Socio-Behavioral Risk Indicators Linked to Untreated Early Childhood Caries and its Clinical Consequences in Preschool Children: A Cross-Sectional Study

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Objectives: *This study aimed to determine the prevalence of and the socio-behavioral risk indicators associated with untreated dental caries (UDC) and its clinical consequences.* ***Study design:*** *A multi-stage cluster sampling approach was used to evaluate 168 preschool children in this cross-sectional study. The risk indicators associated with the presence of one or more decayed teeth (dt ≥ 1) and pulp-involved teeth (pt ≥ 1) were assessed using multiple logistic regression analysis.* ***Results:*** *Overall, the prevalence of dt ≥ 1 and pt ≥ 1 was 82.1% and 27.9%, respectively. Children whose mothers had lower maternal education were 3.7 times more likely to have dt ≥ 1 than those whose mothers were graduates (adjusted odds ratio [AOR] = 3.74, 95% confidence interval [CI] 1.29–10.91). Children whose mothers had a history of maternal caries were 4.2 times more likely to have dt ≥ 1 (AOR = 4.23, 95% CI 1.56–11.44). Children whose mothers had lower maternal education were 5 times more likely to have pt ≥ 1 (AOR = 4.99, 95% CI 2.57–13.39). Underweight children were 7.2 times more likely to have pt ≥ 1 (AOR = 7.17, 95% CI 1.88–5.10). Children whose mothers had a history of maternal caries were 6.6 times more likely to have pt ≥ 1 (AOR = 6.62, 95% CI 7.17–18.88).****Conclusions:*** *Maternal education and caries were found to be significant risk indicators for UDC. The clinical consequences of UDC were related to child age, maternal education and caries, socioeconomic status and underweight.*

Keywords: *Early childhood caries, clinical consequences, risk indicators.*

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INTRODUCTION

Early childhood caries (ECC) is a term defined as the 'presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surface in any primary tooth in a child of ≤71 months of age'.[1] The Bangkok Global Summit (2019) described ECC as 'common, often untreated tooth decay in preschool children that can have a profound impact on children's lives'.[2] ECC is characterised by an early onset and is often associated with rapid development, leading to complete loss of the tooth structure. Despite the fact that ECC is preventable, it is still the world's most prevalent chronic oral disease, with 1.8 billion new cases reported each year.[2,3] It affects more than 600 million children worldwide and remains largely untreated.[1] Furthermore, untreated dental caries (UDC) is a frequent cause of hospitalisation and the need for emergency treatment procedures under general anesthesia in young children, leaving the families of those affected in a hard spot.[2]

Oral cariogenic microbial flora, increased frequency of sugar consumption, lack of regular oral hygiene and hypoplastic enamel defects are all primary risk factors for ECC.[2] However, socioeconomic factors and factors affecting oral health may increase the risk of exposure to ECC.[4] Considering that socioeconomic factors can

affect dietary and oral hygiene habits at the individual and community level, they often have a major impact on biological factors. The relationship between ECC and its risks and predisposing factors is an important area of study given that dental caries (DC) shares more than one risk factor and the magnitude of socio-behavioral risk indicators associated with ECC is unclear. Moreover, difficulty in collecting accurate information from parents/caregivers, the multifactorial aetiology of ECC, and the difficulty in managing confounding variables contributes to inaccurate estimation of ECC burden in young children.[5]

The Kingdom of Saudi Arabia (KSA) has a high burden of oral diseases. The prevalence and severity of DC amongst children in the KSA are nearly 80% for primary teeth and 70% for permanent teeth with a mean dmft of 5.0 and 3.5, respectively.[6] According to current estimates, children in the KSA have not yet met the World Health Organization's (WHO) 2000 target goals.[6] On the other hand, early interventions for the management of ECC in preschool children are almost non-existent in countries with a low and middle income and are inadequate in high-income nations.[6,7,8] The risk factors for ECC vary depending on ethnic and racial backgrounds, research designs and study participants. Furthermore, evidence to determine socio-behavioral risk indicators associated with the clinical consequences of UDC in young children is lacking. Thus, the occurrence and severity of oral diseases caused by UDC and the associated risk indicators should be evaluated. Hence, the current study aimed to estimate the prevalence of untreated UDC and its clinical consequences and determine self-reported socio-behavioral risk indicators associated with both conditions in preschool-aged children. The level of maternal education, family socioeconomic status (SES), frequency of toothbrushing, frequency of carbonated beverage/sugar intake, body mass index (BMI), feeding habits, nocturnal bottle-feeding, duration of bottle-feeding, pattern of dental visits and maternal caries experience were believed to play a role in the onset of ECC and its clinical consequences (Fig. 1).

MATERIALS AND METHOD

Study design and setting

This cross-sectional analysis was conducted in the northern Saudi Arabian province of Al Jouf. This study was conducted from October 2019 to March 2020. The study obtained ethical approval from the Local Committee of Bioethics (LCBE approval number: 02-03/41), Jouf University, KSA, and informed consent was obtained from the parent/guardian after the study objectives were clarified. In addition, approval from the school administration was received for this study. The personal information of all participants was kept private, and no one other than the researchers had access to the collected data. All procedures were carried out in compliance with the Declaration of Helsinki. Preschool children aged 3–6 years old with written informed consent from their parents or guardians were eligible for the study. Children with special health needs and those who declined to participate in this study were excluded. The STROBE guidelines were followed whilst conducting this cross-sectional study.

Sample size calculation

A multi-stage cluster sampling procedure was used to draw a representative sample. In the first stage, the province of Al Jouf was divided into four clusters. The second stage included one kindergarten school from each cluster at random from a list of schools. At the third stage, all children aged 3 to 6 years old from each chosen

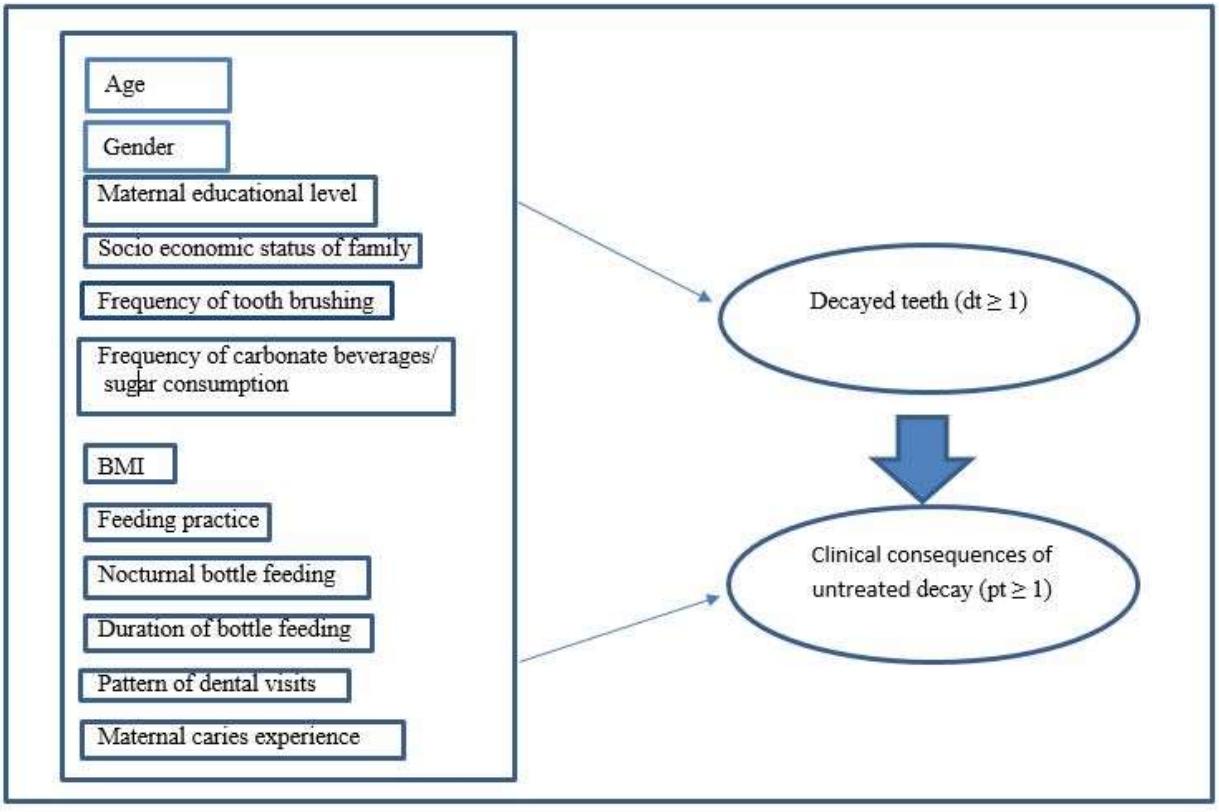

Figure 1 Conceptual research framework of the study.

school were invited to take part in this study. The sample size was determined using the proportion of Saudi children with DC, which was found to be 89%.[9]

The sample size was determined using the formula below.

$N = (Z/D)^2 \times P(1-P)$

$Z = 1.96$; absolute precision $(D) = 0.05$

Anticipated population proportion $(P) = 0.89$[9]; level of significance = 0.05

According to the above formula, a sample size of 151 participants was required in this study.

Data collection

The study was conducted into two parts: a self-reported questionnaire survey was provided to parents of preschool-aged children, and a clinical examination was performed on the child. Parents of all preschool children aged 3–6 years were invited to participate after the schools granted permission. Parents/guardians were asked to fill out a closed-ended questionnaire about their children's demographic, social and behavioural characteristics. A week before the clinical examination, school officials issued informed consent and a self-reported questionnaire to parents of children. The consenting parents were sent a self-reported questionnaire response through the school, which they completed and returned to the school for collection. The self-reported questionnaire items included child's age, gender, frequency of toothbrushing, maternal education level, family SES, frequency of carbonated beverage/sugar intake, BMI, feeding practice, nocturnal bottle-feeding, duration of bottle-feeding, previous dental visits and history of maternal caries experience (Fig. 1). The reliability of each item on the questionnaire was assessed by re-evaluating 10% of the total sample's parents/caregivers a week later (Cronbach's α). All of the questionnaire's items had excellent validity and reliability (0.81).

Clinical examination

Oral examinations were performed in each school using a portable dental chair, periodontal index probes, mouth mirrors, artificial light and disposable cotton rolls for children who had provided written informed consent from their parents/guardians. The decayed ('d') component of the 'dmft' index (decayed, missing, filled teeth) was used to diagnose UDC in accordance with the WHO criteria.[10] The pulpal involvement component ('p') of the 'pufa' index (pulpal involvement, ulceration, fistula, abscess) was used to determine the clinical consequences of UDC.[11] The 'pufa' index was developed to diagnose advanced stages of UDC in countries with a low and middle income, including deprived communities in developed countries, where individuals have limited access to oral healthcare.[11] The 'pufa' index is a valuable tool for determining the clinical consequences of UDC. Apart from the oral examination, each child's BMI (kg/m^2) was estimated in the classroom using his or her height and weight. A stadiometer was used to assess each participant's height without shoes to the nearest 0.5 cm. On a digital scale, participants' body weight was measured closest to 0.1 kg when they were wearing minimal clothes. The clinical examination of study participants was conducted by a single examiner. The examiner underwent training and calibration using the 'dmft' and 'pufa' indices prior to the beginning of the study. Five children from each cluster were re-examined 1 week later to determine intra-examiner reliability, and these children were excluded from further analysis (n = 20). The intra-examiner kappa values for the examiner (MA) were 0.90 for the 'dmft' index and 0.78 for the 'pufa' index.

Statistical analysis

Preliminary data analysis was performed to examine missing values and abnormal observations. The data were analysed by using cross tabulation to find the association between categorical variables. To classify variables associated with the presence of one or more UDC ($dt \geq 1$) and its clinical consequence of one or more pulp-involved teeth ($pt \geq 1$pt 1), simple and multiple logistic regression analyses were performed. A variable with $p < 0.25$ was considered significant in simple logistic regression and included in the multiple logistic regression analysis. The forward LR and backward LR selection methods were used to select variables with $p < 0.05$ in multiple logistic regression analysis. The fit of the final model was evaluated using the Hosmer–Lemeshow test, receiver operating characteristic curve and the interaction between the study variables and multicollinearity. The data were analysed using SPSS version 24.0. Statistical significance was considered at $p < 0.05$.

RESULTS

A total of 260 children were invited to participate in this study. Amongst them, 203 participants (78%) returned completed survey response forms, and 35 participants (17.2%) had missing and inaccurate data, which were omitted from the data analysis. Finally, 168 participants (64.6%) were included in the analysis. Amongst the 168 preschool children, 105 (62.5%) were males, and 63 (38.2%) were females. The participants' mean age was 4.8 years (SD = 1.4). Table 1 shows the presence of $dt \geq 1$ in the study population associated with socio-behavioral characteristics. In this study, 82.1% of participants had $dt \geq 1$. The presence of $dt \geq 1$ was found to be significantly linked to maternal education, with $dt \geq 1$ being more prevalent in low maternal education levels, followed by high school and later graduation. In addition, feeding practice showed a significant difference, indicating that $dt \geq 1$ was higher in children fed only by bottle and lower in children fed only by breast-feeding. The majority of the study participants (96.4%) had a nocturnal bottle-feeding habit, which was significantly linked to a higher incidence of $dt \geq 1$ (83.3 %). Furthermore, maternal DC experience was found to be significantly associated with higher frequency of $dt \geq 1$ (75.8%). However, SES, frequency of toothbrushing, frequency of carbonated beverage/sugar consumption, BMI, duration of bottle-feeding and previous dental visits were not significantly associated with $dt \geq 1$.

Table 2 shows the $pt \geq 1$ related to socio-behavioral characteristics amongst the study participants. Overall, 27.9% of the participants had $pt \geq 1$. The level of maternal education was found to have a significant association with pulp involvement. A higher proportion of teeth with $pt \geq 1$ was observed amongst mothers with a lower education level. The frequency of toothbrushing showed a significant difference in relation to pulpal involvement. A higher proportion of $pt \geq 1$ was observed with irregular brushing frequency, followed by brushing once a day and then twice a day. The BMI showed a significant difference, which indicates that the proportion of $pt \geq 1$ in underweight children was higher, followed by normal weight and overweight participants. Feeding practices also showed a significant difference, which revealed that $pt \geq 1$ was higher in bottle-fed

children, followed by a combination of breast- and bottle-fed and breast-fed participants. When comparing children who had previously visited the dentist with those who were visiting for the first time, those who had previously visited the dentist showed a lower pt ≥ 1. A higher proportion of pt ≥ 1 was observed in children whose mothers had a history of caries.

Table 3 shows that the presence of dt ≥ 1 was associated with child's age, maternal education level, family SES, bottle-feeding, history of previous dental visits, maternal caries experience and nocturnal bottle-feeding practice. Thus, these factors were considered as significant risk indicators for UDC after simple logistic regression analysis. However, in multiple logistic regression analysis, only two variables (maternal education and maternal caries experience) remained significant. The probability of dt ≥ 1 for participants whose mothers had low maternal education level was 3.7 times higher than that of participants whose mothers were graduates (adjusted odds ratio [AOR] = 3.74, 95% confidence interval [CI] 1.29–10.91, p = 0.016). Participants whose mothers had a history of maternal caries experience were 4.2 times more likely to have dt ≥ 1 than those without (AOR = 4.23, 95% CI 1.56–11.44, p = 0.005). No significant interaction was observed between these two variables, and multicollinearity was not present (VIF < 10). The area under the curve was 72.1%. Therefore, the final model with maternal education level and maternal caries experience was considered to have adequate fit.

Table 4 shows that the presence of pt ≥ 1 was related to child's age, gender, maternal education level, family SES, BMI, history of previous dental visits and maternal caries experience. Thus, these factors were considered as significant risk indicators for UDC after simple logistic regression analysis. In multiple logistic regression analysis, child's age, maternal education, SES, BMI and maternal caries experience remained significant. For a one unit increase in child's age, the probability of pt ≥ 1 would increase by 2.3 (AOR = 2.30, 95% CI 1.58–3.34, p < 0.001). Participants whose mothers had a lower education level were 5 times more likely to have pt ≥ 1 than those whose mothers were graduates (AOR = 4.99, 95% CI 2.57–13.39, p = 0.006). Moreover, participants with a higher SES were 12.5 times more likely to have pt ≥ 1 compared with those of

Table 1 Prevalence of untreated dental caries related to socio behavioral characteristics (dt ≥1).

Variables		N (%)	No caries d = 0	Presence of caries (dt ≥1)	p value
Gender	Male	105 (62.5)	19 (18.1)	86 (81.9)	0.917
	Female	63 (37.5)	11 (17.5)	52 (82.5)	
Maternal educational level	High school	40 (23.8)	10 (25.0)	30 (75.0))	0.041*
	Graduate	27 (16.1)	8 (29.6)	19 (70.4)	
	Primary	101 (60.1)	12 (11.9)	89 (88.1)	
Socio economic status of family	Low	25 (14.9)	2 (8.0)	23 (92.0)	0.267
	Middle	115 (68.5)	21 (18.3)	94 (81.7)	
	High	28 (16.7)	7 (25.0)	21 (75.0)	
Frequency of tooth brushing	irregular	131 (78.0)	21 (16.0)	110 (84.0)	0.377
	Twice/day	16 (9.5)	3 (18.8)	13 (81.2)	
	Once/day	21 (12.5)	6 (28.6)	15 (71.4)	
Frequency of carbonate beverages/ sugar consumption	More than once/day	147 (87.5)	27 (18.4)	120 (81.6)	0.648
	once/day	21 (12.5)	3 (14.3)	18 (85.7)	
BMI	Normal weight	100 (59.5)	18 (18.0)	82 (82.0)	0.710
	Underweight	30 (17.9)	4 (13.3)	26 (86.7)	
	Overweight	38 (22.6)	8 (21.1)	30 (78.9)	
Feeding practice	Only breast fed	12 (7.1)	9 (75.0)	3 (25.0)	0.001*
	Combination of breast and bottle fed	144 (85.7)	21 (14.6)	123 (85.4)	
	Only bottle fed	12 (7.1)	0 (0)	12 (100)	
Habit of nocturnal bottle feeding	Yes	162 (96.4)	27 (16.7)	135 (83.3)	0.036*
	No	6 (3.6)	3 (50.0)	3 (50.0)	
duration of bottle feeding	Stopped in less than 1 year	54 (32.1)	14 (25.9)	40 (74.1)	0.156
	Stopped between 1- 2 years	17 (10.1)	3 (17.6)	14 (82.4)	
	Stopped above 2 years	97 (57.7)	13 (13.4)	84 (86.6)	
Pattern of dental visits	First visit to dentist	94 (56.0)	20 (21.3)	74 (78.7)	0.192
	Had previous dental visits	74 (44.0)	10 (13.5)	64 (86.5)	
History of maternal caries experience	Presence of caries	69 (41.1)	24 (24.2)	75 (75.8)	0.010*
	No caries	99 (58.9)	6 (8.7)	63 (91.3)	

dt ≥1: presence of one or more UDC tooth

Table 2 Prevalence of clinical consequences of untreated dental caries related to socio-behavioral characteristics (pt ≥ 1).

Variables		N (%)	No pulp involvement Pt =0	Pulp involvement (pt ≥1)	p value
Gender	Male	105 (62.5)	71 (67.6)	34 (32.4)	0.101
	Female	63 (37.5)	50 (79.4)	13 (20.6)	
Maternal educational level	High school	40 (23.8)	31 (77.5)	9 (22.5)	0.036*
	Graduate	27 (16.1)	24 (88.9)	3 (11.1)	
	Primary	101 (60.1)	66 (65.3)	35 (34.7)	
Socio economic status of family	Low	25 (14.9)	16 (64.0)	9 (36.0)	0.063
	Middle	115 (68.5)	89 (77.4)	26 (22.6)	
	High	28 (16.7)	16 (57.1)	12 (42.9)	
Frequency of tooth brushing	Irregular	131 (78.0)	87 (66.4)	44 (33.6)	0.006*
	Twice/day	16 (9.5)	16 (100)	0 (0)	
	Once/day	21 (12.5)	18 (85.7)	3 (14.3)	
Frequency of carbonate beverages/ sugar consumption	More than once/day	147 (87.5)	106 (72.1)	41 (27.9)	0.948
	once/day	21 (12.5)	15 (71.4)	6 (28.6)	
BMI	Normal Weight	100 (59.5)	74 (74.0)	26 (26.0)	0.001*
	Underweight	30 (17.9)	12 (40.0)	18 (60.0)	
	Overweight	38 (22.6)	35 (92.1)	3 (7.9)	
Feeding practice	Only breast fed	12 (7.1)	12 (100)	0 (0)	0.023
	Combination of breast and bottle fed	144 (85.7)	103 (71.5)	41 (28.5)	
	Only bottle fed	12 (7.1)	6 (50.0)	6 (50.0)	
Habit of nocturnal bottle feeding	Yes	162 (96.4)	115 (71.0)	47 (29.0)	0.120
	No	6 (3.6)	6 (100)	0 (0)	
Duration of bottle feeding	Stopped in less than 1- year	54 (32.1)	42 (77.8)	12 (22.2)	0.468
	Stopped between 1- 2 years	17 (10.1)	68 (70.1)	29 (29.9)	
	Stopped above 2- years	97 (57.7)	11 (64.7)	6 (35.3)	
Pattern of dental visits	First visit to dentist	94 (56.0)	79 (84.0)	15 (16.0)	0.001*
	Had previous dental visits	74 (44.0)	42 (56.8)	32 (43.2)	
History of maternal caries experience	Presence of caries	99 (58.9)	37 (53.6)	32 (46.4)	0.001*
	No caries	69 (41.1)	84 (84.8)	15 (15.2)	

pt ≥ 1: one or more pulp involved tooth

the middle class (AOR = 0.08, 95% CI 0.02–0.43, p = 0.003). For the BMI group, the underweight group was 7.2 times more likely to have pt ≥ 1 compared with the normal weight group (AOR = 7.17, 95% CI 1.88–5.10, p = 0.004). Participants whose mothers had a history of maternal caries were 6.6 times more likely to have pt ≥ 1 than those whose mothers had no history (AOR = 6.62, 95% CI 7.17–18.88, p < 0.001). No significant interaction was observed between all variables, and multicollinearity was not present (VIF < 10). The area under the curve was 91.5%. Therefore, the final model with child's age, maternal education level, SES, BMI and history of maternal caries was considered to have adequate fit.

Table 3 Socio-behavioral risk factors associated with untreated dental caries among the study population (dt ≥1).

Variables		Crude odds ratio	95% CI for Crude odd ratio		p value	Adjusted odds ratio	95% CI for Adjusted odds ratio		p value
			lower	upper			lower	upper	
Age		0.83	0.63	1.09	0.182				
Gender	Female	1.04	0.46	2.37	0.917				
Maternal education level	Primary	3.12	1.12	8.68	0.029	3.74	1.29	10.91	0.016
	High school	1.26	0.42	3.77	0.675	1.15	0.37	3.61	0.813
	Graduate	1				1			
Socioeconomic status of the family	Low	3.83	0.72	20.55	0.117				
	Middle	1.49	0.56	3.97	0.422				
	High	1							
Frequency of tooth brushing	Irregular	1.21	0.32	4.61	0.781				
	Once/day	0.58	0.12	2.78	0.493				
	Twice/day	1							
Frequency of carbonated beverages/ sugar consumption	More than once/day	0.74	0.20	2.70	0.649				
	once/day	1							
BMI	Normal weight	1							
	Underweight	1.43	0.44	4.60	0.551				
	Overweight	0.82	0.32	2.09	0.682				
Duration bottle feeding	Stopped in less than 1 year	1							
	Stopped between 1- 2 years	1.63	0.41	6.54	0.488				
	Stopped above 3 years	2.26	0.97	5.26	0.058				
Pattern of dental visits	First dental visit	0.58	0.25	1.33	0.195				
	Had previous dental visits	1							
History of maternal caries experience	Presence of caries	3.36	1.29	8.73	0.013	4.23	1.56	11.44	0.005
	No caries	1							
Habit of nocturnal feeding	Yes	5.0	0.96	26.11	0.056				
	No	1							

Table 4 Socio-behavioral risk factors associated with the clinical consequences of untreated caries among the study population (pt ≥1).

Variables		Crude odds ratio	95% CI for Crude odds ratio		p value	Adjusted odds ratio	95% CI for Adjusted odds ratio		p value
			lower	upper			lower	upper	
Age		1.29	1.02	1.64	0.036	2.30	1.58	3.34	0.001
Gender	Female	0.54	0.26	1.13	0.103				
Maternal education level	Primary	4.24	1.19	15.08	0.026	4.99	2.57	13.39	0.006
	High school	2.32	0.57	9.52	0.242	1.29	0.15	10.97	0.818
	Graduate	1							
Socioeconomic status of the family	Low	0.75	0.25	2.27	0.611	0.18	0.03	1.13	0.068
	Middle	0.39	0.16	0.93	0.033	0.08	0.02	0.43	0.003
	High	1							

Variables		Crude odds ratio	95% CI for Crude odds ratio		p value	Adjusted odds ratio	95% CI for Adjusted odds ratio		p value
			lower	upper			lower	upper	
BMI	Normal weight	1							
	Underweight	4.27	1.81	10.05	0.001	7.17	1.88	5.10	0.004
	Overweight	0.24	0.07	0.86	0.028	0.05	0.01	0.36	0.003
Duration of bottle feeding	Stopped in less than 1- year	1							
	Stopped between 1- 2 years	1.91	0.58	6.24	0.284				
	Stopped above 2 years	1.49	0.69	3.24	0.311				
Pattern of dental visits	First dental visit	0.25	0.12	0.51	< 0.001				
	Had previous visit	1							
History of maternal caries experience	Presence of caries	4.84	2.35	10.00	< 0.001	6.62	7.17	18.88	0.001
	No caries	1							

DISCUSSION

This study determined socio-behavioral risk indicators associated with UDC and its clinical consequences in preschool children living in the northern region of the KSA. The findings of this study revealed that maternal education and maternal caries experience were significantly associated with UDC in preschool children. Child's age, maternal education, SES, BMI and maternal caries experience were significantly associated with the clinical consequences of UDC after controlling for the effect of other variables. Most of the study participants (82.1%) had dt ≥ 1, and a quarter of the participants (27.9%) had pt ≥ 1. These prevalence rates were consistent with previous studies in different parts of the KSA[6, 9] and Brazil.[12] Despite its high prevalence, ECC is mostly untreated, especially those under the age of 3.[2] Our study has shown that for a one unit increase in child's age, the odds of pt ≥ 1 would increase by 2.3-fold. Given that older children's teeth are subjected to caries risk for a longer duration, their age is commonly used as a risk predictor for DC.[2] This finding indicates that families and communities have been unable to enact meaningful prevention measures in the studied population.

There is substantial evidence to determine the risk factors linked to ECC. In the Middle East and North Africa (MENA) region, the most widely identified socio-demographic and behavioral determinants of dental caries in children are related to child characteristics, family background, oral hygiene and feeding practices and dietary habits.[14] A study from United Arab Emirates region reported that the high prevalence of dental caries in preschool children mainly attributed to on-demand bottle feeding, lower maternal education, frequent sugar consumption, poor oral hygiene and lack of regular dental visits.[15] Unfortunately, there is a scarcity of data on the socio-behavioral risk indicators linked to clinical consequences of UDC in preschool children in Saudi Arabia and other Middle Eastern countries.

In our study, maternal caries increased the risk of developing dt ≥ 1 by 4.2-fold. Current evidence suggests a significant link between maternal and child oral health, indicating that mothers of children with ECC have higher dmft scores.[16] According to studies, untreated caries in the mother and a higher level of salivary S. mutans in the child raise the risk of ECC. The association between mother's and child's oral health could be explained by: (1) the mothers' oral health behavior, perception and knowledge influences the oral health of her children.[17] (2) the mother might be a main source of her children's acquisition of oral S. mutans and Candida sp.[18,19] Children who were bottle-fed at night had a 5-fold increased risk of developing DC in this study, but when confounding variables were taken into account, this association was no longer significant. In Poland, children with a history of breast or bottle-feeding before or during sleep were associated with higher prevalence of ECC.[20] The current understanding of ECC refers to a more complex disease associated with the frequent intake of sugar in the presence of bacteria that adhere to the enamel and is not always related to bottle-feeding.[2] In this study, children who had been bottle-fed for more than 2 years had a higher rate of UDC and pulp involvement than those who had been breast-fed. Surprisingly, no meaningful relationship was observed in the multivariate regression model in this study. A study from India reported that children who were primarily bottle-fed were at a higher risk of untreated caries causing pulp involvement.[21] According to Kato *et al*,[22] breast-feeding for 6–7 months or longer increases the risk of DC due to concurrent eruption of primary teeth during the same period. In a prospective longitudinal study, the high frequency of feeding, including bottle and breastfeeding, was related to DC in early childhood.[23]

Our data showed that the low level of maternal education was associated with a higher rate of occurrence of dt ≥ 1 and its clinical consequences in preschool-aged children. In the western part of Saudi Arabia, a similar pattern was observed.[24] This finding was consistent with other studies reported in Poland and Japan.[20,25]

This may be due to the fact that oral health awareness is related to maternal education levels.[20] In addition, a higher UDC experience was observed in children with lower family income in the present study. By contrast, the risk profile of DC amongst Saudi children appears to be similar to that of developed countries, where oral health behavioural and dietary practices are emphasised more than SES factors.[26]

In the current study, children who consumed sugary food and sweet drinks often had a higher proportion of UDC and its clinical consequences. This could be due to the easy access and frequent exposure to sugary drinks and lack of regular oral hygiene in Saudi children.[24] According to a cohort report, two main characteristics in early childhood diet practices are more significant: the age at which the child is introduced to sugary diet and the frequency of its intake.[27] Furthermore, in this study, most of the children had inconsistent toothbrushing habits. Similar poor oral hygiene habits reported in the Riyadh region showed that the majority of children begin brushing their teeth at the age of 5 or older and brush their teeth less than once a day.[26] In a recent study, no significant link was found between brushing frequency and the incidence of ECC in Japanese children.[25] According to a report, the most important risk indicator for ECC is parents failing to assist children in brushing teeth twice a day or when they do not have time to do so.[28]

Underweight children showed a significant association with the clinical consequences of UDC, which led to higher pulpal involvement in this study. A previous study found that S-ECC is related to underweight and failure-to-thrive, indicating that low BMI could be a result of S-ECC.[29] Sleep disturbance caused by dental pain has also been reported to affect the production of glucocorticoids, which in turn affects the growth and development of a child.[30] Another possible mechanism of the effect of S-ECC on growth may be related to chronic inflammation due to pulpitis and dental abscess; this condition alters the metabolic pathway and leads to increased production of cytokines, such as interleukin-1, which inhibit erythropoiesis in the bone marrow and may lead to anaemia due to chronic disease.[30] Few studies have described an association between DC and obesity.[31,32] In a recent study, malnutrition (overweight or underweight) and ECC were found to have no significant relationship; however, poverty was identified as a major confounding variable.[33]

The current study has few limitations. This study used cross-sectional data to describe the burden of ECC, making it difficult to establish temporary relationships. Moreover, the self-reported information from parents might be subjected to bias, which could lead to inaccurate estimates of association. Another limitation is the small sample size, which could restrict the sample's representativeness. As a result, we could not generalise the results of this study to the entire Saudi population. However, the findings of this study serve as a benchmark for future population-based research. Prospective longitudinal studies are essential to identify risk factors and their effect size. The strengths of the present study were the study design and appropriate statistical analysis to ensure the power of the obtained data. Furthermore, the present study examined multicollinearity and addressed possible bias.

Our findings highlight the importance of ensuring that every child receives dental treatment before the age of 1 year ('first dental visit'). Furthermore, early education and clinical interventions should target expectant mothers explicitly to reduce the transmission of mutans streptococci from mother to infant. As a result of increased oral health literacy and awareness, mothers and their children are more likely to use oral health preventive services. These strategies may aid in improving oral health and function and lowering the risk of ECC and its clinical consequences in pre-schoolers.

CONCLUSIONS

Our findings showed that UDC appears to be strongly associated with the level of maternal education and maternal caries status. Child age, maternal education, SES, BMI and maternal caries experience were significantly associated with the clinical consequences of UDC. Therefore, the socio-behavioral risk indicators should be identified at the earliest age to implement appropriate preventive care to reduce the unwanted burden of ECC and to improve the quality of life of children globally.

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Conflict of interest

The authors have no conflict of interest to declare.

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