

Caries Management By Risk Assessment and the Effect On Caries Diagnosis and Oral  
Health Behaviors

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## **SECTION 1**

## **INTRODUCTION**

Dental caries is a preventable disease (1–3). Researchers now know that caries is a bacterially based disease that arises when pathological factors (e.g., oral bacteria, such as mutans streptococci [MS] and lactobacilli [LB]) outweigh protective factors (e.g., salivary fluoride, saliva flow (3)). The concept of caries management by risk assessment is based on this knowledge; by knowing a patient's level of risk, oral health behavior can be modified to lower caries risk. These changes include an increase in protective or therapeutic factors including, oral self-care and dietary habits, and preventive treatments such as fluoride varnish or prescription fluoride toothpaste. There is also research indicating a patient's perception of his/her oral health and motivation to change self-care behaviors are key to behavior change and therefore must be considered in managing caries (4,5). Caries management by risk assessment involves an individualized discussion with a patient and analysis of protective and pathological factors. Assessment of risk allows correct placement of a patient into a caries risk category; however, research is inconclusive on whether management of caries by risk assessment results in behavior change and reduces caries diagnosis over time.

### **Purpose of the Study**

The purpose of this study was to determine if using a caries risk assessment tool results in improved oral health behaviors and lower caries incidence over time.

## **Significance of the Study**

Emerging research suggests caries management by risk assessment results in improved oral health status(6–8). However, the use of caries risk assessment tools is not widespread in dental practice. The challenge of adopting a new concept and/or time could be possible explanations of this. More studies investigating the value of risk assessment in caries prevention are needed. The results of this study will provide evidence on whether a risk assessment tool, specifically caries management by risk assessment (CAMBRA), is effective in controlling caries status, preventing new decay, or lowering plaque scores as compared to traditional caries management. In this study, traditional caries management was defined as the surgical model of managing caries. If using CAMBRA results in less diagnosed caries, providers can use this knowledge to make evidence-based decisions related to caries preventive strategies and improve the oral health of patients. The results of this study will add to the current body of knowledge supporting a paradigm shift from the surgical model of treating dental caries to a model of disease prevention.

## **Research Questions**

1. For a patient with active caries, does the use of caries management by risk assessment (CAMBRA), as compared to traditional caries management, result in a decrease of new caries lesions?



2. For a patient with active caries, does the use of a caries management by risk assessment (CAMBRA) tool, as compared to traditional caries management, improve oral health behaviors as measured by plaque scores?

### **Hypotheses**

1. There is no difference in new caries diagnosis for patients that have undergone caries management by risk assessment vs. patients who have not undergone risk assessment.
2. There is no difference in oral health behaviors for patients that have undergone caries management by risk assessment vs. patients who have not undergone risk assessment.

## **SECTION 2**

## **REVIEW OF THE RELATED LITERATURE**

Dental caries continues to be a universal chronic disease, affecting both children and adults (1,3). Research has shown that caries is a multifactorial disease that begins with microbiological shifts within the complex biofilm and is affected by salivary flow and composition, exposure to fluoride, consumption of dietary sugars as well as preventive oral hygiene behaviors (2,9,10). Research has also shown that certain risk factors such as frequent snacking, consumption of sugary drinks, suboptimal fluoridated water or insufficient oral self-care methods can further contribute to the development of caries (2,3,11). Furthermore, the caries process has been shown to be a balance between these pathological risk factors and protective factors such as water fluoridation, fluoride-containing dentifrices, chlorhexidine gluconate rinse or products containing xylitol (2,3).

A study by Featherstone found that caries progression depends on the balance between demineralization and remineralization, and that this balance can be swung in the direction of non-invasive caries management and prevention by the active role of the dental care provider (10). Research has also shown that preventive strategies such as fluoride varnish and sealants may also be effective at preventing future dental caries (12–14). Wright, Tampi and Graham et al conducted a systematic review of 23 parallel and split-mouth randomized controlled trials investigating sealants for the prevention of pit-and-fissure caries. Twenty-three studies found that even after seven or more years of follow up, children and adolescents with sealants had a caries incidence of 29%, whereas those without sealants had a caries incidence of 74% (12). Similarly, the American Dental Association Council on Scientific Affairs concluded in a systematic review that

sealants are effective in caries prevention and that sealants can prevent the progression of early non-cavitated carious lesions (13). This same study indicated that the use of sealants is underused in practice, indicating that evidence-based research is not being utilized to its potential.

The use of fluoride in preventing caries has also been researched extensively. In a meta-analysis to determine the effectiveness regarding fluoride therapy, Marinho, et al found that DMFS (decayed, missing or filled tooth surfaces) incidence was found 14% lower in experimental groups that were exposed to fluoride varnish over the course of one year (15). Other preventive factors such as fluoridated water use and more frequent recall have also shown to be effective in preventing caries incidence as well (16,17). A systematic review by Figuero, et al examined the effect of plaque control on gingivitis and caries incidence. The interventions examined were personalized oral health instruction, more frequent prophylaxis, the addition of fluoride varnish, and motivational education (18). Within all studies, there were significant differences in plaque scores in all test groups, including those that received fluoride varnishes every six months and more frequent prophylaxis (less than six months). Interestingly, some studies within this review also reported that a fluoride varnish application *without* a prophylaxis did not significantly reduce caries incidence, showing the significance of preventive care. Plaque control, fluoridated water exposure, chlorhexidine rinse and fluoride dentifrices are all preventive strategies considered and implemented with the use of CAMBRA (19,20). Despite current research indicating that dental caries is dependent on the balance of these factors, caries continues to be managed using traditional surgical methods (11,21)

Unfortunately, this method alone also does not manage or cure caries as a disease and does not eliminate bacteria still present in the mouth that can cause further caries and is not evidence based.

The literature points to a paradigm shift from a surgical approach to dental caries to a medical management model. This approach focuses on early (prenatal if possible) risk assessment of the child and mother, and implementation of appropriate therapeutic interventions, including use of antimicrobials, and a reduction in the levels of caries-producing bacteria (21)(11). Ismail and Bader suggest that most caries diagnosis is still based on the use of an explorer, despite the weak evidence supporting this method (1). Despite the etiology of caries being well-established in the literature, current methods for treating caries do not align with what the evidence is suggesting, that dental caries needs to be managed and can largely be prevented.

Emerging research on caries management by risk assessment suggests it is successful because it allows the identification of a patient's caries risk level allowing the provider to create an individualized preventive plan (11,22). However, despite emerging evidence, adoption of caries management by risk assessment tool to lower caries diagnosis and improve patient's oral health has been slow(11,21). The concept of evidence-based decision making has been incorporated in medicine for some time now, but is fairly new to dentistry (23). Evidence-based dentistry (EBD) has been defined by the American Dental Association as: "An approach to oral health care that requires judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical

expertise and the patient's treatment needs and preferences" (1). EBD suggests that the practitioner consider scientific evidence, their own clinical expertise and the patient's preferences when making clinical decisions. In the absence of evidence-based decision making, all available treatment options and/or preventive strategies may be overlooked.

Because research is showing that certain risk factors can be strong predictors of future caries development (24)(10)(25), caries risk assessments tools such as CAMBRA have been developed in order to aid in the prevention and management of caries (26,27). CAMBRA includes the gathering and assessment of specific oral health and behavioral information from a patient. A dental provider then evaluates the balance of pathological and protective factors and categorizes a patient's risk for future disease (11). As previously discussed, pathological factors include frequency of carbohydrate intake, poor home care practices, suboptimal fluoride exposure, and history of caries, while protective factors include optimal fluoride exposure and good oral hygiene (28). A patient's risk is determined according to the balance of these risk factors. CAMBRA provides a baseline assessment of a patient's risk of developing caries. A practitioner can then determine what preventive strategies should be employed and what care should be provided for an individual based on the risk assessment (28).

Studies have shown that past caries experience is the most powerful single predictor of future caries in all age groups (11)(29)(30). In a randomized clinical trial by Featherstone et al comparing results of using therapeutic CAMBRA interventions, researchers found that the intervention group had significantly lower caries risk over time than the control group (31). The intervention group received the following therapeutic

interventions: topical NaF fluoride varnish, dietary counseling, counseling for the need of a daily fluoride-containing dentrifice, and the need for compliance. Participants were also given a toothbrush and 1,100 ppm F toothpaste, instructed to brush daily at home and prescribed a .12% chlorhexidine gluconate mouth rinse to be used daily (1min) for two weeks, to be repeated every three months. Results suggest with appropriate intervention it is possible to change a patient's caries risk and decrease diagnosed caries. In a retrospective cohort study by Chaffee et al, investigators aimed to assess the predictive capacity of the CAMBRA caries risk assessment tool by using electronic patient records at the University of California San Francisco (26). The researchers found that the presence of caries protective factors, caries risk factors, and disease indicators, as recorded in the baseline CRA (Caries Risk Assessment) forms, were associated with the assigned caries risk category. In a similar retrospective study by Domejean and Featherstone, results showed that using the CAMBRA method is helpful in identifying patients who are at high or extreme risk of developing further caries lesions (25). These findings are significant because they support the concept of using baseline caries risk assessment to identify preventive strategies aimed at preventing future caries and improving a patient's overall health.

Not only is the use of CAMBRA successful at identifying a patient's caries risk, the use of a risk assessment has also been using in identifying strategies that lead to improved oral health. In a randomized, parallel group two-year clinical trial, researchers assessed whether combined antibacterial and fluoride therapy benefits the balance between caries pathological and protective factors (31). One hundred and twelve

participants in the high caries risk category, according to CAMBRA, were randomly assigned to either a control or intervention group. The intervention group used a fluoride dentifrice, a 12% chlorhexidine rinse, and .05% fluoride rinse based upon diagnosis of low salivary flow. Results showed that the intervention group had a statistically significant (24%) lower mean caries incidence and overall caries risk was lowered (26). A similar study concluded that ‘visible cavitation,’ ‘caries radiographic penetration of the dentin,’ and ‘interproximal enamel lesions or radiolucencies’ at follow up were directly related to the overall caries risk (22). The findings of these studies suggest that using caries risk assessment may lower caries risk over time by introducing a patient to protective measures like fluoride varnish or chlorhexidine rinse. Given certain risk factors are predictors of future caries, a risk assessment tool allows the practitioner and patient to decide on a preventive care plan to prevent such future caries. Identification of a patient’s caries risk is thought to be significant in preventing further caries risk for two main reasons: 1) provides the ability to individualize preventive strategies to prevent further caries and 2) provides a visual tool to use to promote behavior change.

The use of CAMBRA calls for behavior change from the patient to prevent further caries as well. The theory of planned behavior suggests that a person’s attitude, subjective norm (the belief that specific important persons think he/she should or should not perform a specific behavior), and a person’s belief in their ability to perform a certain behavior all contribute to whether behavior change actually takes place (5,32). Attitude represents the individual’s perceived benefits and drawbacks of adopting a certain behavior. Perceived behavioral control is determined by an individual’s perception of the



presence or absence of resources and opportunities or barriers to adopt certain behaviors (32). The theory of planned behavior has been extensively used in health sciences research (4,5). A cross-sectional study by Boudreau and Godin investigated the intention of an overweight or obese individual's intention to change eating behaviors, found that intention to change behavior was associated with perceived behavioral control and having a favorable attitude toward change (32). It was found that an individual must understand the benefits of change and have a desire to change to achieve end results. Changing patient oral health perceptions and behavior is vital to managing caries and is a significant part of CAMBRA (11). The theory of planned behavior supports the concept of caries management by risk assessment, as it posits the identification of determinants of behavior change and personalized educational interventions are needed to prevent future caries.

Caries researchers suggest that further investigations into caries management by risk assessment is needed to engage dental practitioners in evidence-based decision-making. Additionally, if the use of CAMBRA is found to improve oral health, payers may recognize that preventing disease is more cost effective and reimburse preventive strategies. Ultimately, the balance between protective and pathological factors is dependent on a patient's motivation to change oral self-care behaviors. CAMBRA may be a tool that provides a patient with objective information and opens dialogue regarding oral self-care behaviors. Currently, there is insufficient research to conclude that CAMBRA leads to behavior change and decreases the incidence of new caries. Therefore, the purpose of this study was to investigate whether caries management by

risk assessment leads to behavior change and ultimately reduces the incidence of new carious lesions.

### **SECTION 3**

## **SYNOPSIS**

*Objective:* To determine whether a caries management by risk assessment tool improves oral health behaviors and results in less caries diagnoses over time.

*Methods:* A sample consisting of 207 patient records from the School of Dentistry (SOD) dental hygiene clinic were screened for inclusion and exclusion criteria. Inclusion criteria for the control group included patients eighteen years of age or older with their first visit to SOD dental hygiene clinic between years 2010-2011, no record of CAMBRA completion, and two or more dental hygiene clinic visits. Inclusion criteria for the intervention group included patients eighteen years of age or older with their first visit to the SOD's dental hygiene clinic between 2012-2016, two or more completions of CAMBRA, and two or more dental hygiene clinic visits. Using the CAMBRA form, the following changes in protective factors and risk factors for the experimental group were recorded using a standard form: visible heavy plaque on teeth, drinks water from fluoridated municipal supply, use of fluoride toothpaste at least once a day, use of fluoride toothpaste at least 2x/day, use of fluoride mouth rinse (0.05%NaF) daily, use of 5000 ppm F fluoride toothpaste daily, and chlorhexidine prescribed/used one week each of last 6 months.

*Results:* A total of 207 patient records comprised the study sample. One hundred subjects were in the control group and one hundred and seven were in the intervention group. In both the control and intervention groups, at least 50% of the subjects presented with active caries at visit one. The total number of visits ranged from two to eleven. Plaque scores were significantly higher in the control group at the last visit (p-

value=0.0442). Subjects in the intervention group, who completed CAMBRA, had lower plaque scores indicating improved self-care behaviors. However, differences in new caries diagnoses at the last visit were not statistically significant between groups. Although statistical significance was not attained, the percentage of subjects with a new caries diagnosis at the last visit was lower for the intervention group (intervention=18.69%, control=29%). Subjects in the intervention group increased the number of protective factors over the course of their visits, except for the use of a prescribed chlorhexidine rinse. The most common reported protective factor was the use of fluoride toothpaste daily. Over the course of five visits, there was an increase in total protective factors for subjects in the intervention group.

*Conclusion:* The results of this study showed subjects with a CAMBRA improved their self-care behaviors and had lower plaque index scores. Differences in new caries diagnosis were not statistically significant between control and intervention, but the percentage of subjects with a new caries diagnosis at the last visit was lower for the intervention group. The results of this study support existing evidence, as the use of caries management by risk assessment appears to offer a preventive approach to oral health care delivery.

## **MANUSCRIPT**

This manuscript will be submitted to Community Dentistry and Oral Epidemiology.

### **Introduction**

Dental caries is preventable, yet continues to be a universal, chronic disease (1–3). Caries is a multifactorial disease that begins with microbiological shifts within the complex biofilm and is affected by salivary flow and composition, exposure to fluoride, consumption of dietary sugars, as well as preventive oral behaviors (2,9,10). Researchers now know that caries is a bacterially based disease that can be balanced by altering protective and pathological factors. Achieving optimal balance between pathological risk factors and protective factors such as water fluoridation, fluoride-containing dentifrices, chlorhexidine gluconate rinse or products containing xylitol may prevent the initiation of the caries process (2,3). Research has also shown that using preventive strategies such as fluoride varnish as well as sealants are effective at preventing future dental caries (12–14). The use of fluoride in preventing caries has also been researched extensively and shown to significantly lower caries (15,33). Lastly, the use of fluoridated water use as well as more frequent recall visits have been widely studied and shown to improve oral health and lower caries incidence rates (19,20).

Despite current research indicating that dental caries is dependent on the balance of pathological and protective factors, caries continues to be managed using traditional surgical methods (11,21) Unfortunately, this method alone does not approach caries as a disease to be managed and does not address the bacteria still present in the mouth that can cause further caries. The concept of caries management by risk assessment is based on

knowledge of a patient's level risk and oral health behavior and modifying risk factors to lower caries risk (7,11,25). These changes include an increase in protective or therapeutic factors, changes in oral self-care and dietary habits, and protective or preventive treatments such as fluoride varnish or prescription fluoride toothpaste. Caries management by risk assessment (CAMBRA) involves initiation of a discussion with a patient, analysis of protective and pathological factors, and assessment of a patient's motivation to change behavior. CAMBRA is a tool that was created to represent the multifactorial nature of dental caries disease and to emphasize the balance between pathological and protective factors in the caries process (3).

CAMBRA provides a baseline assessment of a patient's oral health status with regard to caries. A practitioner can then determine what preventive strategies should be employed and what oral health care should be provided for a patient based on the risk assessment (28). Plaque control, fluoridated water exposure, chlorhexidine rinse and fluoride dentifrices are all preventive strategies considered and implemented with the use of CAMBRA. CAMBRA provides the opportunity to discuss and elicit a patient's perception of his/her oral health and motivation to change self-care behaviors are key to behavior change and therefore must be considered in managing caries (4,5).

The literature points to a paradigm shift from a surgical approach to dental caries to a medical strategy that focuses on risk assessment and implementation of appropriate therapeutic intervention, including use of antimicrobials, risk assessment of infants at 6 months of age, and a reduction in the levels of caries-producing bacteria (11,21). Current research on CAMBRA shows it is successful at identifying a patient's caries risk and

results in a lowered caries risk over time. In a randomized, parallel group two-year clinical trial, researchers assessed whether combined antibacterial and fluoride therapy benefits the balance between caries pathological and protective factors (31). One hundred and twelve participants in the high caries risk category, according to CAMBRA, were randomly assigned to either a control or intervention group. The intervention group used a fluoride dentifrice, a 12% chlorhexidine rinse, and .05% fluoride rinse based upon diagnosis of low salivary flow. Results showed the intervention group had a statistically significant (24%) lower mean caries incidence and overall caries risk was lowered (26). A similar study concluded that ‘visible cavitation,’ ‘caries radiographic penetration of the dentin,’ and ‘interproximal enamel lesions or radiolucencies’ at follow up were directly related to the overall caries risk (22). The findings of these studies suggest that using caries risk assessment may lower caries risk over time by introducing a patient to protective measures like fluoride varnish or chlorhexidine rinse. However, there is not sufficient research to strongly state the use of CAMBRA lowers number of caries diagnoses over time. Therefore, the purpose of this study was to determine if using a caries risk assessment tool results in improved oral health behaviors and lower caries incidence over time.

## **Methods**

This study used a retrospective, experimental design to determine whether a caries management by risk assessment tool improves oral health behaviors and results in less caries diagnoses over time. The independent variable was completion of the CAMBRA risk assessment. The dependent variables were newly diagnosed caries, caries status and



oral health behaviors and plaque score. The study took place at the University of Minnesota School of Dentistry (SOD) during October 2017 and January 2018. A sample consisting of 207 patient records from the SOD dental hygiene clinic were screened for inclusion and exclusion criteria. Inclusion criteria for the control group included patients eighteen years of age or older with their first visit to SOD dental hygiene clinic between years 2010-2011, no record of CAMBRA completion, and two or more dental hygiene clinic visits. Inclusion criteria for the intervention group included patients eighteen years of age or older with their first visit to the SOD's dental hygiene clinic between 2012-2016, two or more completions of CAMBRA, and two or more dental hygiene clinic visits. Exclusion criteria included patient's age less than eighteen years old, less than two dental hygiene visits total or less than two dental hygiene visits with recorded CAMBRA scores, or less than two recorded plaque scores.

Patient records using inclusion/exclusion parameters were queried in the SOD's electronic health record housed in AxiUm. All patient records are assigned a chart number by the University of Minnesota's School of Dentistry, so the investigator did not know the identity of the patient. Patient's gender, age and dental insurance type were recorded. Using the CAMBRA form, the following changes in protective factors and risk factors for the experimental group were recorded using a standard form: visible heavy plaque on teeth, drinks fluorinated water from municipal supply, fluoride toothpaste at least once a day, fluoride toothpaste at least 2x/day, fluoride mouth rinse (0.05%NaF) daily, 5000 ppm F fluoride toothpaste daily, and chlorhexidine prescribed/used one week each of last 6 months (See Appendix A). Additionally, plaque scores were recorded as

low, moderate or high. It was determined that these factors would indicate any changes in the patient's oral health behavior. Changes in caries status and new caries diagnoses for both the experimental and control groups were recorded using a standard form (See Appendix B). To ensure consistency in recording, only the investigator performed the data collection.

Fisher's exact tests were used to compare new caries diagnoses, caries status, oral health behaviors, and plaque score outcomes between the two groups at the first, second and last patient visits. In addition, generalized estimating equations (GEE) models for binary or ordinal data were used to compare the outcomes between the groups across all visits. These models were adjusted for age, gender, insurance status, and time from first visit. GEE models were used because the number of visits an individual patient has are potentially correlated. P-values less than 0.05 were considered significant. SAS V9.3 (SAS Institute Inc., Cary, NC) was used for the analysis. This study was approved by the University of Minnesota and was determined by the IRB to be exempt (IRB #00000159).

## **Results**

A total of 207 subjects (n=207) comprised the study sample. One hundred subjects were in the control group and one hundred and seven were in the intervention group. Table 1 shows subject characteristics. The control and intervention groups were fairly homogenous with regard to gender, age and type of dental insurance (See Table 1). In both the control and intervention groups, at least 50% of the subjects presented with active caries at visit one (See Table 2). Not all subjects had the same number of visits during the study, but all subjects had at least 2 visits over the course of one year. The

total number of visits ranged from two to eleven, however, after visit five, the number of CAMBRA forms were inconsistent and infrequent in the dental record, therefore there was not sufficient data to report mean totals after visit five. Subjects who completed CAMBRA improved their self-care behaviors. The results showed plaque scores were statistically significant between groups at the last visit ( $p$ -value=0.0442). However, differences in new caries diagnosis were not statistically significant between groups (see table 5). No relationship between new caries diagnosis and high plaque score with age, gender and type of insurance was found (See Table 2). Although statistical significance was not attained, the percentage of subjects with a new caries diagnosis at the last visit was lower for the intervention group (See Table 3). Correlated with this finding was the change in oral self-care behaviors in the intervention group. Subjects in the intervention group increased the number of protective factors over the course of their visits, except for the use of a prescribed chlorhexidine rinse (see Table 6). The most common reported protective factor was the use of fluoride toothpaste daily. Over the course of five visits, there was an increase in total protective factors for subjects in the intervention group (see Table 7).

## **Discussion**

The purpose of this study was to determine whether a caries management by risk assessment tool improves oral health behaviors and results in fewer caries diagnoses over time. Findings failed to reject the null hypothesis that there would be no difference in new caries diagnosis for subjects undergoing CAMBRA vs. subjects who did not. Even though statistical significance was not obtained, there was a greater reduction in new

caries in the intervention group (see Table 5). This finding is clinically significant and suggests a risk management approach to caries may be superior to traditional strategies. Subjects in the intervention group had significantly lower plaque scores at their last visit indicating a change in oral self-care behaviors ( $p = 0.0442$ ). A caries risk assessment approach, specifically CAMBRA, appears to have led subjects to adopt behaviors that improve oral health. Subjects in the intervention group increased their use of six of the eight protective factors over time, including a 7.66% increase in patients who used 5000 ppm fluoride toothpaste from visit one to visit three.

The findings support previous research suggesting that the use of a caries management by risk assessment protocol provides the ability to individualize preventive strategies for new caries, such as the use of fluoride toothpaste, and specifically identifying pathological factors putting the patient at risk for caries. The decrease in plaque scores over time suggests that patients adopted several positive changes in their self-care habits and complied with the high caries risk protocol suggested through CAMBRA. The results of this study support similar research studies comparing traditional methods to a caries management by risk assessment (34). Findings reinforce current research that caries is a multifactorial disease, affected by the ratio of protective vs. pathological factors.

Evidence to date suggests using a caries risk assessment tool, like CAMBRA, may lower a patient's risk for caries in the future. Discussing the results of the caries risk assessment with the patient is a critical step that may contribute to the patient's motivation to change their oral self-care habits. CAMBRA allowed patients the

opportunity to visually see their risk vs. protective factors ratio, reflect on their oral-self care health behaviors and make autonomous decisions regarding their oral health.

Traditional preventive strategies commonly involve providing a patient with information, toothbrushing and/or flossing demonstrations and recommendations for changing behaviors. Historically, advice giving methods have been used to provide patient education. Providing instructions or solutions to improve an individual's oral hygiene does not support patient autonomy. This method of patient education serves the agenda of the oral healthcare provider instead of the individual's interests related to their long-term oral health goals. Evidence-based research indicates advice giving methods or fear tactics are ineffective and will not sustain long-term positive behaviors (35,36).

In contrast, CAMBRA is very person-centered approach. After identifying factors contributing to new caries, a personalized care plan is then created in partnership with the patient. CAMBRA requires providers spend more time discussing the etiology of caries and contributing pathologic and protective factors. Patients are then free to eliminate risk related behaviors and/or adopt behaviors that prevent caries. Patients may be more apt to accept the caries risk protocol because CAMBRA encourages them to be involved in the decision-making process. The literature suggests autonomy in decision-making increases patient compliance with oral self-care recommendations (37). Studies on motivational interviewing (MI) suggest behavior change is achieved by helping clients explore and resolve doubt in their own ability to change (37,38). CAMBRA may facilitate this type of exploration and discussion between provider and patient. Potentially, the balance between pathological and preventive factors can be moved

beneficially in the direction of preventing caries initiation and progression by an active interception.

Emerging evidence suggests caries management by risk assessment is a preventive strategy that should be adopted in practice, as it may lower a patient's risk for future caries and improves self-care habits (7,29). Effective risk management involves the understanding of risk and intentionally minimizing it with the best intention of securing the most successful outcome for the patient. The carious process is effectively reversible in the early stage, before the lesion has completely penetrated the enamel. Therefore, a caries risk assessment should be regarded as an important minimal intervention strategy and should incorporate both the identification and management of both protective and etiological factors of the disease. CAMBRA offers a preventive approach that can be used to determine an individual's expected caries experience over a period of time and the likelihood of new caries activity and progression rate of existing carious lesions.

Future studies should involve a longer study period as well as a greater number of subjects. Specific protective or risk factors within CAMBRA to determine if one or more have greater impact on caries development should also be a research focus. A limitation of this study was the study setting as well as control of the CAMBRA discussion and presentation. In the School of Dentistry, subjects were not with the same student and faculty for all clinic visits, and therefore, general clinical notes, recorded plaque scores and frequency of CAMBRA form completions were not consistent between providers.

Additionally, the limited sample size and length of time may have prevented a statistically significant effect of CAMBRA on new caries diagnosis.

### **Conclusion**

The results of this study showed subjects who completed CAMBRA improved their self-care behaviors as demonstrated by lower plaque index scores. However, differences in new caries diagnosis were not statistically significant between control and intervention. Overall, this study supports existing evidence that the use of caries management by risk assessment appears to offer a preventive approach to oral health care delivery.

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## **SECTION 4**

## **TABLES**

Table 1. Subject characteristics

Variable	Control	Intervention
	n=100	n=107
Age range (in years)		
18-30	2	2
31-40	6	5
41-50	8	3
51-60	11	12
61-70	16	27
71-80	24	34
80+	33	24
Gender		
Male	54	62
Female	46	45
Dental insurance		
Private	23	25
State	18	23
None	59	59

Table 2. Subject characteristics vs. visits with reported new caries diagnosis or high plaque score

	New caries diagnosis	High plaque score
Control		
	Total visits with new caries diagnoses=118	Total visits with high plaque score=32
Age category	80+ years (36)	80+ (16)
Gender	Male (64)	Male (26)
Dental insurance	None (65)	None (27)
Intervention		
	Total visits with new caries diagnoses=120	Total visits with high plaque score=18
Age category	71-80 years (42)	51-60 and 80+ (5)
Gender	Male (72)	Male (12)
Dental insurance	None (59)	None (9)

Table 3. Percentages of patients with new caries diagnosis at first and last visits

	1 <sup>st</sup> visit	Last visit
Control	49.00	29.00
Intervention	41.14	18.69

Table 4. Plaque score percentages at first and last visits

	Light	1st visit	Last visit
Control		56.32	53.75
Intervention		70.71	57.61
	Moderate		
Control		32.18	32.5
Intervention		23.23	39.13
	High		
Control		11.49	13.75
Intervention		6.06	3.26

Table 5. Comparison of new caries diagnosis and plaque scores between groups at first and last visit (P >0.05)

n (%)	First visit	Last visit
New Caries Diagnosis	0.2667	0.1018
Plaque score	0.1036	0.0442

Table 6. Changes in Risk Factor and Protective Factors: Visit one vs. three (intervention group only)

Risk Factor	Visit 1	Visit 3	Difference
Visible heavy plaque on teeth	32.71	46.43	+13.72
Protective Factors			
Drinks fluorinated water from municipal supply	78.5	82.14	+3.64
Fluoride toothpaste at least once a day	94.39	94.64	+0.25
Fluoride toothpaste at least 2x/day	71.96	76.79	+4.83
Fluoride mouthrinse (0.05%NaF) daily	36.45	39.2	+2.84
5000 ppm F fluoride toothpaste daily	8.41	16.07	+7.66
Chlorhexidine prescribed/used one week each of last 6 months	1.87	1.79	-0.08
Xylitol gum/lozenges 4x daily last 6 months	1.87	7.14	+5.27
MI paste during last 6 months	0.00	0.00	0.00

Table 7. Mean Risk and Protective Factors Over Time

Visit	N Obs (# of subjects)	Variable	Mean
1	107	Total R	1.8
		Total P	3.6
2	107	Total R	2.2
		Total P	3.8
3	103	Total R	2.0
		Total P	3.9

4	86	Total R	1.8
		Total P	3.9
5	61	Total R	2.0
		Total P	4.0

R=risk factors

P=protective factors



## **SECTION 5**

## **PRACTICAL APPLICATION**

A dental hygienist has a unique role for many reasons. His or her regular time with the patient, unique relationship and expertise are all critical opportunities to direct this change in the delivery of oral health care. Dental hygienists have the responsibility of educating the public, but using a caries risk assessment tool such as CAMBRA within the dental hygiene visit can increase knowledge and motivation to change behavior for the patient as well as potentially reduce caries incidence. Traditional methods of treating caries are no longer sufficient as they do not focus on the prevention but rather treating the disease. Although completing a caries risk assessment does not require a vast amount of time, routine care or periodontal treatment visits with the dental hygienist allow ample time for assessment and discussion of caries risk. Simply adding a caries risk assessment to a routine care visit, or recall, could have significant impact on public health.

The vast amount of information available to the patient can actually be a barrier to the prevention of caries, especially if it is not grounded in evidence-based research. A dental hygienist's scientific knowledge of the caries process combined with a trusted relationship with the patient positions him or her to be the gatekeeper of this unreliable information to the patient. The public may not have the foundation and resources that a dental hygienist has in relation to oral health. Using a caries risk assessment tool allows

the hygienist the opportunity to discuss the caries process using evidence-based research and his or her expertise, assisting the patient in making an educated decision. Discussion of risk and protective factors and treatment recommendations should be incorporated into the dental hygiene visit by using a tool such as CAMBRA.

A final recommendation is to incorporate a conversation between the dental hygienist, patient and dentist regarding the caries management by risk assessment. Having the dentist and dental hygienist confirm the caries risk assessment results and recommendations with the patient is critical in motivating the patient to change behavior and increase trust. Most dentists agree that the carious process is effectively reversible in the early stage. Therefore, caries risk assessment should be regarded as an important minimal intervention strategy, and should incorporate both the identification and management of protective and etiological factors of the disease.. With a slight change in the structure of the dental visit, providers can shift the management of caries. Research is pointing to the use of preventive strategies for oral health and should be used by health care providers to improve the general health of the public.

## **SECTION 6**

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## **APPENDICES**

**APPENDIX A: SUBJECT ENROLLMENT FORM AND DATA COLLECTION INSTRUMENT (BOTH GROUPS)**

Subject ID \_\_\_\_\_ Chart review/enrollment date \_\_\_\_\_

Individual enrolling subject: \_\_\_\_\_

Age: \_\_\_\_\_

Gender: Male                      Female

Group: Control                      Intervention

Insurance type: \_\_\_\_\_ None

Date of first recorded dental hygiene appointment in Axium: \_\_\_\_\_

Date of final recorded hygiene appointment in Axium: \_\_\_\_\_

Caries status at initial dental hygiene visit:    Active                      At risk                      Controlled

Caries status at final dental hygiene visit:    Active                      At risk                      Controlled

Plaque level at first visit: \_\_\_\_\_ Plaque level at last visit: \_\_\_\_\_

*Intervention group only:*

Date of first recorded plaque level: \_\_\_\_\_ Score: \_\_\_\_\_

Date of final recorded plaque level: \_\_\_\_\_ Score: \_\_\_\_\_

Number of protective factors at first visit: \_\_\_\_\_

Number of protective factors at final visit: \_\_\_\_\_

Number of risk factors at first visit: \_\_\_\_\_

Number of risk factors at final visit: \_\_\_\_\_

Date	Caries status	New caries diagnosis	Plaque level	Exam
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N

**APPENDIX B: DATA COLLECTION INSTRUMENT-INTERVENTION GROUP ONLY**

Chart #	Date:	Date:	Date:	Date:	Date:	Date:
	Answer	Answer	Answer	Answer	Answer	Answer
<b>RISK FACTORS</b>						
1.Visible heavy plaque on teeth	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
<b>PROTECTIVE FACTORS</b>						
2.Drinks fluorinated water from municipal supply	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
3. Fluoride toothpaste at least once a day	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
4.Fluoride toothpaste at least 2xday	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
5.Fluoride mouth rinse (0.05%NaF) daily	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
6.5000 ppm F fluoride toothpaste daily	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
7.Chlorhexidine prescribed/used one week each of last 6 months	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
8.Xylitol gum/lozenges 4x daily last 6 months	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
9.MI paste during last 6 months	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
<b>SUMMARY</b>						
# of YES Risk Factors						
# of YES Protective Factors						

Date	Caries status	New caries diagnosis	Plaque level	Exam
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N
	A C AR	Y/N		Y/N

## **APPENDIX C: IRB RESPONSE**

Project number: IRB #00000159.

Principal Investigator: Krista Kriegler

Title: Caries management by risk assessment and the effect on caries diagnosis and oral health behaviors

Protocol Type: (E) Exempt Approval Date: June 23, 2017