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Unmasking caries risk: a multi-regional study in Saudi Arabia

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Abstract

Background Dental caries are common and troublesome and may affect individuals' health conditions. It is crucial to comprehend the caries experience for prevention, management, and enhancing oral health. Techniques such as CAMBRA can help assess an individual's risk factors for caries lesions. This study aims to assess the caries risk in five distinct regions of Saudi Arabia, utilizing the CAMBRA methodology.

Methods This multiregional cross-sectional study was conducted at university dental clinics across the five regions of Saudi Arabia, using a Caries Management by Risk Assessment (CAMBRA) tool. This study used binary logistic regression analysis, the Pearson Chi-square test, and descriptive analysis as statistical methods.

Results A total of 551 respondents participated in the study, with 59.7% being male and 40.3% being female. The age group with the highest proportion was 20–29, making up 31.6% of the participants. All participants exhibited at least one caries lesion (100%), with white spots (66.4%) and enamel lesions (56.1%) being the most prevalent. The moderate-risk category encompassed the largest proportion of participants, accounting for 60% of the total. High caries risk had a significant association with age group ($P < 0.001$), education ($P < 0.001$), profession ($P < 0.001$), and socio-economic status ($P < 0.001$). Furthermore, only age and socio-economic status showed a significant relationship with high caries risk in the multiple logistic regression.

Conclusion The CAMBRA tool indicates a high prevalence of moderate risk across the five regions of Saudi Arabia, identifying age and socio-economic status as significant predictors of caries risk.

Keywords Caries, Management, Prevention, Risk

Introduction

Dental caries poses a significant public health challenge due to its widespread prevalence, pain-inducing nature, high treatment costs, and potential to disrupt nutrition [1–3]. Dental caries harms about 100% of adults and between 60% and 80% of children worldwide, based on a 2012 oral health survey by the World Health Organization [4]. The multifaceted nature of dental caries, involving factors such as bacteria, nutrition, and host response, makes it a global concern despite ongoing advancements in scientific understanding [5, 6]. Addressing dental caries requires a comprehensive preventive approach,

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including the identification and evaluation of individuals susceptible to future caries using various assessment tools and models [5]. Several studies investigating the prevalence of dental caries have been conducted in the Kingdom of Saudi Arabia (KSA), revealing consistently high rates of caries in both adults and children [7]. Some of these studies, including systematic reviews have provided insights into the extent of caries over specific periods [8]. For instance, dental cavities affect 70% of children in permanent dentition and 80% of elementary school pupils in primary dentition [8]. Another study found that dental caries was common in the permanent dentition, with a mean DMFT of 3.34 in the primary dentition and 5.38 in the permanent dentition [9]. Similarly, Al-Ansari [10] reported mean DMFT values of 7.35 in adult permanent dentition and 7.34 in primary dentition. Studies across various regions of Saudi Arabia have demonstrated differing levels of dental caries prevalence [11–13]. However, a recent systematic review highlighted wide-ranging prevalence measures, extending from 21 to 100% in primary teeth as well as from 5 to 99% in permanent teeth [7]. Dental caries results from a variety of factors, encompassing oral microbiota, salivary production, and composition, as well as lifestyle factors like dietary habits, tooth brushing, and the use of fluoride-containing toothpaste [14–18]. Consequently, tailoring dental care plans to everyone's specific risk factors is essential. To achieve this, many dental professionals advocate for the implementation of the evidence-based Caries Management by Risk Assessment (CAMBRA) technique used to evaluate and manage caries risk in children and adults [18]. People as young as six years old have their current risk of caries assessed using CAMBRA based on disease signs, risk factors, and protective factors [19]. CAMBRA has not been used as much as it may be to assess caries risk in Saudi Arabian citizens [6]. Therefore, the purpose of this study was to evaluate caries risk in five different regions of Saudi Arabian using the CAMBRA.

Methods

Design of study

This study used a cross-sectional survey technique, carried out within the university dental clinics affiliated with the dental colleges across five different regions of Saudi Arabia. The study utilized a CAMBRA tool [20]. Prior to obtaining formal informed consent, the research team ensured the voluntary participation of all participants and briefed them about the study's purpose before obtaining written informed consent. For minors, we obtained informed consent from their parent or guardian. After completing survey forms, participants had an intra-oral examination and a bitewing radiography to determine how clean their teeth were and to look for any indications of caries.

Data collection

Participants were recruited from outpatient departments of university dental clinics in five regions, together with their partners (e.g., siblings, family members, or friends). Participants had to be at least six years old, fluent in both English and Arabic, and live in Saudi Arabia. A stratified simple random sampling technique, proportional to the population size, was employed to select participants from the five regions (i.e., north, west, south, east, and centre). The study was conducted from March 15, 2023, to December 15, 2023. The Ethical approval was taken from the Institutional Scientific Research and Bioethical Committee.

Study instrument

The study questionnaire consisted of a socio-demographic section and a CAMBRA caries risk assessment section. The sociodemographic section includes gender, age group, occupation, place of residence, region, educational level, and socio-economic status. The CAMBRA section includes four disease indicators (i.e., visible cavities or radiographic penetration of the dentin, radiographic approximal enamel lesions, white spots on smooth surfaces, restorations in the last three years), eight protective factors, and eight risk factors [20]. Additionally, this tool was tested and utilized among the Saudi Arabian population in a prior study [6].

Estimation of sample size

Based on the single proportion formula [21], we calculated the sample size and arrived at an initial estimate of 384 samples. This calculation was based on a presumed proportion (p) of 0.5, chosen to account for the highest possible variance and sample size [21], as no prior studies had been conducted across regions in Saudi Arabia. Furthermore, a significance level (z) of 1.96 and a margin of error (E) of 0.05 were used. After factoring in a 40% dropout rate to accommodate potential missing data and wrong data entry, the adjusted sample size was determined to be 640.

Data analysis

Initially, we conducted data cleaning to rectify missing values and erroneous data entries. Using Statistical Product and Service Solution (SPSS) version 27, the statistical analyses used in this study included binary logistic regression analysis, the Pearson Chi-square test, and descriptive analysis. Frequencies and percentages were presented using descriptive analysis. The relationship between sociodemographic traits and caries risk was examined using the Pearson Chi-square test. In order to determine the important variables connected to high-risk caries, we performed a binary logistic regression analysis. To find the crude odds ratio (COR) of predictors,

basic logistic regression was used in the first stage of the logistic regression process. In order to calculate their adjusted odds ratio (AOR), factors with p-values less than 0.25 were deemed important and added to the multiple logistic regression analysis. The multiple logistic regression used both forward LR and backward LR approaches, and the entry method was used to execute the final model. Using analyses of variable interactions, Hosmer and Lemeshow tests, classification accuracy, and the area under the receiver operating characteristic curve (AUC), the final model's suitability was evaluated.

Table 1 Socio-demographic characteristics of the participants ($n=551$)

Characteristics	Groups	Number (%)
Gender		
	Male	329 (59.7)
	Female	222 (40.3)
Age group		
	6–19	81 (14.7)
	20–29	174 (31.6)
	30–39	141 (25.6)
	40–49	87 (15.8)
	50–59	54 (9.8)
	≥ 60	14 (2.5)
Residence		
	Rural	179 (32.5)
	Urban	372 (67.5)
Region		
	North	146 (26.5)
	South	129 (23.4)
	East	112 (20.3)
	West	92 (16.7)
	Centres	72 (13.1)
Education		
	None	71 (12.9)
	Primary and below	37 (6.7)
	Secondary	111 (20.1)
	Higher secondary	111 (20.1)
	Bachelor	165 (29.9)
	Masters	33 (6.0)
	PhD	5 (0.9)
	Others	18 (3.3)
Profession		
	Business	115 (20.9)
	Doctor	41 (7.4)
	Engineer	8 (1.5)
	Lawyer	2 (0.4)
	Teaching	60 (10.9)
	Mechanic	5 (0.9)
	Student	135 (24.5)
	Housewife	46 (8.3)
	Others	139 (25.2)
Socio-economic status		
	Lower	74 (13.4)
	Lower middle	225 (40.8)
	Middle	165 (29.9)
	Upper	87 (15.8)

Results

Table 1 presents the socio-demographic characteristics of the study respondents. A total of 551 respondents participated in the study, consisting of males (59.7%) and females (40.3%). Those aged 20–29 had the highest proportion (31.6%). The majority of the respondents were from urban areas (67.5%). The highest proportion of the participants were from the northern region (26.5%) and possessed a bachelor's degree (29.9%). Furthermore, about half of the participants were of lower middle class (40.8%).

Table 2 illustrates the distribution of study participants based on disease indicators, risk factors, and protective factors. All participants exhibited at least one disease indicator (100%), with white spots (66.4%) and enamel lesions (56.1%) being the most prevalent. Among the identified risk factors, frequent snacks (62.1%) were the most commonly observed, followed by visible heavy plaque on teeth (56.1%). As for protective factors, fluoridated communities (61.0%) ranked highest, followed closely by fluoride toothpaste (60.6%).

Figure 1 shows that the 'moderate' risk category encompassed the largest proportion of participants, accounting for 60% of the total, whereas only 4% fell into the 'extremely' high-risk category of caries risk assessment.

Table 3 presents the association between socio-demographic characteristics and caries risk. The results indicate that caries risk categories had a significant association with age group ($P<0.001$), education ($P<0.001$), profession ($P<0.001$), and socio-economic status ($P<0.001$). In terms of age, the prevalence of high risk was higher in individuals over 60 years old (71.4%) compared to the other age groups. Those with a PhD (100%) had a higher frequency of intermediate risk than the other groups. Among the professions, mechanics had the highest prevalence of extremely high risk (20%) when compared to other professions. In terms of socioeconomic position, the lower class had a higher prevalence of extremely high risk (8.1%), followed by the lower middle class (5.3%).

Table 4 presents the factors associated with high-risk caries using simple and multiple logistic regression analyses. In the multiple logistic regression analysis, only age and socio-economic status demonstrated a significant association with high caries risk. In terms of age groups, the 20–29-year-olds were 1.8 times more likely than the 6–19-year-olds to have a high caries risk (AOR=1.82, $P=0.144$). The 30-39-year-olds were 3 times more likely to have high-risk caries compared to the 6-19-year-olds (AOR=3.04, $P=0.006$); the 40–49 were 9.6 times more

Table 2 The study respondents according to disease indicators, risk, and protective factors ($n = 551$)

Disease Indicators	Yes *N* (%)	No *N* (%)
Visible cavities or radiographic penetration of the dentin	254 (46.1)	297 (53.9)
Radiographic approximal enamel lesions (not in dentin)	309 (56.1)	242 (43.9)
White spots on smooth surfaces	366 (66.4)	185 (33.6)
Restorations in last three years	176 (31.9)	375 (68.1)
Risk Factors		
Visible heavy plaque on teeth	309 (56.1)	242 (43.9)
Frequent snack (> 3 × daily between meals)	342 (62.1)	209 (37.9)
Deep pits and fissures	213 (38.7)	338 (61.3)
Recreational drug use	72 (13.1)	479 (86.9)
Inadequate saliva flow by observation	69 (12.5)	482 (87.5)
Saliva reducing factors (medications/radiation/systemic)	171 (31.0)	380 (69.0)
Exposed roots	74 (13.4)	477 (86.6)
Orthodontic appliances	106 (19.2)	445 (80.8)
Protective Factors		
Home/work/school is a fluoridated community	336 (61.0)	215 (39.0)
Fluoride toothpaste at least once daily	334 (60.6)	217 (39.4)
Fluoride toothpaste at least 2 × daily	111 (20.1)	440 (79.9)
Fluoride mouth rinse (0.05% NaF) daily	85 (15.4)	466 (84.6)
Fluoride varnish in last six months	82 (14.9)	469 (85.1)
Chlorhexidine prescribed/used one week each of last six months	88 (16.0)	463 (84.0)
Xylitol gum/lozenges 4 × daily last six months	102 (18.5)	449 (81.5)
Calcium and phosphate paste during last six months	151 (27.4)	400 (72.6)

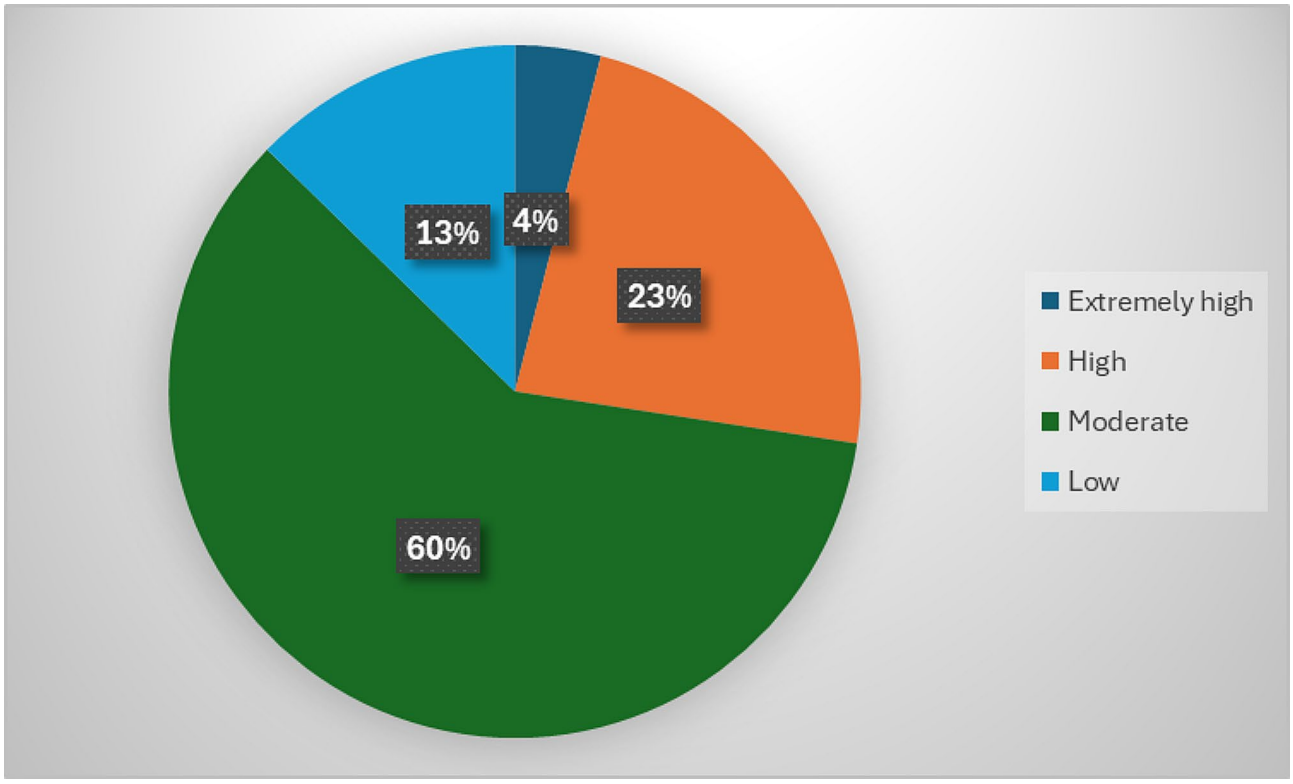

Fig. 1 Caries assessment

Table 3 The association between socio-demographic characteristics and caries risk ($n=551$)

Variable		Caries risk				*P*
		Extremely high N (%)	High N (%)	Moderate N (%)	Low N (%)	
Gender						0.730
	Male	14 (4.3)	82 (24.9)	192 (58.4)	41 (12.5)	
	Female	8 (3.6)	47 (21.2)	138 (62.2)	29 (13.1)	
Age group						**< 0.001**
	6–19	3 (3.7)	7 (8.6)	48 (59.3)	23 (28.4)	
	20–29	6 (3.4)	22 (12.6)	122 (70.1)	24 (13.8)	
	30–39	8 (5.7)	27 (19.1)	88 (62.4)	18 (12.8)	
	40–49	0 (0)	42 (48.3)	43 (49.4)	2 (2.3)	
	50–59	4 (7.4)	21 (38.9)	26 (48.1)	3 (5.6)	
	≥ 60	1 (7.1)	10 (71.4)	3 (21.4)	0 (0)	
Residence						
	Rural	11 (6.1)	40 (22.3)	109 (60.9)	19 (10.6)	0.245
	Urban	11 (3.0)	89 (23.9)	221 (59.4)	51 (13.7)	
Region						0.101
	North	11 (7.5)	39 (26.7)	78 (53.4)	18 (12.3)	
	South	5 (3.9)	26 (20.2)	76 (58.9)	22 (17.1)	
	East	4 (3.6)	30 (26.8)	69 (61.6)	9 (8.0)	
	West	1 (1.1)	16 (17.4)	65 (70.7)	10 (10.9)	
	Centres	1 (1.4)	18 (25.0)	42 (58.3)	11 (15.3)	
Education						**< 0.001**
	None	2 (2.8)	27 (38.0)	36 (50.7)	6 (8.5)	
	Primary and below	3 (8.1)	11 (29.7)	7 (18.9)	16 (43.2)	
	Secondary	6 (5.4)	27 (24.3)	64 (57.7)	14 (12.6)	
	Higher secondary	4 (3.6)	23 (20.7)	73 (65.8)	11 (9.9)	
	Bachelor	4 (2.4)	29 (17.6)	113 (68.5)	19 (11.5)	
	Masters	0 (0)	4 (12.1)	27 (81.8)	2 (6.1)	
	PhD	0 (0)	0 (0)	5 (100)	0 (0)	
	Others	3 (16.7)	8 (44.4)	5 (27.8)	2 (11.1)	
Profession						**< 0.001**
	Business	6 (5.2)	41 (35.7)	62 (53.9)	6 (5.2)	
	Doctor	1 (2.4)	4 (9.8)	31 (75.6)	5 (12.2)	
	Engineer	0 (0)	0 (0)	8 (100)	0 (0)	
	Lawyer	0 (0)	0 (0)	1 (50.0)	1 (50.0)	
	Teaching	1 (1.7)	8 (13.3)	46 (76.7)	5 (8.3)	
	Mechanic	1 (20.0)	1 (20.0)	3 (60.0)	0 (0)	
	Student	7 (5.2)	16 (11.9)	81 (60.0)	31 (23.0)	
	Housewife	2 (4.3)	16 (34.8)	18 (39.1)	10 (21.7)	
	Others	4 (2.9)	43 (30.9)	80 (57.6)	12 (8.6)	
Socio-economic status						**< 0.001**
	Lower	6 (8.1)	22 (29.7)	27 (36.5)	19 (25.7)	
	Lower middle	12 (5.3)	53 (23.6)	142 (63.1)	18 (8.0)	
	Middle	4 (2.4)	40 (24.2)	96 (58.2)	25 (15.2)	
	Upper	0 (0)	14 (16.1)	65 (74.4)	8 (9.2)	

likely to have high-risk caries compared to the 6-19-year-olds (AOR=9.59, $P<0.001$); the 50-59-year-olds were 8.6 times more likely to have high-risk caries compared to the 6-19-year-olds (AOR=8.56, $P<0.001$); and those in the 60+years were 34 times more likely to have high-risk caries compared to the 6-19-year-olds (AOR=34.04, $P<0.001$). In terms of socioeconomic status, those in lower middle status were 2.4 times less likely to have high-risk caries compared to those with lower status (AOR=0.42, $P=0.006$), those in middle status were 2.9 times less likely to have high-risk caries compared to those with lower status (AOR=0.34, $P=0.001$), and those in upper status were 4.5 times less likely to have high-risk

Table 4 Factors associated with high-risk caries ($n=551$)

Factors	Group	COR (95% CI)	*P* Value	AOR (95% CI)	*P* Value
Gender					
	Male	1			
	Female	0.80 (0.54, 1.18)	0.256	-	-
Age group					
	6–19	1		1	
	20–29	1.36 (0.63, 2.96)	0.435	1.82 (0.81, 4.08)	0.144
	30–39	2.34 (1.09, 5.04)	**0.029**	3.04 (1.38, 6.71)	**0.006**
	40–49	6.63 (3.03, 14.52)	**< 0.001**	9.59 (4.17, 22.04)	**< 0.001**
	50–59	6.12 (2.61, 14.34)	**< 0.001**	8.56 (3.50, 20.97)	**< 0.001**
	≥ 60	26.03 (6.18, 109.66)	**< 0.001**	34.04 (7.80, 148.51)	**< 0.001**
Residence					
	Rural	1			
	Urban	0.92 (0.62, 1.37)	0.692	-	-
Region					
	North	1			
	South	0.61 (0.36, 1.03)	**0.065**	-	-
	East	0.84 (0.49, 1.42)	0.509	-	-
	West	0.44 (0.23, 0.82)	**0.009**	-	-
	Centres	0.69 (0.37, 1.29)	**0.242**	-	-
Education					
	None	1			
	Primary and below	0.88 (0.39, 1.99)	0.762	-	-
	Secondary	0.61 (0.33, 1.14)	**0.124**	-	-
	Higher secondary	0.47 (0.25, 0.88)	**0.020**	-	-
	Bachelor	0.36 (0.20, 0.67)	**0.001**	-	-
	Masters	0.20 (0.06, 0.63)	**0.006**	-	-
	PhD	-			
	Others	2.28 (0.79, 6.56)	**0.128**	-	-
Profession					
	Business	1			
	Doctor	0.20 (0.07, 0.55)	**0.002**	-	-
	Engineer	-	-		
	Lawyer	-	-	-	-
	Teaching	0.26 (0.12, 0.57)	**0.001**	-	-
	Mechanic	0.97 (0.16, 6.00)	0.969	-	-
	Student	0.30 (0.17, 0.53)	**< 0.001**	-	-
	Housewife	0.93 (0.46, 1.87)	0.839	-	-
	Others	0.74 (0.44, 1.23)	**0.247**	-	-
Socio-economic status					
	Lower	1		1	
	Lower middle	0.68 (0.39, 1.16)	**0.150**	0.42 (0.23, 0.78)	**0.006**
	Middle	0.60 (0.33, 1.07)	**0.083**	0.34 (0.18, 0.65)	**0.001**
	Upper	0.32 (0.15, 0.66)	**0.002**	0.22 (0.10, 0.48)	**< 0.001**

COR = crude odds ratio, AOR = Adjusted odds ratio, CI = confidence interval.

caries compared to those with lower status (AOR = 0.22, $P<0.001$).

Discussion

This study evaluated the caries risk across five regions of Saudi Arabia using CAMBRA tool. The study's findings revealed that every participant (100%) exhibited at least one indication of caries, with 56.1% displaying clinically or radiographically confirmed dentin or enamel lesions. Additionally, 31.9% of individuals had undergone restorative treatment within the past three years. Consistent with prior research [6, 22–25], our study corroborates that visible cavities and white spot lesions constitute most lesions. The primary risk factors identified were plaque accumulation (56.1%) and frequent consumption of sugary foods (62.1%). Conversely, factors such as

recreational drug use, orthodontic appliances, reduced salivary flow, exposed roots, and saliva-reducing conditions were less prevalent. These results align with earlier studies [6, 19, 22, 25], indicating a similar distribution of risk factors.

In this study, most participants (61.0%) reported fluoridated toothpaste as the primary protective factor, with over half (60.6%) indicating regular daily brushing. Less than half of the participants utilized calcium and phosphate paste, xylitol, fluoride varnish, or mouthwash. These findings align with previous research suggesting an increase in the high-risk caries group regardless of topical treatments or water fluoridation [6, 26]. Furthermore, clinical research by Featherstone et al. [27] demonstrated a significant reduction in caries with fluoride therapy and targeted antibacterial treatments.

The majority of participants in this study were classified as having a moderate risk of caries (60%), followed by those in the high caries risk category (23%). These results are consistent with prior studies [28, 29], although some studies have reported a higher prevalence of the high-risk group [23, 30, 31]. The recruitment of participants from a dental department, where individuals typically seek dental treatment, may explain the higher prevalence of caries risk in the present study. In this study, the prevalence of moderate risk was slightly higher among females (62.2%), the 20–29 years (70.1%), those residing in the western region (70.7%), individuals with a PhD (100%), and engineers (100%). These findings closely resemble those of studies by Iqbal et al., [6], where a higher prevalence of moderate risk was observed among females (16.7%). While no significant association between regions and caries risk was found in the present study, a notably higher prevalence of extremely high risk was observed in the northern region (7.5%). This observation is noteworthy, as previous studies have not extensively explored regional variations in CAMBRA.

Moreover, the results of this study suggest that age and socio-economic status are independently associated with a high risk of caries. Advanced age and lower socio-economic status were associated with an increased likelihood of high-risk caries. Age-related changes in oral hygiene habits, prolonged consumption of sugary foods and drinks, and possible reductions in saliva production—which naturally coats teeth—all contribute to an increased risk of dental problems [12, 32, 33]. In terms of socioeconomic position, people in lower socioeconomic brackets could have less access to preventive treatments, dental care, and information about good oral hygiene habits [34–36]. Additionally, because of factors like restricted access to healthy options or food instability, they can be more inclined to consume sugary foods and beverages [37].

A precise assessment of dental caries risk can enhance patient counselling and treatment plans. A proper risk analysis requires the use of patient-centric, easily understandable tools, like CAMBRA. With the aid of these tools, indicators of risk can be found, and then a customized treatment plan can be created for each patient. CAMBRA can improve a patient's relationship with the dentist by involving them in the process of decision-making. Among the study's shortcomings was its design. Including patients from the dental department may have influenced the study's conclusions because the majority of participants were at higher risk and there was no control group to compare the results with. On the other hand, the results may have additional value because the study was carried out in all five regions of Saudi Arabia. Additionally, the research employed a self-report measure, which can introduce bias into the responses.

Conclusion

This study conducted a multi-regional survey utilizing the Caries Management by Risk Assessment (CAMBRA) to evaluate risk of caries among population of five regions of Saudi Arabia. The study findings reveal that age and socio-economic status are associated with a high risk of caries. We recommend future studies calibrate CAMBRA as a caries prediction tool or determine whether using it actually has a caries-controlling effect.

Abbreviations

CAMBRA Caries Management By Risk Assessment

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Author contributions

Conceptualization: MAO. Methodology AI, HAA. Investigation and analysis: MNSA. Writing-Original draft preparation: AI, MAO. Editing, Reviewing: SA, OK. All authors read and approved the final manuscript.

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Data availability

The datasets generated and/or analyzed during the current studyare available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by Local Ethics Committee of Bioethics for Research at college of dentistry, Jouf University with the reference No 09-06-43.

Competing interests

The authors declare no competing interests.

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