Original Article

Predictors of Caries Risk among Egyptian Children Attending Pediatric Dental Clinics at a University Hospital

Rabaa Mahmoud Aboubakr[1], Doaa Mohsen Alkhadragy[1], Mai Monuir El Said Okda[1], Hadeer Wael Mohamed Rady[1], Rasha Mokhtar Elnagar[2,3]

[1]Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Mansoura University, [2]Department of Medical Microbiology and Immunology, Faculty of Medicine, Mansoura University, Mansoura, Egypt, [3]Department of Basic Medical Sciences, College of Medicine, AlMaarefa University, Riyadh, Saudi Arabia

Abstract

Background: Dental caries is the most prevalent dental disease. The external validity of the available caries risk assessment (CRA) tools is not established, especially among pediatric population.

Objectives: To assess caries risk using the caries management by risk assessment (CAMBRA) protocol among Egyptian children aged 3–12 years and suggest variables that could potentially be used to develop a simpler CRA model.

Materials and Methods: For this cross-sectional study, we recruited 320 children aged 3 to <6 years (Group I) and 320 children aged 6–12 years (Group II). CAMBRA was used to collect data about disease indicators, biological and environmental factors, and protective factors among study participants. Each child was examined clinically to collect data about past caries experiences and to measure plaque scores.

Results: The risk of caries was high in 92.5% of Group I and 83.4% of Group II participants. The overall dmft was 5.71 ± 3.18 for Group I and 4.78 ± 2.53 for Group II. In Group I, a significant positive relation was found between the overall mean caries risk score and past caries experience (dmft; $r = 0.344$, $P < 0.001$) and mean plaque index ($r = 0.463$, $P < 0.001$). In Group II, a significant positive relation was found between the overall mean caries risk score and dmft score ($r = 0.511$, $P < 0.001$), *S. mutans* count ($r = 234$, $P < 0.001$), *Lactobacilli* count ($r = 0.316$, $P < 0.001$), and plaque index ($r = 0.463$, $P < 0.001$). Participants' age, parents' education, and parents' occupation had a negative significant effect on the overall mean caries risk score.

Conclusion: This study suggests predictors that can be used in the development of a new CRA model for children aged 3–12 years.

Keywords: Child, dental caries, dental caries susceptibility, Egypt, risk assessment

Address for correspondence: Dr. Rabaa Mahmoud Aboubakr, Department of Pediatric Dentistry and Dental Public Health, Faculty of Dentistry, Mansoura University, Mansoura 11354, Egypt.
E-mail: rabaa@mans.edu.eg

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INTRODUCTION

The American Academy of Pediatric Dentistry (AAPD) recognizes early childhood caries as a significant chronic disease, resulting from an imbalance between multiple risk and protective factors over time.[1] When pathological factors overcome the preventive factors, dental hard tissue break down occurs, which can lead to pain and tooth loss.[2] Risk assessment may be a useful tool in caries prevention and management. It can be used as a strategy for improving the efficiency and effectiveness of preventive procedures and programs. Better and more cost-effective treatment can be provided by using risk assessment rather than providing treatments independent of the individual's risk.[3] To identify those at risk, several caries risk assessment (CRA) models have been developed such as the AAPD Caries-risk Assessment Form, Cariogram, the American Dental Association model, and the caries management by risk assessment (CAMBRA) protocol.[4]

CAMBRA was developed at the University of California, San Francisco (UCSF), in 2003, and has been updated several times based on clinical outcomes.[5-8] Risk is measured by several factors that contribute to caries progression or reversal: clinical observations, preventive factors, biological and environmental risk factors, and the clinical judgment of the care provider.[6,8] In CAMBRA, separate forms are used for CRA for two age ranges: aged 0 to <6 years and aged ≥6 years through adulthood. The caries risk level is classified by health care workers as low, moderate, high, or extremely high/extreme, depending on factors involved in the management of caries.[7] Recently, CRA has become the basis of preventive and minimal invasive approaches to caries management.[9,10] Worldwide, caries risk has been assessed using different CRA tools, but CAMBRA is most commonly used.[11] However, some of CAMBRA's items such as 5000 ppm F toothpaste, F varnish in the past 6 months, 0.05% sodium fluoride mouth rinse daily, and 0.12% chlorhexidine gluconate mouth rinse daily 7 days monthly, cannot be generalized in all countries because of differences in individuals' health awareness and socioeconomic levels. As stated by Young and Featherstone,[12] protocols and forms should be easy to understand and apply in clinical practice for successful caries management by risk assessment. In addition, there is a need for use of unified models across countries and similar studies to enable direct comparisons, and thus help provide consolidated data. In Egypt, there is insufficient evidence about the feasibility of using CAMBRA as a CRA tool among children.[13] Therefore, this study was conducted to collect data about the distribution of caries risk among Egyptian preschool- and school-aged children, and potentially suggest variables for developing a simpler CRA model that can easily be adopted universally.

MATERIALS AND METHODS

Study design, setting, and participants

This cross-sectional study was conducted in the Pediatric Department of the Faculty of Dentistry at Mansoura University, Mansoura, Egypt, between June 01 and September 30, 2022.

The study was conducted after obtaining approval from the Ethics Committee of the Faculty of Dentistry at Mansoura University. Legal guardians of the study participants were informed about the aim and specific objectives of the research and the value of their children's participation. Furthermore, they were informed that participation was voluntary and that the children's identities would be kept anonymous and confidential. Written informed consent was collected from parents/legal guardians prior to the data collection stage.

Sample size and group allocation

Oral screening was carried out for 5324 children who attended the pediatric dental clinic during the study period, of which 4320 children fulfilled the study criteria, which were being aged 3–12 years, free from systemic diseases or disabilities, and parents providing consent for participation. The eligible children (4320) were categorized into two groups: Group I (aged 3 to <6 years: 2592) and Group II (aged 6–12 years: 1728). The presumed population proportion was based on the reported prevalence of dental caries in Egypt: for Group I, it was considered as 61.4%,[14] and for Group II, as 60%.[15] An online sample size calculator was used to calculate the required sample (https://www.calculator.net/sample-size-calculator.html): with a 95% confidence level, 5% margin of error, the final subsample size for each group was calculated as 320 children for Group I and 305 children for Group II. Subsequently, a simple random sampling technique was used to recruit 320 children in each group (N = 640) [Figure 1].

Examiners training and calibration

Clinical examination was carried out by three clinical instructors in the Departments of Pediatric Dentistry and Dental Public Health. Although the examiners were well-trained in measuring oral hygiene and dental caries indexes, their skill was calibrated after a period of training on the assigned indexes. For training, each examiner practiced the examination on a group of 10 children for 2 days (n = 20). After two days, every examiner independently examined the same group of 20 children and

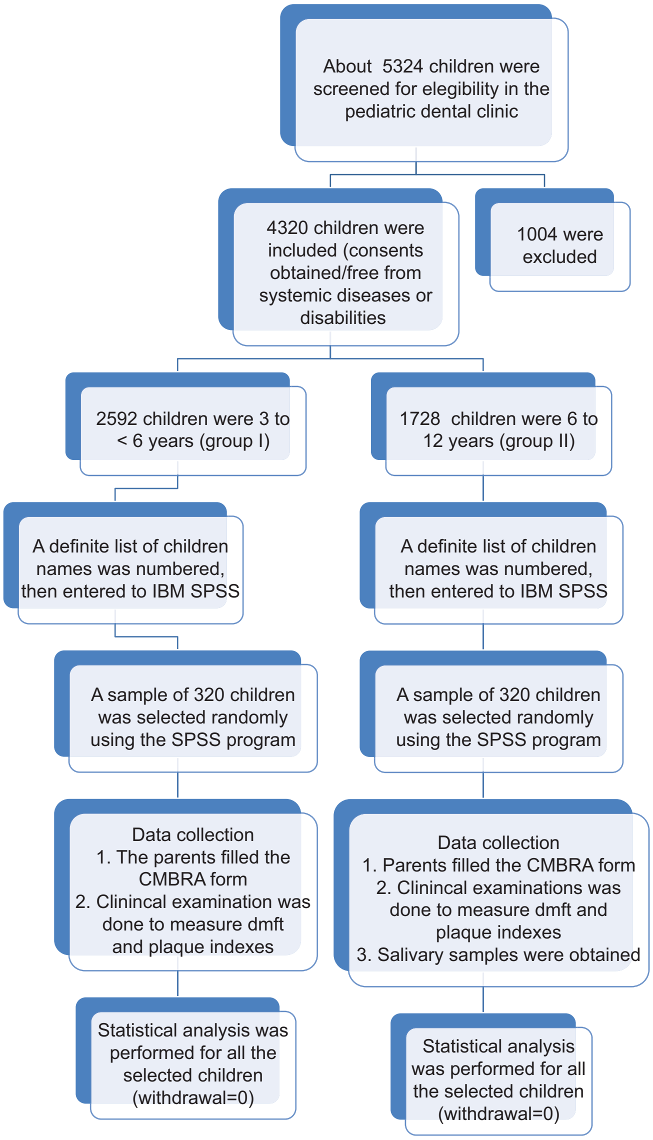

Figure 1: Flowchart showing study design and sample selection

compared their findings with those of the other examiners in the team; the inter-examiner reliability was >86%, which was considered good.[16] Regarding intra-examiner reliability, each examiner examined a group of 25 subjects twice, with a time interval of at least 30 minutes between examinations; the intraclass correlation coefficient was >93%; which was considered excellent based on Fleiss.[17]

Data collection

The participants' risk for caries was assessed for both groups using CAMBRA.[18] These risk assessment forms enable investigators to collect data about disease indicators, biological and environmental factors, and protective factors. Any disease indicator listed on the forms was scored +3, any item related to biological and environmental factors was scored +2, and any item related to protective factors was scored −1. For Group I, overall scores of −4 to −1 indicated minimal risk for caries, 0 to 3 moderate risk, 4 to 13 high risk, and 14 to 18 extremely high risk. For Group II, overall scores of −8 to −2 indicated minimal risk for caries, −1 to 2 moderate risk, 3 to 17 high risk, and 18 to 30 extremely high risk.[19]

In addition, social indicators such as parents' education levels and occupations were used to evaluate the socioeconomic levels of the participating children.[20,21]

Clinical examination

The oral examination was conducted in the pediatric dental clinic in regular dental chairs using artificial light. To assess the oral hygiene of children in Group II, the examiner used the Silness and Loe plaque index,[21] wherein a score of <1 indicates minimal risk for future caries and a score of >2 indicates elevated risk, while scores 1–2 indicated moderate risk. To assess the oral hygiene of children in Group I, plaque was determined to be present (score of 1) or absent (score of 0) based on the eruption date of teeth specified in the plaque index. To assess dental caries in primary/permanent teeth, examiners used indexes of decayed/Decayed, missing/Missed, and filled/Filled primary/permanent teeth/Tooth (dmft/DMFT) index.[22] A Community Periodontal Index (CPI) probe was used to detect dental caries using criteria of the World Health Organization for the diagnosis of dental caries.[22] A dmft/DMFT score of ≤1 indicated insignificant risk for dental caries, and a score of ≥6 indicated elevated risk for future caries, while scores more than 2 to 5 indicated moderate risk.

Salivary parameters

Children in Group II were instructed to refrain from eating or drinking for 1 hour before salivary sample collection. They were seated in a relaxed, upright position and given equal pieces of paraffin pellets (Paraffin pellets, Ivoclar Vivadent Marketing Ltd., Gurugram, India). They were instructed to chew for 30 s and then swallow the collected saliva, and then continue chewing for 5 min, spitting out the collected saliva every 1 min into 15-mL graduated test tubes. To calculate the stimulated salivary flow rate (SSFR) in milliliters per minute, the amount of collected saliva was divided by 5.[23] A SSFR of ≥1 mL/min indicates insignificant risk, and an SSFR of ≤0.5 mL/min indicates elevated risk for future caries.[23]

Bacterial isolation

The salivary samples were transported on the same day as collected to the Microbiology Diagnostic and Infection Control Unit at the Medical Microbiology and Immunology Department, Faculty of Medicine, Mansoura University, for microbiological testing. Two selective culture media were used: *Lactobacillus* MRS agar (Titan Biotech Ltd., Rajasthan, India) for isolation of *Lactobacillus* species and BD DIFCO™ Mitis Salivarius Agar 500 g (Becton, Dickinson and Company, Sparks, MD, USA) for isolation of *Streptococcus mutans*. All culture plates were incubated anaerobically at 37°C for 48 h. The bacterial colonies were identified according to their morphological and biochemical characteristics.[24,25] The bacterial count was conducted with an automated cell counter (Biotec Laboratory Equipment, Alexandria, Egypt), with a bacterial count of >10^6 colony-forming units (CFU) for *S. mutans*[26] and >10^5 CFU for *Lactobacillus* indicated elevated risk for future dental caries.[13]

Statistical analysis

To analyze the data, SPSS version 20.0 (IBM Corp. Chicago, IL, USA) was used. Standard descriptive statistics such as means, standard deviations, and frequencies were calculated to determine the characteristics of the sample. To compare two or more means, the Mann–Whitney *U* and Kruskal–Wallis tests were used for nonparametric data, and independent two-sample *t* test and one-way analysis of variance was used for normally distributed data. To examine the correlations between at least two continuous variables, we used Pearson's correlation coefficient for normally distributed data and Spearman's coefficient for nonparametric data. We performed linear regression analysis to determine the effect of significant predictors on dependent variables. The confidence interval was set at 95%, and *P* value <0.05 was considered statistically significant.

RESULTS

The mean ages of study participants were 5.04 ± 0.91 years in group I and 8.34 ± 1.48 years in group II. Both groups had more boys than girls. Of the parents, none had postgraduate degrees; parents with middle-level education predominated in both groups I (58.4%) and II (58.1%), as did parents with nonskilled occupations (70.9% and 60.3%, respectively) [Table 1].

Risk of caries

Of the 320 participants in Group I, 296 (92.5%) demonstrated high risk of caries, while the remaining 24 (7.5%) demonstrated moderate risk [Figure 2]. Of the 320 participants in group II, 267 (83.4%) demonstrated high risk of caries, 21 (6.6%) moderate risk, and 32 (10%) low caries risk.

In Group I, the total mean dmft score was 5.71 ± 3.18, with 5.3% of the children having a score of 1 and 1.3% a score of 20. In Group II, the overall mean dmft score was 4.78 ± 2.53, with 9.4% of the children having a score of 1, while 0.9% had a score of 11. In Group II, the mean DMFT was 0.61 ± 0.94, with 66.6% of the children having a score of 0 and 0.9% having 4 [Figures 3 and 4]. About 37.8% of the children in Group I had plaque, which was scored as present (1) or absent (0). The overall mean plaque score in group II was 1.59 ± 0.82, with a score of 3 found in 3.1% of the children; only 0.6% of the children demonstrated a score of 0 [Figure 5].

Table 1: Demographic characteristics of study participants (*N*=320)

Demographic characteristics	Group I, *n* (%)	Group II, *n* (%)
Gender		
Male	162 (50.6)	177 (55.3)
Female	158 (49.4)	143 (44.7)
Parent's education		
No education	98 (30.6)	100 (31.3)
Middle-level education	187 (58.4)	186 (58.1)
University education	35 (10.9)	34 (10.6)
Parent's occupation		
Nonskilled	227 (70.9)	193 (60.3)
Semiskilled	58 (18.1)	93 (29.1)
Skilled	35 (10.9)	34 (10.6)

n – Number of participating children in Group I and II

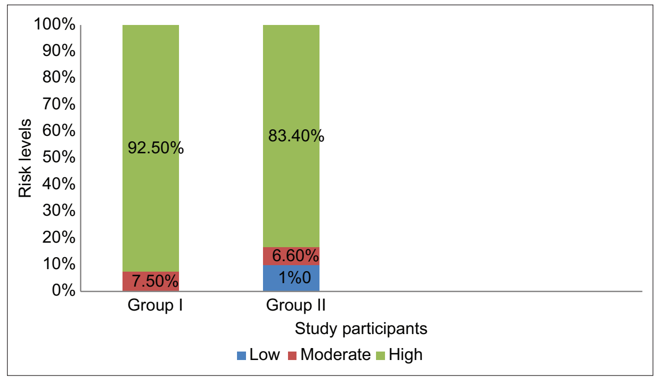

Figure 2: Distribution of risk levels among study participants

In Group I, the caries risk level was high for similar proportions of boys (49.8%) and girls [50.2%; Table 2]. Of the parents of the children at high risk, a majority (59.7%) had a middle-level education, and a majority (73.6%) had nonskilled occupations. Among the children in Group II, a higher caries risk level was more characteristic of boys (57.3%) than girls (42.7%). Of the parents of the children at high risk, a majority (55.8%) had a middle-level education, and a majority (61.4%) had nonskilled occupations.

Among children in Group I, the overall mean caries risk score was 8.61; the mean caries risk score was slightly higher for girls (8.86) than for boys [8.35; Table 3]. The parents' education levels and occupations differed significantly (*P* < 0.001) regarding overall mean risk score:

Table 2: Risk levels among study participants

Demographic characteristics	Group I			Group II		
	Low caries risk	Moderate caries risk, *n* (%)	High caries risk, *n* (%)	Low caries risk, *n* (%)	Moderate caries risk, *n* (%)	High caries risk, *n* (%)
Gender						
Male	-	15 (62.5)	147 (49.8)	10 (31.3)	7 (33.3)	153 (57.3)
Female	-	9 (37.5)	148 (50.2)	22 (68.8)	14 (66.7)	114 (42.7)
Parent's education						
No education	-	4 (16.7)	94 (31.9)	3 (9.4)	6 (28.6)	91 (34.1)
Middle-level education	-	10 (41.7)	176 (59.7)	22 (68.8)	15 (71.4)	149 (55.8)
University education	-	10 (41.7)	25 (8.5)	7 (21.9)	0	27 (10.1)
Parent's occupation						
Nonskilled	-	9 (37.5)	217 (73.6)	11 (34.4)	18 (85.7)	164 (61.4)
Semiskilled	-	5 (20.8)	53 (18)	14 (43.8)	3 (14.3)	76 (28.5)
Skilled	-	10 (41.7)	25 (8.5)	7 (21.9)	0	27 (10.1)
Total[a]	-	24 (7.5)	296 (92.5)	32 (10)	21 (6.6)	267 (83.4)

[a]Percentages in this row reflect the total number of children in each group

Table 3: Relation between overall mean caries risk score and demographic and clinical characteristics of Group I

Participant's characteristics	Mean risk score	Comments
Overall mean risk score	8.61±2.97	
Gender		
Male	8.86±3.04	
Female	8.35±2.88	
Independent samples *t*-test	1.541 (P<0.124)	
Parent's education level		
No education (a)	9.42±3.08	(a) vs. (c): P<0.001*,#
Middle-level education (b)	8.66±2.69	(b) vs. (c): P<0.001*,#
University education (c)	6.09±2.72	
One-way ANOVA	13.61 (P<0.001*)	
Parent's occupation		
Nonskilled (d)	9.24±2.79	(d) vs. (f): P<0.001*,#
Semiskilled (e)	7.67±2.73	(e) vs. (f): P<0.001*,#
Skilled (f)	6.09±2.72	
One-way ANOVA	14.37 (P<0.001*)	
Dental caries experience		
DMFT		
<1 (g)	4.88±1.99	(g) vs. (i): P<0.001*,#
1–6 (h)	8.30±2.96	(h) vs. (i): P<0.001*,#
>6 (i)	9.66±2.52	
One-way ANOVA	9.70 (P<0.001*)	
Plaque index		
Present	10.37±2.43	
Absent	7.54±2.75	
Independent samples *t*-test	9.612 (P<0.001*)	

*Statistically significant at P<0.05; #Multiple comparison (with Bonferroni test) – Statistically significant differences between three educational levels, as well as occupation categories and DMFT scores. DMFT – Decayed, missing and filled teeth

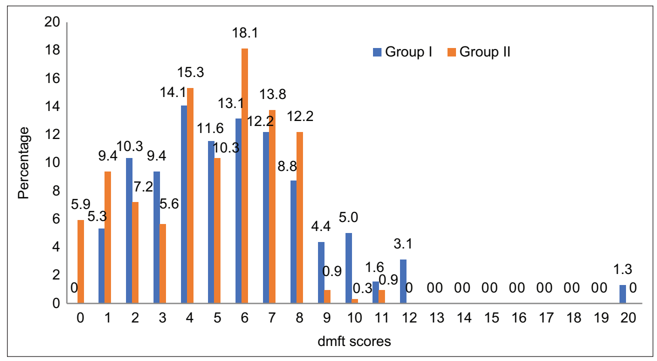

Figure 3: Distribution of dmft scores among study participants. dmft – decayed, missing, and filled tooth

among all socioeconomic indicators, the overall mean caries risk score was highest for children whose parents had no education (9.42) and for those whose parents had nonskilled occupations (9.24). Among dmft scores, children with mean dmft scores >6 had the highest mean caries risk score (9.66). Furthermore, children whose teeth exhibited plaque had a higher overall mean caries risk score (10.37) than children without plaque (7.54).

The overall mean caries risk score among children aged 6 to 12 years was 7.29. The mean risk score for girls (7.28) was almost equal to that for boys (7.30). These scores were higher among children whose parents had no education (8.96) and those whose parents had semiskilled occupations (7.85) compared with children in the other categories. About caries and plaque, the mean risk scores were highest among children with dmft scores >6 (10.09), SSFRs <0.5 (8.17), and plaque indexes of <2 (9.56). Regarding bacteria, the mean risk score was highest for children with *S. mutans* counts of $>10^6$ (9.78) and *Lactobacilli* counts of $>10^5$ [11.44; Table 4].

Correlation and linear regression analyses

In Group I, a significant positive relation was found between the overall mean caries risk score and past caries experience (dmft; $r = 0.344$, $P < 0.001$) and mean plaque index ($r = 0.463$, $P < 0.001$). In Group II, a significant positive relation was found between the overall mean caries risk score and each of the following: DMFT ($r = 0.511$, $P < 0.001$), *S. mutans* count ($r = 234$, $P < 0.001$), *Lactobacilli* count ($r = 0.316$, $P < 0.001$), and plaque index ($r = 0.463$, $P < 0.001$) [Table 5].

According to the linear regression model with all five predictors, $R^2 = 0.383$, F (2.348) = 39.024, $P < 0.000$, both dmft and mean plaque scores had significant positive

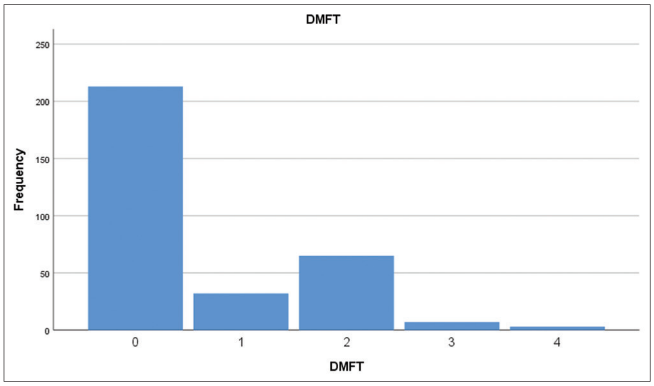

Figure 4: Distribution of DMFT scores among study participants (Group II). DMFT – Decayed, Missing, and Filled tooth

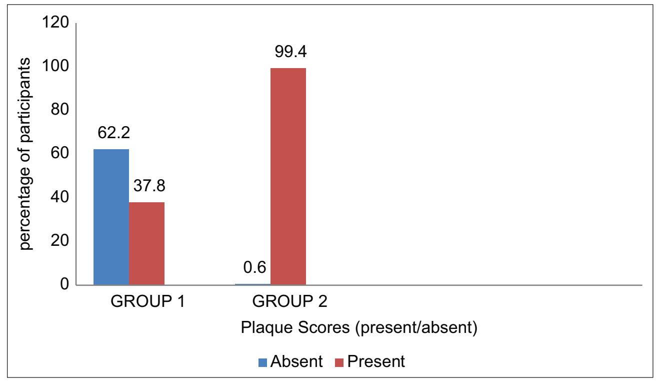

Figure 5: Distribution of plaque scores among study participants

Table 4: Relation between overall risk scores and demographic and clinical characteristics of Group II

Participant's characteristics	Mean risk score	Comments
Overall mean risk score	7.29±4.39	
Gender		
Male	7.28±3.71	
Female	7.30±5.11	
Mann–Whitney *U*-test	11.580 (*P*<0.088)	
Parent's education level		
No education (a)	8.96±4.44	(a) vs. (c): *P*<0.001*,®
Middle-level education (b)	6.85±4.23	(b) vs. (c): *P*<0.001*,®
University education (c)	4.74±3.26	
Kruskal–Wallis test	5.79 (*P*<0.055)	
Parent's occupation		
Nonskilled (d)	7.47±4.19	(d) vs. (f): *P*<0.001*,®
Semiskilled (e)	7.85±4.84	(e) vs. (f): *P*<0.001*,®
Skilled (f)	4.74±3.26	
Kruskal–Wallis test	0.901 (*P*<0.637)	
Dental caries experience		
DMFT		
<1 (g)	2.00±3.05	(g) vs. (i): *P*<0.001*,#
1–6 (h)	6.02±2.95	(h) vs. (i): *P*<0.001*,#
>6 (i)	10.09±3.60	
One-way ANOVA	98.822 (*P*<0.001*)	
Plaque index		
<1 (j)	3.91±3.31	(j) vs. (k): *P*<0.001*,®
1–2 (k)	9.01±4.23	(j) vs. (l): *P*<0.001*,®
>2 (l)	9.56±2.99	
Kruskal–Wallis test	77.441 (*P*<0.001*)	
Overall bacterial counts		
Streptococcus mutans		(m) vs. (n): *P*<0.006*,®
$<10^5$ (m)	4.85±3.52	(m) vs. (o): *P*<0.001*,®
10^5–10^6 (n)	5.38±2.44	
$>10^6$ (o)	9.78±4.24	
Kruskal–Wallis test	20.336 (*P*<0.001*)	
Lactobacilli		(*P*) vs. (q): *P*<0.001*,®
$<10^4$ (p)	4.46±3.75	(*P*) vs. (r): *P*<0.001*,®
10^4–10^5 (q)	6.60±3.42	
$>10^5$ (r)	11.44±4.09	
Kruskal–Wallis test	43.597 (*P*<0.001*)	
Salivary flow rate		
<0.5 (s)	8.17±4.58	(s) vs. (t): *P*<0.03*,®
0.5–1 (t)	6.18±2.99	(s) vs. (u): *P*<0.003*,®
>1 (u)	3.28±2.71	
Kruskal–Wallis test	11.105 (*P*<0.004*)	

*Statistically significant at *P*<0.05; #Multiple comparison (with Bonferroni test) – Statistically significant differences between three DMFT categories; ®Pairwise comparison. DMFT – Decayed, missing and filled teeth

regression weights, which indicated that increasing dmft scores and plaque scores were expected to increase overall mean caries risk scores [Table 6]. Participants' age, parents' education, and parents' occupation had a negative significant effect on overall mean caries risk score, which indicates that increases in these variables had less effect on the overall mean caries risk score (i.e. reduced the caries risk level). Furthermore, plaque scores had the highest main effect on the overall mean caries risk score (B = 2.224) followed by past caries experience (B = 1.585) [Table 6].

In terms of predictors of caries risk among children in Group I (according to the linear regression model with all three predictors, $R^2 = 0.359$, F (2.221) =21.632, $P < 0.000$), dental caries experience, *Lactobacilli* count, and plaque index scores showed significant positive relations with overall mean caries risk score. This finding indicates that an increase in the value of these predictors produced an increase in the overall mean caries risk score. Dental caries experiences (dmft) had the greatest effect on overall mean caries risk score (B = 0.246, $P < 0.000$) [Table 7].

DISCUSSION

Dental CRA, based on a child's age, social/biological factors, protective factors, and clinical findings, should be a routine component of oral health-care examinations.[27] Therefore, an accurate measurement model for CRA is necessary to ensure that children are provided with the best possible dental services. The CAMBRA concept provides dentists with scientific, evidence-based solutions with which to treat dental caries disease.[28] However, similar to the other CRA models, this protocol has not been adequately validated, especially among children aged <6 years.[2] Therefore, the present study attempted to determine the caries risk among a sample of children aged 3–12 years using CAMBRA forms and suggest a new CRA model based on the study results.

In the present study, high risk of caries was reported among both Groups I and II participants. This was likely explained by the lower socioeconomic level of the participating children, as 89% (Group I) and 89.4% (Group II) of parents had no education or middle-level education. In addition, 70.9% (Group I) and 60.3% (Group II) of the parents had nonskilled occupations. In fact, this finding was consistent with that of Iqbal *et al*.,[29] who found that 85% of their participants were at a high risk for caries and the remaining were at moderate risk. They attributed their results to the recruitment of the study sample from a dental department where most participants were seeking dental treatment and not routine care. Sudhir *et al*.[30] and Rechmann *et al*.,[31] obtained similar results, wherein 58.33% and 53.7% of their study samples, respectively, were at high risk for caries. Their results could be attributed to the same reasons as that of the study by Iqbal *et al*.,[29] as they recruited their participants from public clinics. In contrast, Muhson *et al*.[32] reported moderate caries risk in 55.4% of their participants. A recent study conducted in Egypt[13] concluded that out of 52 participants, high and moderate risk children were equal (17 each).

Table 5: Relation between overall mean caries risk score and participant's characteristics

Participant's characteristics	*r* (*P*)	
	Group I (Pearson correlations)	Group II (Spearman's coefficient)
Age	−0.121 (0.03*)	0.026 (0.644)
Gender	−0.086 (0.124)	0.096 (0.088)
Parent's education	−0.288 (<0.001*)	−0.127 (0.024*)
Parent's occupation	−0.361 (<0.001*)	−0.052 (0.351)
Past caries experience	0.344 (<0.001*)	0.511 (<0.001*)
Streptococcus mutans count	-	0.234 (<0.001*)
Lactobacilli count	-	0.316 (<0.001*)
Salivary flow rate	-	0.141 (0.012*)
Plaque index	0.463 (<0.001*)	0.462 (<0.001*)

*Correlation is significant at the $P<0.05$ (two-tailed). *r* – The correlation coefficient

In the present study, within groups, boys and girls had nearly equal mean caries risk scores, the younger children had higher scores than the older children. Of the children aged 6 to 12 years (Group II), boys were at higher risk for caries than girls. This could likely be explained as girls taking better care of their oral hygiene than boys.[33] Iqbal *et al*.[29] found that 86.6% of boys versus 83.3% of girls were at high risk for caries. In contrast, the risk for caries was similarly high in Group I for boys (49.8%) and girls (50.2%). In younger children (as in Group I), it is difficult to detect differences in oral health care between boys and girls, as both genders have similar level of commitment to oral hygiene instructions, as concluded by Pawlaczyk-Kamieńska *et al*.[34]

The findings of the present study indicate that sociodemographic factors such as parents' education level and occupation, past caries experiences (mean dmft), and mean plaque scores were significant predictors of caries risk among children aged <6 years, and dental caries experience, mean plaque scores, and *Lactobacilli* count were considered significant predictors among children aged 6 to 12 years. These findings were consistent with those of Prasai Dixit *et al*.,[35] who concluded that a combination of microbial tests (*S. mutans* and *Lactobacillus*) and past caries experience in a CRA model, rather than various alternatives alone, was the most efficient method in determining which patients were at risk. Liu *et al*.[36] later found that baseline dental caries experience is a better predictor than results of salivary tests (*S. mutans* and *Lactobacillus*) in screening children for caries risk.[37] Similarly Lin *et al*.,[38] concluded that past dental caries experience was the best predictor

Table 6: Significant predictors of caries risk among children aged <6 years

Variables	Unstandardized coefficients		Standardized coefficients (β)	*t*	*P*	95% CI for *B*	
	B	SE				Lower limit	Upper limit
Age	−0.532	0.148	−0.163	−3.600	<0.001*	−0.822	−0.241
Parent's education	−0.693	0.325	−0.144	−2.132	0.034*	−1.333	−0.054
Parent's occupation	−0.596	0.299	−0.136	−1.992	0.047*	−1.185	−0.007
Past caries experience	1.585	0.258	0.303	6.147	<0.001*	1.078	2.093
Plaque score	2.224	0.279	0.364	7.960	<0.001*	1.674	2.774

*Statistically significant at $P<0.05$. Dependent variable: Overall mean caries risk score. *B* – Unstandardized coefficient; SE – Standard error; CI – Confidence interval

Table 7: Significant predictors of caries risk among children aged ≥6 years

Variables	Unstandardized coefficients		Standardized coefficients (β)	*t*	*P*	95% CI for *B*	
	B	SE				Lower limit	Upper limit
Past caries experiences	0.246	0.033	0.449	7.410	<0.001*	0.180	0.311
Lactobacilli count	0.081	0.033	0.137	2.463	0.014*	0.016	0.146
Plaque index	0.094	0.027	0.197	3.523	<0.001*	0.041	0.146

*Statistically significant at $P<0.05$. Dependent variable – Overall mean caries risk score. *B* – Unstandardized coefficient; SE – Standard error; CI – Confidence interval for preschool children and school-age children/adolescents during CRA. Fernando *et al*.[39] and Kopycka-Kedzierawski *et al*.[40] demonstrated a highly positive correlation between past caries experience and future caries development.

For bacterial assessment, the study results support testing for only *Lactobacillus*, and not *S. mutans,* in caries prediction, in contrast to findings of other studies.[41,42] Earlier, de Camargo *et al*.[43] had found that *S. mutans* counts did not add any value in predicting caries when past caries experience was used as a caries predictor. In addition, Sounah and Madfa[44] demonstrated a significant correlation between *S. mutans* and *Lactobacillus* in carious tissue without significant differences between levels of *S. mutans* and *Lactobacillus* isolated from saliva samples. Similarly, Milgrom *et al*.[45] demonstrated that *Lactobacillus* is an important contributory bacterium in tooth decay, but its role in initiation of the lesion is not well supported. Furthermore, Kim *et al*.[46] demonstrated that *S. mutans* colonies as predictors of future caries were present in 50% of the general population and even smaller proportions of people with lower degrees of caries.

With regard to other predictors, the presence of dental plaque is associated with high risk for caries, as it is indicative of disease.[47] In addition, parents' education and occupation levels were significantly related to dental caries risk among children aged <6 years in the present study. This could be attributed to the relation between parents' educational level and oral health awareness, as children of parents who have better education levels tend to have better oral hygiene practices.[48] Thirunavukkarasu *et al*.[49] showed that all sociodemographic variables examined in their study (including parents' occupations) were linked strongly and significantly to the caries risk profile. Ghasemianpour *et al*.[50] concluded that a higher level of parental education was negatively related to dental caries indexes in their study sample. Abbass *et al*.[51] demonstrated that dmft was inversely correlated with both socioeconomic status and parental education but did not indicate the importance of age or gender in CRA. These findings were corroborated by those of Naik *et al*.,[52] who reported no association between age or gender and CRA.

Cagetti *et al*.[53] conducted a systematic review to evaluate the power of the available CRA models in estimating caries risk according to the actual and future caries status. They concluded that scientific evidence of the usefulness of standardized CRA models was insufficient and recommended establishing newer options for the diagnosis of dental caries and therapy. In a later systematic review with the same purpose, Coelho *et al*.[2] recommended conducting further studies with adequate follow-up periods, using placebo controls, and testing the effect of every CAMBRA component individually. On the other hand, they stated that the protocol for children aged <6 years was not evaluated in any of the studies included in their review; therefore, this protocol could not be validated adequately. Thus, in this study we attempted to devise new CRA models for both age groups.

Limitations

Participants were recruited from Pediatric Dental Clinic at the Faculty of Dentistry in Mansoura University, a governmental institution in which most of the patients were from low socioeconomic backgrounds, and this may be the reason for the high risk of caries in a large proportion of participants. Therefore, further multi-centre studies from Egypt and elsewhere are required to validate the findings of this study.

CONCLUSION

This study suggested some predictors that can be used as a new model for CRA among children aged 3–12 years. For children aged <6 years, the model could comprise sociodemographic factors, dental caries experience, and dental plaque. For children aged 6–12 years, the model could comprise dental caries experience, *Lactobacillus* count, and dental plaque. However, further studies with larger samples are required to validate the predictive feasibility of such a model across different populations, as a simple unified model such as this can be used globally and would facilitate comparison of results between different countries and studies.

Ethical consideration

The study received ethical approval from the Ethics Committee of the Faculty of Dentistry, Mansoura University (Ref. no.: M28060722; date: May 4, 2022). Written informed consents were collected from parents/legal guardians prior to the data collection stage. In addition, the procedures followed were in accordance with the Declaration of Helsinki, 2013.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Peer review

This article was peer-reviewed by two independent and anonymous reviewers.

Author Contributions

Conceptualization: R.M.A.; Methodology: R.M.A., D.M.A., M.M.E., H.W.M., and R.M.E.; data analysis, R.M.A. and

R.M.E.; writing – original draft preparation: R.M.A. and R.M.E.; writing – review and editing: R.M.A., D.M.A., M.M.E., H.W.M., and R.M.E.; supervision: R.M.A.

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Conflicts of interest

There are no conflicts of interest.

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