association between gender, workplace, dental specialty and years of experience in clinical dentistry with the CAMBRA practice behaviors scores of dentists in Saudi Arabia. This model used skills and attitudes as control variables. The final model revealed gender and specialty as significant predictors of practice behaviors, males were less likely than females to obtain high practice behavior scores (AOR = 0.36, 95% CI, 0.15, 0.88) and general dentists were three times more likely to score higher than dentists with a specialty (AOR = 3.14, 95% CI, 1.35, 7.28). Dentists who score low in attitudinal scores were less likely to score high on practice behaviors (AOR = 0.29, 95% 0.11, 0.76) (Presented in table 23, 24 in Appendix C)

While there were a number of explanatory variables that were not significant determinants of either knowledge, attitudes and practice behaviors, it is important to highlight that some of these variables did present large effect sizes, for example, in the final multivariate regression model for practice behaviors, the AOR for skills was 2.43 with a p value of .05. Likewise, in the bivariate analysis we found instances where the associations between the variables were

not significant, however, the OR were sizeable, for example, the OR for the association between attitude and workplace was 1.70 with a p value of 0.18 and attitude with years of experience was 0.54 with a p value of 0.11. One could consider that a larger sample size, potentially, could result in significant relationships between these variables.

Chapter 4: Discussion

To our knowledge, our study is among the first to examine the demographical determinants of knowledge, attitudes and practice behaviors of caries management by risk assessment (CAMBRA) among dentists in Saudi Arabia, although, previous studies have examined the determinants of knowledge, attitudes , and practice behaviors about caries risk assessment and minimally invasive dentistry in general in other countries for example, France, and India.[22, 105, 106, 111]

The study sought to find demographical determinants of caries risk assessment and management knowledge, skills, attitudes and practice behaviors of dentists in Saudi Arabia. We hypothesized that the measured demographic characteristics were significantly associated with Saudi dentist's knowledge, skills, attitudes and practice behaviors of caries risk assessment and management. Study showed results that workplace and specialty were significant determinants of knowledge but neither gender nor years of experience were significantly associated with total knowledge about CAMBRA. Gender and years of experience have been noted in other studies as variables that do not significantly associate with the knowledge, attitude and skills of dental practitioners. For example in a study about knowledge, attitude and skills of dental practitioners in Puducherry, India, gender and years of experience were noted as non-significant determinants of knowledge, attitude and skills of dental practitioners.[106] In spite of these findings, we pursued this study because there are no studies that have examined demographical variables such as gender and years of experience as potential determinants of CAMBRA knowledge in Saudi Arabia.

The distribution of CAMBRA total knowledge scores in our study resulted in approximately 47% of the respondents scoring in the higher performing category for total

knowledge, that is, scores at 63 or above. Nonetheless, in the Francisco et al study 77% of the participants, dental hygienists, obtained high CAMBRA knowledge scores, specifically, they answered correctly 8 out of 9 items in the knowledge section of the survey. Whereas this seems to point to a better performance for the dental hygienists in the knowledge section of the survey, our survey included three more items that were case-based skills, therefore, one cannot make a claim about the dental hygienists outscoring the participants from our study. However, a comparison of the amount of correct responses by item between the dental hygienists and the participants in our study revealed identical results in specific knowledge items such as "dental caries is a multifactorial disease" where 98% of the respondents from both groups answered correctly. Another item where both groups obtained high scores, close to 100% correct, was the item stating that "decreased saliva flow increases risk for dental caries disease". The dental hygienists outscored the participants in our study in the following true and false statement: "dental caries is a transmissible disease"; the percentage of correct responses were 86% and 72.7% respectively. Conversely, the participants in our study outscored them in the following true and false statement: "white spot lesions are considered carious lesions"; the percentage of correct responses 62.5% and 42%.

In regards to the examination of demographical determinants of skills scores, in this study no significant associations were found between the demographical variables and the skills outcomes. However, there are several noteworthy findings, specifically, the majority of the participants did not identify correctly the caries risk of the moderate and high risk cases presented in the skills section of the survey, that is, 64.2% (n=81) and 53.2% (n=67) respectively and approximately 39% (n=44) of the respondents indicated that they used a sharp explorer to diagnosing and assessing caries.

Hence, this points to the need for more education about assessing and evaluating the caries risk of patients among the participants of this study. This finding is in accordance with the Domejean et al. study, [105] where the authors are recommending "to equip future dentists with the competencies required to undertake caries risk assessment".

Young et al. highlighted the challenges of current caries risk assessment classifications. [112] The authors claimed that "Many CRA tools have been published for clinical use including the American Dental Association (ADA) CRA forms, the caries management by risk assessment (CAMBRA*), the American Academy of Pediatric Dentistry (AAPD) CRA tool (CAT) and a computerized program called the Cariogram. However, the evidence for the validity for most of these existing systems is limited. The CRA process is often not standardized for the clinics. Several studies confirmed that in the absence of specific instructions and calibration, different clinicians will assign different and thus incorrect risk levels when using the same CRA form on the same patient."[112] This concern is raised by the findings from our study because the majority of the participants did not correctly identify the caries risk of the moderate and high-risk cases presented in the skills section of the survey. Potentially, the wrong responses from the participants could point to problems with the taxonomy employed in CAMBRA and/or the need for standardization and calibration activities that could lead to a higher consensus among dentists when assigning patient caries risks levels.

With regards, to the anticipated associations between the demographical variables and attitudinal scores, the results from this study revealed no significant associations between the demographic characteristics and attitude towards CAMBRA. Further analysis of the attitudinal scores revealed that practice behaviors scores were found to be a significant determinant of attitudinal scores. Specifically, individuals who scored low in practice

behaviors were more likely to score low in attitudinal scores (AOR= 0.30 CI 95%, 0.11, 0.79) which is to be expected.

Results from the practice behavior multivariable logistic regression analysis showed that male dentists were less likely than females to obtain high practice behaviors scores. In other words, males were less likely to select always as an option for the measured practice behaviors (AOR= 0.37, CI 95% 0.15, 0.88) (Presented in table 24 in Appendix C) These outcomes concur with the findings from a national survey of French dentists about their knowledge, opinions and practices in the assessment of caries risk. Practice behaviors were associated with gender (male) (OR= 0.67, CI 95%, 0.48, 0.95).[105]

Moreover, similar to the findings from our study, outcomes from this national survey revealed that lack of time was the main reason for not undertaking caries risk assessment, that is, 67.2% (n=137) .[105] In our study 73% (n=51) of the respondents indicated that time was a barrier for the utilization of CAMBRA. Likewise, in both studies, about a third of the participants indicated not using a caries risk assessment method.[105] Conversely, in the dental hygienists study by Francisco et al,[20] the findings revealed that a larger than anticipated number of respondents, 71%, felt that they had time to assess caries risk during regular appointments. The authors of this study claimed that this was an unanticipated finding considering that in the literature most studies highlight lack of time[105] as the main barrier for not using evidence-based decision-making as the basis for dental treatment approaches. In our study, approximately 73% of the respondents indicated that time was the most cited barrier for using CAMBRA, therefore, our findings are in agreement with the literature that identifies time as a barrier for the use of caries risk assessment and management protocols.

Approximately, 72% of the participants in our study indicated that they were employing a caries risk assessment protocol in their practices. This outcome is consistent with the results from two studies; one from by Riley et al.[113] and the other by McBride et al. [104] where 69% and 83% of the dentists, respectively, performed caries risk assessment. Thus, the majority of dentists in these studies and our study claimed using a caries risk assessment protocol.

Our study examined the demographical determinants of knowledge, attitudes and practice behaviors about CAMBRA using a modified survey instrument. Although, none of the demographical determinants were significantly associated with knowledge or attitudes, the amount of participants scoring 63 and above on the knowledge section, the median and above, versus 62 and below was 46.6%. Hence, these results indicate that there is a need for targeted education for this population of Saudi Arabian dentists about CAMBRA and/or caries risk assessment and management.

Another point of importance illustrated by the findings from the present study, is that scores on the attitudinal items which measured dentists' attitudes about caries risk assessment and management and their level of confidence with these practices (Presented in table 13 in Appendix A), indicated that more than one third of the respondents scored on the attitudinal items 5 and below with a median score of 6, thus, this finding points to a segment of the participants that do not belief and/or do not have the expected professional attitude towards CAMBRA practices. Furthermore, 37% of the respondents indicated that they were not comfortable performing caries assessment on patients in their dental practice. These findings are important because there is an abundance of literature and studies that earmarked attitudes as a variable that mediates transfer of knowledge into practice, hence, it is important for educational institutions to consider theories about behavior change when designing

educational programs that ultimately aim at changing professional practice behaviors.[114] For example, among one of the most recognized theories in the health care industry about behavior change is the Theory of Planned Behavior by Ajzen, I. (1991).[107] The Theory of Planned Behavior suggests that behavior is dependent on one's intention to perform a behavior and that an individual's attitude is one among several variables that are determinants of intention.[107]

In regards to the CAMBRA and/or caries risk assessment and management, the results from this study point to a significant relationship between outcomes on the practice behaviors and gender; and practice behaviors and specialty. The final multivariable logistic regression model points to a less than always use of practice behaviors among men and specialists that are typically used for the treatment of individuals whose caries risk levels are either moderate or high (Presented in table 24 in Appendix C).

In conclusion, based on the results of this study, there is a need for the development of caries risk assessment and management professional development and, standardization and calibration sessions about caries risk assessment and management. Our findings suggest that the need for further caries risk assessment management training need is higher among specialists than general dentists. Also, the findings from our study revealed that among male dentists there is a need for content training but also educational interventions that aim at addressing barriers for the implementation of caries risk assessment and management in practice, such as time. [115] Our conclusions are consistent with those in the study about knowledge, attitudes and practice behaviors of dental hygienists by Francisco et al, after which the survey instrument used in our study was modeled. In their conclusion, the authors stated that there "is a need to improve practicing dental hygienists' knowledge and

involvement in the active management of caries. Focused training in the use of established CRA/management tools should be designed to improve their knowledge and enhance practice behaviors.".[20] This statement is noteworthy because we used in our investigation an adaptation of the survey employed in the previously mentioned study; thus, one can affirm that there is consensus between the findings from both studies.

4.1. Limitations

Among the limitations of this study is the lack of participants above 25-34 years old, that is, from 130 respondents, 121 chose the age category of 25-34 years old. One could consider that because the survey was administered through social media younger dentists would respond since they are more likely to be social media users than dentists whose age is above 34 years old. Also, the vast of majority of the respondents were of Saudi nationality; therefore, the age and nationality variables were omitted from the regression models because the sample size would violate parametric analysis assumptions.[109] Furthermore, the item that asked participants to enter the institution where they earned their dental degree was completed by 119 participants. From the 119 responses, 80 respondents indicated their degree was from King Abdulaziz University, the remaining 15 respondents reported various universities and 27 participants did not provide a response to this item. A decision was made to drop this item from the models because this item had the largest amount of missing data on the survey. The preponderance of respondents were from King Abdulaziz University (KAU); it is important to highlight that the PI of this study is a graduate and a faculty member from KAU and his professional social media contacts were initially approached to participate in the study, therefore, the high participation from KAU dentists was expected.

Other limitations include the cross-sectional nature of the present study that precludes statements of causation or temporality.[116] Also, our study used self-reported data that may be

subject to differential recall and other biases.[116]

4.2 Recommendation

Since most of the respondents indicated that they obtained their bachelor of dental science degrees from local government sponsored universities and government hospitals, it is recommended that universities evaluate their dental and assess the extent of the content included in their programs about caries risk assessment and management. Furthermore, government hospitals should continuously evaluate their dentists' knowledge of caries risk assessment and management and provide them a robust professional development program to prepare them to better address the caries risk prevalence in Saudi Arabia which is between 66% and 75% depending on the regions.[5-8]

Chapter 5: Conclusion

Within the limitations of this study, the present study investigated determinants of CAMBRA knowledge, attitudes and practice behaviors among Saudi Arabian dentists. According to the results of this study, workplace and specialty were significant determinants of CAMBRA knowledge and the studied demographical variables were not significant determinants of CAMBRA attitudes. Moreover, CAMBRA total knowledge and skills scores revealed that less than half of the participants scored above the median; therefore, within the limitations of this study, this is potential evidence indicating that there is a need for more educational training in this area for the participants.

With regards to CAMBRA and/or caries risk assessment and management practices, gender and specialty were significantly associated with practice behaviors. Males were less likely than female to select "Always" among the practices listed on the survey. Additionally, general dentists 3 times more likely than specialist to select "always" among the practices listed on the survey.

In regards to specialty, time after time we found general dentists out performing specialists. These groups, even though they were conferred a degree in dental sciences need continuing education in CAMBRA or they may see it not relevant to their scope of practice. There is a need to further and continuously assess the academic needs of specialists in the caries risk assessment area and to develop and deploy targeted educational interventions. Universities could provide continuing education targeting the knowledge gaps of specialists while securing content about caries risk assessment and management in the dental degree programs.

In conclusion, the outcomes from this study point to a need for educational interventions for Saudi Arabian dentists aimed at improving knowledge about CAMBRA and to influence their practice behaviors.

Appendix A

Table 2. Descriptive Statistics for Demographic Data

Variables		Count	Percentage %
Gender	Male	72	56.3%
	Female	56	43.8%
Age	25 to 34	121	94.5%
	Above 34	7	5.5%
Workplace	Government	87	68.0%
	Other	41	32.0%
Level of Education	Undergraduate	88	68.8%
	Postgraduate	40	31.3%
Specialty	General Dentist	73	57.0%
	Specialist	55	43.0%
Years of Experience	Less than 5 years	78	60.9%
	5 and above	50	39.1%
Where did first find information	Internet	1	1.0%
	Scholarly Sources	101	99.0%
Frequency of use of CAMBRA	Use	73	71.6%
	Not Use	29	28.4%

Table 3. Descriptive Statistics for First Time Getting Information Related to CAMBRA

Variables	Count	Percentage %
Internet	1	1%
Scientific Articles	5	4.9%
Dental School	84	82.4%
Books	1	1%
Professional meetings and conferences	4	3.9%
Continuing education classes	7	6.9%

Appendix A

Table 4. Descriptive Statistics for Continuing to Get Information Related to CAMBRA

Variables		Count	Percentage %
Internet	Use	67	76.1%
	Don't use	21	23.9%
Scientific Articles	Use	69	79.3%
	Don't use	18	20.7%
Dental School	Use	63	70.0%
	Don't use	27	30.0%
Books	Use	34	42.0%
	Don't use	47	58.0%
Professional meetings and conferences	Use	37	44.6%
	Don't use	46	55.4%
Continuing education classes	Use	42	51.2%
	Don't use	40	48.8%

Table 5. Descriptive Statistics for Reasons Not Using CAMBRA

Variables		Count	Percentage %
Lack of time	Yes	51	72.9%
	No	19	27.1%
Lack of material	Yes	35	52.2%
	No	32	47.8%
Uncooperative patients	Yes	36	54.5%
	No	30	45.5%
Lack of knowledge	Yes	20	30.3%
	No	46	69.7%
Work place regulations	Yes	33	51.6%
	No	31	48.4%

Appendix A

Table 6. Descriptive Statistics for Caries Detection Methods

Variables		Count	Percentage %
Radiographs	Use	124	98.4%
	Don't use	2	1.6%
Transilliumination	Use	38	35.8%
	Don't use	68	64.2%
Blunt Instrument	Use	95	81.9%
	Don't use	21	18.1%
Visual Inspection	Use	121	98.4%
	Don't use	2	1.6%
Detector Dyes			
	Use	25	23.8%
	Don't use	80	76.2%
Saliva Test (Bacterial Assay)	Use	25	24.0%
	Don't use	79	76.0%
Sharp Explorer	Use	44	38.9%
	Don't use	69	61.1%

Appendix A

Table 7. Descriptive Statistics for Knowledge Data

Variables		Count	Percentage %
"White spot lesions are considered carious lesions."	True	80	62.5%
	False	48	37.5%
"Dental caries is a transmissible disease."	True	93	72.7%
	False	35	27.3%
"Dental caries is a multifactorial disease."	True	128	100.0%
	False	0	0.0%
"An individual with a history of carious lesions within the past three (3) years is at high risk for future dental caries activity."	True	105	82.7%
	False	22	17.3%
"Low socioeconomic status does not increase an individual's risk for dental caries disease."	True	29	23.0%
	False	97	77.0%
“Decreased saliva flow increases risk for dental caries disease.”	True	127	100.0%
	False	0	0.0%
"There is no evidence to support the twice a year or more application of fluoride varnish to reduce risk of carious lesions in adults of high caries risk."	True	29	22.8%
	False	98	77.2%
"Patients at moderate or high risk of dental caries need to be counseled about the role of sugary and starchy foods in increasing caries risk."	True	120	94.5%
	False	7	5.5%
"Chlorhexidine is known to kill all caries pathogenic organisms."	True	34	26.8%
	False	93	73.2%

Appendix A

Table 8. Descriptive Statistics for Case #2 (Low Risk)

Variables		Count	Percentage %
What is the caries risk of this patient?	Low	120	95.2%
	Moderate	4	3.2%
	High	2	1.6%
When would you give the patient a recall appointment?	7 to 12 months	100	78.7%
	5 to 6 months	23	18.1%
	every 4 months	1	0.8%
	every 3 months	3	2.4%
When you recall the patient would you provide another caries risk assessment?	Yes	67	52.8%
	No	60	47.2%
How frequently would you take radiographs for this patient?	Bitewings every 25 to 36 months	43	34.1%
	Bitewings every 19 to 24 months	36	28.6%
	Bitewings every 7 to 18 months	38	30.2%
	Bitewings every 6 months	9	7.1%

Table 9. Descriptive Statistics for Case #3 (Moderate Risk)

Variables		Count	Percentage %
What is the caries risk of this patient?	Low	8	6.3%
	Moderate	45	35.7%
	High	73	57.9%
When would you give the patient a recall appointment?	7 to 12 months	11	8.7%
	5 to 6 months	48	38.1%
	every 4 months	18	14.3%
	every 3 months	49	38.9%
When you recall the patient would you provide another caries risk assessment?	Yes	112	89.6%
	No	13	10.4%
How frequently would you take radiographs for this patient?	Bitewings every 25 to 36 months	7	5.5%
	Bitewings every 19 to 24 months	16	12.6%
	Bitewings every 7 to 18 months	44	34.6%
	Bitewings every 6 months	60	47.2%

Appendix A

Table 10. Descriptive Statistics for Case #1 (High Risk)

Variables		Count	Percentage %
What is the caries risk of this patient?	Low	16	12.7%
	Moderate	51	40.5%
	High	59	46.8%
When would you give the patient a recall appointment?	7 to 12 months	11	8.7%
	5 to 6 months	48	37.8%
	every 4 months	17	13.4%
	every 3 months	51	40.2%
When you recall the patient would you provide another caries risk assessment?	Yes	111	87.4%
	No	16	12.6%
How frequently would you take radiographs for this patient?	Bitewings every 25 to 36 months	4	3.1%
	Bitewings every 19 to 24 months	18	14.2%
	Bitewings every 7 to 18 months	41	32.3%
	Bitewings every 6 months	64	50.4%

Appendix A

Table 11. Median, Mean, and Mode for Variables

Variables	Median	Mean	Mode
Knowledge	61.9	63.38	62
Skills	6	6.2	6
Attitudes	6.5	6.18	7
Practice Behaviors	3	2.73	3

Table 12. Dichotomized Scores for Variables

Variables	Median	Count	Percentage
Knowledge	62% and below	63	53.4%
	63% and above	55	46.6%
Skills	5 and below	39	31%
	6 and above	79	69%
Attitudes	5 and below	44	37.3%
	6 and above	74	62.7%
Practice Behaviors	2 and below	56	44.4%
	3 and above	70	55.6%

Appendix A

Table 13. Descriptive Statistics for Attitude Data

Variables		Count	Percentage %
Performing caries risk assessment is an integral part of dental practice	Agree	119	94.4%
	Disagree	7	5.6%
Untreated dental caries disease can lead to life-threatening health complications	Agree	98	77.8%
	Disagree	28	22.2%
Caries management mainly includes providing dental restorations	Agree	38	30.4%
	Disagree	87	69.6%
I feel I have enough time to perform caries risk assessment on each patient	Agree	33	26.2%
	Disagree	93	73.8%
I am confident in my ability to explain caries risk assessment results with the patient	Agree	101	80.2%
	Disagree	25	19.8%
I am confident in my ability to identify carious lesions in the stages when they can be reversed	Agree	99	78.6%
	Disagree	27	21.4%
In my dental practice, I am comfortable performing caries risk assessment on patients	Agree	79	63.2%
	Disagree	46	36.8%
Monitoring incipient lesions is a cost-effective way of treating caries	Agree	108	85.7%
	Disagree	18	14.3%
CAMBRA is a useful tool in classifying patients to manage caries	Agree	107	85.6%
	Disagree	18	14.4%

Appendix A

Table 14. Descriptive Statistics for Practice Behavior Data

Variables		Count	Percentage %
Fluoridated over the counter toothpaste	Never	5	3.9%
	Sometimes	12	9.4%
	Frequently	23	18.1%
	Always	87	68.5%
Over the counter fluoride rinse or gel	Never	13	10.2%
	Sometimes	34	26.8%
	Frequently	44	34.6%
	Always	36	28.3%
Neutral sodium prescription strength (5000 ppm) fluoride paste or gel radio	Never	48	38.1%
	Sometimes	45	35.7%
	Frequently	23	18.3%
	Always	10	7.9%
Xylitol gum, lozenges, or mints	Never	23	18.3%
	Sometimes	31	24.6%
	Frequently	32	25.4%
	Always	40	31.7%
Calcium phosphate products	Never	67	53.2%
	Sometimes	35	27.8%
	Frequently	19	15.1%
	Always	5	4.0%
Antimicrobial rinse	Never	20	15.7%
	Sometimes	55	43.3%
	Frequently	35	27.6%
	Always	17	13.4%
Individualized oral hygiene instructions	Never	5	4.0%
	Sometimes	11	8.7%
	Frequently	24	19.0%
	Always	86	68.3%
Individualized re-care intervals	Never	11	8.7%
	Sometimes	19	15.0%
	Frequently	32	25.2%
	Always	65	51.2%

Appendix B

Table 15. Bivariate Associations Between Knowledge and Demographic Variables

Variables	Knowledge	95.0% CI for OR		
	Odds Ratio	Lower	Upper	P-value
Gender (Male)	1.19	0.59	2.41	0.623
Workplace (GOV)	1.97	0.91	4.26	0.084
Level of Education (DDS)	2.55	1.15	5.66	0.021
Specialty (GD)	1.90	0.92	3.88	0.079
Nationality (Saudi)	2.55	0.25	25.21	0.423
Years of Experience (5<)	1.24	0.60	2.55	0.547

Table 16. Bivariate Associations Between Skills and Demographic Variables

Variables	Skills	95.0% CI for OR		
	Odds Ratio	Lower	Upper	P-value
Gender (Male)	1.33	0.61	2.90	0.472
Workplace (GOV)	0.59	0.25	1.39	0.232
Level of Education (DDS)	0.74	0.31	1.76	0.502
Specialty (GD)	0.78	0.35	1.71	0.546
Years of Experience (5<)	0.91	0.41	2.02	0.826

Appendix B

Table 17. Bivariate Associations Between Attitude and Demographic Variables

Variables	Attitude	95.0% CI for OR		
	Odds Ratio	Lower	Upper	P-value
Gender (Male)	2.29	1.09	4.83	0.029
Workplace (GOV)	1.70	0.77	3.76	0.188
Level of Education (DDS)	0.53	0.23	1.21	0.134
Specialty (GD)	0.69	0.33	1.45	0.332
Years of Experience (5<)	0.54	0.25	1.16	0.115

Table 18. Bivariate Associations Between Practice Behaviors and Demographic Variables

Variables	Practice Behaviors	95.0% CI for OR		
	Odds Ratio	Lower	Upper	P-value
Gender (Male)	0.33	0.16	0.71	0.004
Workplace (GOV)	0.83	0.39	1.77	0.640
Level of Education (DDS)	3.00	1.36	6.60	0.006
Specialty (GD)	3.11	1.49	6.49	0.003
Years of Experience (5<)	1.09	0.53	2.25	0.806

Appendix C

Table 19. Multivariable Logistic Regression Between Total Knowledge and Demographic Variables (Initial Model)

Variables	B	SE	Wald	df	AOR	95.0% CI for AOR		Sig.
						Lower	Upper	
Attitudes (Median<)	-0.35	0.45	0.60	1	0.70	0.28	1.71	0.437
Practice Behaviors (Median<)	-0.26	0.41	0.42	1	0.76	0.34	1.72	0.517
Gender (Male)	0.30	0.40	0.55	1	1.35	0.61	3.00	0.455
Workplace (GOV)	0.84	0.42	3.88	1	2.32	1.00	5.36	0.049
Specialty (GD)	0.86	0.44	3.82	1	2.36	0.99	5.62	0.051
Year of Experience (5<)	0.05	0.41	0.01	1	1.05	0.46	2.37	0.903

Table 20. Multivariable Logistic Regression Between Total Knowledge and Demographic Variables (Final Model)

Variables	B	SE	Wald	df	AOR	95.0% CI for AOR		Sig.
						Lower	Upper	
Attitudes (Median<)	-0.37	0.45	0.67	1	0.69	0.28	1.67	0.412
Practice Behaviors (Median<)	-0.19	0.40	0.24	1	0.82	0.37	1.80	0.623
Workplace (GOV)	0.90	0.42	4.57	1	2.46	1.07	5.62	0.033
Specialty (GD)	0.83	0.40	4.17	1	2.30	1.03	5.14	0.041

Appendix C

Table 21. Multivariable Logistic Regression Between Skills and Demographic Variables

Variables	B	SE	Wald	df	AOR	95.0% CI for AOR		Sig.
						Lower	Upper	
Attitudes (Median<)	-0.05	0.48	0.01	1	0.94	0.36	2.46	0.912
Practice Behaviors (Median<)	0.84	0.45	3.41	1	2.32	0.95	5.69	0.065
Gender (Male)	0.19	0.44	0.19	1	1.21	0.51	2.90	0.657
Workplace (GOV)	-0.64	0.47	1.85	1	0.52	0.20	1.32	0.174
Specialty (GD)	-0.08	0.47	0.03	1	0.91	0.36	2.31	0.858
Year of Experience (5<)	-0.05	0.44	0.01	1	0.94	0.39	2.27	0.905

Table 22. Multivariable Logistic Regression Between Attitudinal and Demographic Variables

Variables	B	SE	Wald	df	AOR	95.0% CI for AOR		Sig.
						Lower	Upper	
Practice Behaviors (Median<)	-1.19	0.49	5.88	1	0.30	0.11	0.79	0.015
Skills (Median<)	-0.05	0.49	0.01	1	0.95	0.36	2.49	0.917
Gender (Male)	0.20	0.49	0.17	1	1.22	0.46	3.25	0.680
Workplace (GOV)	0.31	0.48	0.43	1	1.37	0.53	3.54	0.512
Specialty (GD)	-0.25	0.51	0.25	1	0.77	0.28	2.12	0.616
Year of Experience (5<)	-0.36	0.49	0.53	1	0.69	0.26	1.84	0.465

Appendix C

Table 23. Multivariable Logistic Regression Between Practice Behavior and Demographic Variables (Initial)

Variables	B	SE	Wald	df	AOR	95.0% CI for AOR		Sig.
						Lower	Upper	
Attitudes (Median<)	-1.20	0.49	5.87	1	0.30	0.11	0.79	0.015
Skills (Median<)	0.85	0.45	3.46	1	2.34	0.95	5.76	0.063
Gender (Male)	-1.05	0.45	5.34	1	0.34	0.14	0.85	0.021
Workplace (GOV)	0.31	0.48	0.43	1	1.37	0.53	3.55	0.512
Specialty (GD)	1.29	0.47	7.36	1	3.64	1.43	9.27	0.007
Year of Experience (5<)	-0.23	0.46	0.24	1	0.79	0.31	1.98	0.619

Table 24. Multivariable Logistic Regression Between Practice Behavior and Demographic Variables (Final)

Variables	B	SE	Wald	df	AOR	95.0% CI for AOR		Sig.
						Lower	Upper	
Attitudes (Median<)	-1.23	0.49	6.24	1	0.29	0.11	0.76	0.012
Skills (Median<)	0.88	0.45	3.83	1	2.43	1.00	5.91	0.050
Gender (Male)	-0.99	0.44	4.98	1	0.36	0.15	0.88	0.026
Specialty (GD)	1.14	0.42	7.13	1	3.14	1.35	7.28	0.008

Appendix D

Knowledge, Attitudes and Practice Behaviors of Caries Risk Assessment and Management Survey

Participant Letter for Anonymous Surveys

NSU Consent to be in a Research Study Entitled

Who is doing this research study?
This person doing this study is Dr. Ahmad Malluh with the Department of Cariology and Restorative Dentistry, College of Dental Medicine. They will be helped by Dr. Ana Karina Mascarenhas.

Why are you asking me to be in this research study?
You are being asked to take part in this research study because you are a dentist who is currently working in Saudi Arabia.

Why is this research being done?
The purpose of this study is to measure knowledge, attitudes and practice behaviors of dentists who work in Saudi Arabia about caries risk assessment and management.

What will I be doing if I agree to be in this research study?
You will be taking a one-time, anonymous survey. The survey will take approximately 15 minutes to complete. Furthermore, we are asking you, if you agree, to forward the survey invitation to your colleagues in Saudi Arabia.

Are there possible risks and discomforts to me?
This research study involves minimal risk to you. To the best of our knowledge, the things you will be doing have no more risk of harm than you would have in everyday life.

What happens if I do not want to be in this research study?
You can decide not to participate in this research and it will not be held against you. You can exit the survey at any time.

Will it cost me anything? Will I get paid for being in the study?
There is no cost for participation in this study. Participation is voluntary and no payment will be provided.

How will you keep my information private?
Your responses are anonymous. Information we learn about you in this research study will be handled in a confidential manner, within the limits of the law. All responses to this survey will be collected anonymously and no personal information or identifiers will be collected. This data will be available to the researcher, the Institutional Review Board and other representatives of this institution, and any granting agencies (if applicable). All confidential data will be kept securely stored in a password protected computer. Moreover, the data files will be encrypted and password protected. All data will be kept for 36 months from the end of the study and destroyed after that time by deleting all the online survey submissions and erasing or deleting all the data files employed in this study.

Who can I talk to about the study?
If you have questions, you can contact Dr. Ahmad Malluh at +966503019010 or +13057996448, or Dr. Ana Karina Mascarenhas at +16176051755. If you have questions about the study but want to talk to someone else who is not a part of the study, you can call the Nova Southeastern University Institutional Review Board (IRB) at (954) 262-5369 or toll free at 1-866-499-0790 or email at IRB@nova.edu.

Do you understand and do you want to be in the study?

If you have read the above information and voluntarily wish to participate in this research study, please read the instructions below.

For the following questions, please select the most appropriate response. We anticipate that you will be able to complete the survey in less than 15 minutes. After you complete and submit the survey, please we are asking you to send the survey invitation to other dentists who are dentists in Saudi Arabia. By doing this you will help us to collect more responses from other dentists and thus making this study more comprehensive. The deadline for the submission of the survey is January 30, 2019.

Thank you and we appreciate your help!

Gender:

a. Male
b. Female

Your age today:

a. 25-34
b. 35-44
c. 45-54
d. 55-64
e. 65+

Nationality:

a. Saudi Arabian
b. Other

Place of Work/Employment:

a. Governmental University
b. Ministry of Health
c. National Guard Hospital
d. King Faisal Specialist Hospital and Research Centre
e. Armed Forces Hospital
f. Private College
g. Private Clinic
h. Not employed
i. Other

What is the highest level of education you have completed?

a. Bachelors of Dentistry
b. Certificate of Advanced Graduate Study (CAGS)
c. Masters
d. Saudi Board
e. PhD

What is your specialty:

a. General Dentist
b. Endodontics
c. Prosthodontics
d. Periodontics
e. Pediatric Dentistry
f. Orthodontics
g. Oral Maxillofacial Surgery
h. Oral Maxillofacial Pathology
i. Oral Maxillofacial Radiology
j. Public Health
k. Advanced General Dentistry
l. Restorative/Operative

Please provide the name of the institution where you earned your dental degree?

Please provide the name of the institution where you earned your advanced dental education degree? If you do not have an advanced degree enter "None"

How many years have you practiced clinical dentistry?

a. <5
b. 5-10
c. 11-15
d. 16-20
e. 21-25
f. 26+

Do you know what is Caries Management by Risk Assessment (CAMBRA)?

a. Yes
b. No

How often do you use CAMBRA?

a. Every Patient
b. More than 50% of patients
c. Less than 50% of patients
d. Do not use

Reason for not using CAMBRA?

a. Lack of time
b. Lack of materials
c. Uncooperative patients
d. Lack of knowledge
e. Work place regulations

Where did you first get information related to CAMBRA from?

a. Internet
b. Scientific articles
c. Dental School
d. Other dentists
e. Books
f. Professional meetings and conferences
g. Continuing education classes

Where do you continue to get information related to CAMBRA from?

a. Internet
b. Scientific articles
c. Dental School
d. Other dentists
e. Books
f. Professional meetings and conferences
g. Continuing education classes

Hours of continuing education in caries risk assessment within last five (5) years.

a. 0
b. 1-4
c. 5-8
d. 9+

Which of the following methods do you use to assess caries?

a. Radiographs
b. Transillumination
c. Blunt instrument
d. Visual inspection
e. Detector dyes
f. Saliva test (Bacterial assay)
g. Sharp explorer
h. Other

Factors Influencing Caries Risk Assessment (Please indicate if you agree or disagree)

Factors Influencing Performing Caries Risk Assessment	Agree	Disagree
Performing caries risk assessment is an integral part of dental practice		
Untreated dental caries disease can lead to life-threatening health complications		
Caries management mainly includes providing dental restorations		
I feel I have enough time to perform caries risk assessment on each patient		
I am confident in my ability to explain caries risk assessment results with the patient		
I am confident in my ability to identify carious lesions in the stages when they can be reversed.		
In my dental practice, I am comfortable performing caries risk assessment on patients		
Monitoring incipient lesions a cost-effective way of treating caries?		
CAMBRA is a useful tool in classifying patients to manage caries		

Knowledge Statements (please state whether you believe each statement is true or false)

Knowledge Statements	True	False
"White spot lesions are considered carious lesions."		
"Dental caries is a transmissible disease. "		
"Dental caries is a multifactorial disease."		
"An individual with a history of carious lesions within the past three (3) years is at high risk for future dental caries activity. "		
"Low socioeconomic status does not increase an individual's risk for dental caries disease."		
"Decreased saliva flow increases risk for dental caries disease."		
"There is no evidence to support the twice a year or more application of fluoride varnish to reduce risk of carious lesions in adults of high caries risk. "		
"Patients at moderate or high risk of dental caries need to be counseled about the role of sugary and starchy foods in increasing caries risk. "		
"Chlorhexidine is known to kill all caries pathogenic organisms "		

Please answer the following questions based on the case below.

Case 1: 28- year-old male, came for a recall appointment upon examination, Multiple white spot lesions on the labial surfaces of the maxillary anterior teeth adequate saliva flow, fair oral hygiene, no history of fluoride exposure, last dental visit was 6 months ago.

What is the caries risk of this patient?

a. Low
b. Moderate
c. High

When would you give the patient a recall appointment:

a. 7-12 months
b. 5-6 months
c. Every 4 months
d. Every 3 months

When you recall the patient would you provide another caries risk assessment?

a. Yes
b. No

How frequently would you take radiographs for this patient?

a. Bitewings every 25-36 months
b. Bitewings every 19-24 months
c. Bitewings every 7-18 months
d. Bitewings every 6 months

Please answer the following questions based on the case below.

Case 2: 22-year-old male, no history of decayed, missing, or filled teeth, no carious lesions present, adequate saliva flow, good oral hygiene, last dental visit more than three years ago, chief complaint of chipped maxillary anterior tooth.

What is the caries risk of this patient?

a. Low
b. Moderate
c. High

When would you give the patient a recall appointment:

a. 7-12 months
b. 5-6 months
c. Every 4 months
d. Every 3 months

When you recall the patient would you provide another caries risk assessment?

a. Yes
b. No

How frequently would you take radiographs for this patient?

a. Bitewings every 25-36 months
b. Bitewings every 19-24 months
c. Bitewings every 7-18 months
d. Bitewings every 6 months

Please answer the following questions based on the case below.

Case 3: 49-year-old female, history of several restorations and missing teeth, history of periodontal surgery, no new carious lesions, no lesions restored in the last three years, fair oral hygiene, uses salivary reducing medications, last dental visit was six months ago with radiographs, chief complaint is broken lower molar.

What is the caries risk of this patient?

a. Low
b. Moderate
c. High

When would you give the patient a recall appointment:

a. 7-12 months
b. 5-6 months
c. Every 4 months
d. Every 3 months

When you recall the patient would you provide another caries risk assessment?

a. Yes
b. No

How frequently would you take radiographs for this patient?

a. Bitewings every 25-36 months
b. Bitewings every 19-24 months
c. Bitewings every 7-18 months
d. Bitewings every 6 months

When responding to the following questions, please consider your primary practice setting - the clinical setting in which you spend the most hours per week. Consider these questions as they relate to patients assessed to be moderate or high risk for dental caries.

When making caries management recommendations for patients of moderate or high caries risk, how often do you recommend each of the following?	**Never**	**Sometimes**	**Frequently**	**Always**
Fluoridated over the counter toothpaste				
Over the counter fluoride rinse or gel				
Neutral sodium prescription strength (5000 ppm) fluoride paste or gel				
Xylitol gum, lozenges, or mints				
Calcium phosphate products				
Antimicrobial rinse				
Individualized oral hygiene instructions				
Individualized re-care intervals				

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