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CASE REPORT

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Caries Management by Risk Assessment vs. Traditional Preventive Strategies: Effect on Oral Health Behaviors and Caries Diagnoses: A Retrospective Case-Control Observational Design

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Abstract

Results showed patients who had undergone Caries Management by Risk Assessment (CAMBRA) had statistically significant lower plaque scores and improved their oral self-care behaviors. 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.

KEYWORDS

CAMBRA, caries management by risk assessment, dental caries, oral health education

1 | INTRODUCTION

Dental 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.[1-3] Traditionally, caries preventive strategies have focused on providing oral health education and brushing and flossing demonstrations.[4] Assessment of caries risk has not been part of this traditional strategy of prevention. Current scientific evidence has shown the success to caries prevention and management lies with assessing a patient's risk for caries, then altering the complex dental biofilm and modifying oral factors to improve health. A validated tool that was created to represent the multifactorial nature of dental caries disease is caries management by risk assessment (CAMBRA), as it emphasizes the balance between pathological and protective factors in the caries process.[2,4-7] CAMBRA identifies pathological factors as poor oral self-care practices, frequency of carbohydrate intake suboptimal fluoride exposure, cariogenic bacteria, and a history of caries.[8] Protective factors include optimal fluoride exposure, dietary control of sucrose and good oral hygiene habits.[8] A growing body of evidence suggests CAMBRA can lower caries risk by altering the balance between protective and pathological factors.[7,9] The theoretical framework posits that by collecting information about a patient's unique caries balance a clinician can "assess" the risk of future demineralization based on weighing the disease indicators (past caries history), and pathological risk factors against existing protective factors. Using the knowledge gained from CAMBRA, a patient can implement behavior change to reduce risk factors, enhance protective factors, and, if needed, receive minimally invasive restorative treatment resulting in control of the disease.[2] A caries risk assessment form (CRA) is validated tool that was created to represent the balance /imbalance theory when implementing CAMBRA. The CRA form

collects information on physical proof (cavitations, white spots, radiolucencies) of the existence (past or present) of caries disease, as well as protective and pathological risk factors. The form identifies pathological factors as poor oral self-care practices, frequency of carbohydrate intake suboptimal fluoride exposure, cariogenic bacteria, and a history of caries.[6] Protective factors include optimal fluoride exposure, dietary control of sucrose and good oral hygiene habits.[6]

Using CAMBRA, a dental provider gathers specific oral health and behavioral information from a patient, evaluates the balance of pathological and protective factors and categorizes a patient's risk for future disease.[8] CAMBRA results serve as a springboard for a discussion between a provider and patient about caries risk, modification of protective and pathological factors, as well as the patient's motivation to change behavior.[10-17]

In recent years, several studies have shown the use of CAMBRA results in lowering a patient's caries risk category over time.[8,12,17] In a retrospective experimental study by Featherstone, et al., the investigators compared three groups of high caries risk patients that either: 1) never received the anticaries products, 2) took the products once and never returned for refills and, 3) took the anticaries products and returned for at least one more refill. After 18 months, statistical significance in caries increments between groups was demonstrated.[8] Findings from this study suggest using a CAMBRA tool, which includes the preventive regimen may lower caries risk over time. Findings from a practice-based clinical setting showed similar evidence that CAMBRA lowers caries risk by addressing protective and pathological factors.[8] International research has shown CAMBRA efficacious in predicting future caries diagnoses.[9,10,18] An observational study of children living in rural communities in Ecuador found that specific risk factors recorded with CAMBRA such as current active decay, frequent snacking or heavy plaque were indicative of future caries. The investigators recommended CAMBRA become a standard tool for comprehensive oral examination and be used as the basis for a preventive and treatment plan.[18] Gauba et al. evaluated a CAMBRA-based therapeutic and preventive model for high caries risk children in a pediatric dentistry clinic. One hundred systemically healthy children ages 4–8 were enrolled in the program. The children underwent caries risk assessment and customized preventive interventions (motivational interviewing and counseling, oral prophylaxis, fluoride varnish, fissure sealants) and restorative procedures. The CAMBRA-based program showed highly favorable results, as only 3/100 children developed new carious lesion at the end of one year.[9] Kudlure et al. found CAMBRA was valid and highly predictive in determining the caries risk among institutionalized children.[10] To date, there is insufficient evidence to conclusively state that the use of CAMBRA reduces caries risk or lowers number of caries diagnoses vs. traditional oral health education strategies. More evidence is needed about the efficacy of the CAMBRA tool to modify caries risk factors to favor health and reduce caries diagnoses. Therefore, the purpose of this study was to determine if a caries risk assessment tool reduces caries risk and lower caries diagnoses vs. using traditional oral health education.

1.1 | Research Questions

1. For a patient with active caries, does the use of CAMBRA, as compared to traditional oral health education result in a decrease of new caries lesions?
2. For a patient with active caries, does the use of CAMBRA when compared to traditional oral health education improve oral health behaviors as measured by plaque scores?

1.2 | 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

2 | STUDY POPULATION AND METHODOLOGY

This study used a retrospective, case-control observational design. Prior to the implementation of CAMBRA protocol in the dental hygiene clinic in 2012, students provided traditional oral health education and brushing and flossing demonstrations. A sample consisting of 207 patient records from the SOD dental hygiene clinic were screened for inclusion and exclusion criteria. Inclusion criteria for the test group included patients eighteen years of age or older with their first visit to the SOD's dental hygiene clinic between 2012 and 2016, two or more dental hygiene clinic visits and two or more completions of CAMBRA. 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 and 2011, no record of CAMBRA completion, 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.

For this study, a planned sample size of 100 in each group had 80% power to detect an effect size based on a chi-square test for two proportions (eg, new caries rates from the two groups) at the 0.05 alpha level. Using inclusion/exclusion criteria, patient records were queried in the SOD's electronic health record database. Because the study was retrospective, study parameters were based on data in the patient record; clinical observation data such as disease indicators could not be assessed. Using the CRA form, the blinded primary investigator recorded changes in caries status and new caries diagnoses as noted in the dental record for both the test and control groups. Caries diagnoses were made by dentist faculty using both clinical and radiographic examination during the dental hygiene appointment. Additionally, any change in the following protective factors for the test group at the first, second and last patient visits of the study period were recorded: drinks fluorinated water from municipal supply, fluoride toothpaste at least once a day, fluoride toothpaste at least 2xday, fluoride mouth rinse (0.05%NaF) daily, 5000 ppm F fluoride toothpaste daily, and chlorhexidine prescribed/used one week each of last 6 months. To assess plaque levels on teeth, plaque scores, based on the Silness and Loe plaque index (PI), were obtained and recorded as low, moderate or high.[11] The dental literature supports the use of the PI, as cariogenic organisms have been used as outcome measures to assess oral self-care behaviors.[2,5,12] Additionally, gender, age and dental insurance type were recorded for both the test and control groups (Appendix A). To ensure consistency in recording, only the primary investigator performed the data collection.

All patients in the study sample were seen by students in the baccalaureate dental hygiene program at the University of Minnesota School of Dentistry (SOD). Beginning in semester two of the six semester curriculum, dental hygiene students provide care to adult patients in the SOD clinics, and therefore had varying skill levels using CAMBRA during the study period. Dental hygiene students provided care for the same patients while they were enrolled in the dental hygiene program. The average timeframe between patient visits was six months.

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. The study conforms to recognized standards in the US Federal Policy for the Protection of Human Subjects. Informed consent was obtained from all participants. This study was approved by the University of Minnesota and was determined by the IRB to be exempt (IRB #00000159).

TABLE 1 Subject characteristics

	Control	Intervention
Variable	$n = 100$	$n = 107$
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 (dental coverage purchased by patient)	23	25
State (payment for services paid by state government)	18	23
None	59	59

2.1 | Operational Definitions

Traditional oral health education: providing a patient with information about dental disease processes, toothbrushing and/or flossing demonstrations and recommendations for changing behaviors.

3 | RESULTS

A total of 207 patients ($n = 207$) comprised the study sample. One hundred records comprised the control group and one hundred and seven comprised the test group. Table 1 shows patient demographics. The control and test groups were fairly homogenous with regard to gender, age and type of dental insurance. The majority of patients in both groups were over the age of 60 and did not have any type of dental insurance. In

both the control and test groups, at least 50% of the patients presented with active caries at visit one (Table 2). Not all patients had the same number of visits during the study, but all patients 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.

Dental records showed patients who completed CAMBRA improved their oral self-care behaviors. Plaque scores in the test group decreased and scores were statistically significant between groups at the last visit (p-value = 0.0442). Correlated with this finding was the increase in the number of protective factors over the course of five visits in the test group (see Table 3). The only protective factor that did not increase in use was a prescribed chlorhexidine rinse. The most common reported protective factor was the use of fluoride toothpaste daily.

Differences in new caries diagnosis were not statistically significant between groups (Table 4). No relationship between new caries diagnosis, plaque score, age, gender or type of insurance was found. Although statistical significance was not attained, raw data showed the percentage of new caries diagnoses at the last visit was lower for the test group (Table 2).

TABLE 3 Test Group: Mean Risk and Protective Factors Over Five Visits

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

Abbreviations: R=risk factors; P=protective factors.

TABLE 4 Comparison of new caries diagnosis and plaque scores between groups at first and last visit ($p > 0.05$) Control vs. Test Group

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

4 | 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, as compared to traditional oral health education strategies. Patients in the test 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 patients to adopt behaviors that may improve oral health. Records from the test group showed patients increased their use of six of the eight protective factors over time, including a 7.66% increase in the use of 5000 ppm fluoride toothpaste from visit one to visit three. Findings failed to reject the null hypothesis that there would be no difference in new caries diagnosis for patients of record with CAMBRA vs. patients who did not undergo risk assessment. However, even though statistical significance was not obtained, raw data showed a greater reduction in new caries in the test group (Table 4). The small sample size may have prevented a statistically significant effect of CAMBRA on new caries diagnosis.

TABLE 2 Patients with new caries diagnosis at first and last visits (%)

	First visit	Last visit
Control	49.00	29.00
Intervention	41.14	18.69

The findings support previous research suggesting the use of a caries management by risk assessment protocol provides the ability to individualize preventive strategies such as the use of fluoride toothpaste, and specifically modify pathological factors putting the patient at risk for caries. The decrease in plaque scores over time suggests that patients were motivated to adopt several positive changes in their oral self-care habits and complied with the CAMBRA high caries risk protocol. The findings of this study add to the body of knowledge affirming the superiority of caries management by risk assessment over traditional oral health education methods.[5,8,13-16]

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 a patient is a critical step that may contribute to the patient's motivation to change

their oral self-care habits. CAMBRA allows patients the opportunity to visually see their risk vs. protective factors ratio, reflect on their oral self-care habits 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 and does not support patient autonomy. Empirical research indicates advice giving methods or fear tactics are ineffective, do not support patient autonomy and will not sustain long-term positive behaviors.[17,19] 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. 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 choose 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[23]. Studies on motivational interviewing (MI) suggest behavior change is achieved by helping patients explore and resolve doubt in their own ability to change[23–25]. CAMBRA may facilitate this type of exploration and discussion between provider and patient and 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 improve oral health behaviors thus lowering a patient's risk for future caries.[8,16] 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, CAMBRA offers an early minimal intervention strategy, as it predicts an individual's expected caries experience over a period of time and allows identification of individualized preventive treatment strategies to mitigate disease.

A limitation of this study was the study setting, as well as control of the students' CAMBRA presentation and discussion. General clinical notes, recorded plaque scores, and frequency of CAMBRA form completions were not consistent among student providers. Patients' reported use of preventive regimens were based on self-reports. Additionally, the limited sample size and length of time may have prevented a statistically significant effect of CAMBRA on new caries diagnosis. Future studies should include longer prospective studies with larger sample populations. Specific protective or risk factors within CAMBRA to determine if one or more have greater impact on caries development should also be a future research focus.

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CONFLICT OF INTEREST

The authors declare they have no conflict of interests.

AUTHOR CONTRIBUTIONS

Krista Kriegler, first author, contributed to acquisition, analysis, and interpretation of data and drafted the manuscript. Dr. Christine Blue, second author, contributed to the conception and design of the study, supported the analysis and interpretation of the data, and critically revised the manuscript.

ETHICAL APPROVAL

The manuscript is not being considered for publication elsewhere (see separate files for conflict of interest statements).

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APPENDIX A

Subject enrollment form and data collection instrument (both groups)

Subject ID_____Chart review/enrollment date_____.
Individual enrolling subject: _____.
Age: _____.
Gender: MaleFemale.
Group: ControlIntervention.
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: ActiveAt riskControlled.
Caries status at final dental hygiene visit: Active At riskControlled.
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

Caries Risk Assessment Form (Intervention Group only)

Chart #	Date:	Date:	Date:	Date:	Date:	Date:
	Answer	Answer	Answer	Answer	Answer	Answer
Risk Factors						
1. Visible heavy plaque on teeth	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
Protective factors						
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
Summary						
# of YES Risk Factors						
# of YES Protective Factors						