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RESEARCH ARTICLE **PREVENTIVE DENTISTRY & PUBLIC HEALTH**

Association of Bottle-Feeding and Maternal Behaviors with Early Childhood Caries among Preschool Children in Brack Al-Shatti, Libya: A Cross-Sectional Study

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ABSTRACT

Early Childhood Caries (ECC) is one of the most prevalent chronic diseases among children worldwide. Its development is strongly associated with early-life behavioral and feeding practices, particularly bottle-feeding habits and maternal behaviors, which play a critical role in the initiation and progression of dental caries. This study aimed to estimate the prevalence of (ECC) and examine its association with bottle-feeding practices and maternal behaviors among children in Brack Al-Shatti, Libya. A cross-sectional study was conducted between October and December 2025 involving 224 mother-child pairs. Data were collected using a structured, pre-tested questionnaire assessing Baseline Characteristics of the Study Populations, infant feeding practices, and oral hygiene behaviors. Early childhood caries was assessed through visual oral examination conducted by trained personnel. Associations were evaluated using Chi-square tests and multivariable logistic regression analysis, with statistical significance set at $p < 0.05$. The overall prevalence of ECC was 55.4%. Bivariate analysis revealed significant associations with adding sugar/honey to formula ($p = 0.002$), maternal pre-tasting ($p = 0.002$), nocturnal bottle-feeding ($p = 0.004$), and pacifier use ($p = 0.020$). Multivariable analysis identified adding sugar/honey to formula as the strongest independent risk factor (AOR = 3.63; 95% CI: 1.42–9.27; $p = 0.007$), followed by maternal pre-tasting (AOR = 2.05; $p = 0.025$) and nocturnal bottle-feeding (AOR = 2.05; $p = 0.048$). Protective factors included cleaning bottles before use (AOR = 0.41; $p = 0.006$) and cleaning the child's mouth after feeding (AOR = 0.34; $p = 0.001$). (ECC) is highly prevalent among children in Brack Al-Shatti and is significantly associated with modifiable maternal feeding behaviors. Preventive strategies should prioritize parental education on hygienic bottle-feeding practices, avoiding the addition of sugar to infant formula, and establishing early oral hygiene habits.

العلاقة بين الرضاعة الصناعية وتسوس الأسنان المبكر لدى الأطفال ما قبل المدرسة في براك الشاطئ، ليبيا: دراسة مقطعية

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الملخص

يُعد تسوس أسنان الطفولة المبكرة من أكثر الأمراض المزمنة شيوعاً بين الأطفال على مستوى العالم. ويرتبط هذا المرض ارتباطاً وثيقاً بالأنماط السلوكية والغذائية في المراحل العمرية الأولى. حيث تُعد الرضاعة الصناعية وبعض الممارسات الخاطئة لدى الأمهات من أبرز العوامل التي تسهم في تفاقم هذه المشكلة. هدفت هذه الدراسة إلى استقصاء العلاقة بين الرضاعة الصناعية وتسوس أسنان الطفولة المبكرة لدى الأطفال، وتحديد مدى ارتباطها بالسلوكيات الغذائية الخاطئة للأمهات في منطقة براك الشاطئ، ليبيا. أُجريت دراسة مقطعية شملت عينة مكوّنة من 224 ثنائياً (أم وطفل). جُمعت البيانات باستخدام استبانة مُحكمة لتقييم الخصائص الديموغرافية، أنماط وأساليب تغذية الرضع، وسلوكيات العناية بنظافة الفم. وتم تحليل البيانات إحصائياً باستخدام اختبار مربع كاي (χ^2) وتحليل الانحدار اللوجستي المتعدد عند مستوى دلالة إحصائية ($p < 0.05$). أظهرت النتائج أن معدل انتشار تسوس أسنان الطفولة المبكرة بلغ 55.4%. كما بين التحليل المتغير الثنائي وجود ارتباطات ذات دلالة إحصائية بين الإصابة بالتسوس، إضافة المحليات (مثل السكر أو العسل) إلى الحليب($p = 0.002$) ، تذوق الأم للرضّاعة ($p = 0.002$)، والتغذية بالرضّاعة أثناء الليل ($p = 0.004$). كما حدّد تحليل الانحدار اللوجستي المتعدد عوامل الخطر المستقلة، حيث زادت احتمالية الإصابة بالتسوس عند إضافة المحليات (AOR = 3.63)، وعند قيام الأم بتذوق الرضّاعة (AOR = 2.05).في المقابل، برزت نظافة الرضّاعة (AOR = 0.41) وتنظيف فم الطفل بعد التغذية (AOR = 0.34)كعوامل وقائية تقلل من احتمالية الإصابة. تخلص هذه الدراسة إلى أن تسوس أسنان الطفولة المبكرة ينتشر بمعدلات مرتفعة في منطقة براك الشاطئ، ويرتبط بشكل ملحوظ بسلوكيات غذائية خاطئة قابلة للتعديل. وتوصي الدراسة بوضع استراتيجيات وقائية تركز على تثقيف الوالدين وخصوصا الامهات حول ممارسات الرضاعة الصحية، والتحذير من إضافة المحليات إلى الحليب، وتعزيز عادات نظافة الفم في سن مبكرة.

الكلمات المفتاحية

تسوس أسنان الطفولة المبكرة
التغذية بالرضاعة الصناعية
ممارسات تغذية الرضع
سلوكيات الأم
الأطفال ما قبل المدرسة
نظافة الفم
عوامل الخطر لتسوس الأسنان.

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Introduction

Oral health is a fundamental component of a child's overall health, influencing physical growth, nutritional status, and psychological development [1]. Despite advances in global healthcare, oral diseases remain a major public health challenge. Dental caries is recognized as the most common preventable non-communicable disease affecting the hard tissues of the teeth, imposing a substantial health and economic burden on families and healthcare systems [1, 2]. Global estimates suggest that approximately 530 million children are affected by caries in their primary dentition [3]. In severe cases, treatment may require comprehensive dental rehabilitation under general anesthesia, a procedure associated with increased medical risks and significant financial costs [4].

Early Childhood Caries (ECC) is of particular concern due to its aggressive nature and rapid progression. According to the American Academy of Pediatric Dentistry, ECC is defined as "the presence of one or more decayed, missing (due to caries), or filled tooth surfaces in any primary tooth of a child younger than 72 months of age" [5]. A more severe form, Severe Early Childhood Caries (S-ECC), is characterized by "the development of smooth-surface lesions in toddlers younger than three years old" [5]. Beyond pain and infection, ECC has been associated with sleep disturbances, impaired growth, poor nutritional status, reduced quality of life, and lower body weight compared to caries-free peers [6, 7]. The etiology of ECC is multifactorial, involving an imbalance in the oral microbiome where cariogenic bacteria, particularly *Mutans streptococci*, predominate [8, 9]. This process is further exacerbated by developmental enamel defects, such as enamel hypoplasia, which increase susceptibility to demineralization [10].

Infant feeding practices are a decisive factor in disease initiation and progression. While exclusive breastfeeding confers numerous health benefits, caries risk is influenced more by specific feeding behaviors than by the type of milk itself [11]. Breast milk contains antimicrobial proteins and enzymes, and the muscular effort required during breastfeeding may reduce milk stagnation around the dentition [12]. However, prolonged breastfeeding beyond 24 months, particularly when nocturnal, may become a risk factor if not accompanied by adequate oral hygiene practices [13, 14, 15]. Frequent nighttime feeding prolongs the retention of fermentable substrates on tooth surfaces during sleep—a period of reduced salivary flow—facilitating repeated acid attacks that overwhelm enamel remineralization capacity [11].

Furthermore, inappropriate bottle-feeding practices significantly amplify this risk. The mechanics of bottle-feeding facilitate liquid pooling around the maxillary incisors, leading to a pattern historically known as "nursing bottle caries" [9]. This risk is further compounded by maternal caregiving practices such as adding sugar or honey to formula, introducing sweetened juices in bottles, or dipping pacifiers in sugary substances [11]. These early dietary behaviors shape long-term taste preferences, fostering a predilection for sweet foods while reducing acceptance of healthier options, thereby perpetuating high sugar consumption [16, 17]. Such caregiving practices, often used to soothe children, inadvertently establish a cariogenic oral environment. Consequently, this burden is disproportionately higher in socioeconomically disadvantaged populations, where limited access to dental care and low preventive oral health literacy create a persistent cycle of disease [18].

Moreover, maternal influence extends beyond feeding practices to the psychological construct of maternal self-efficacy. Mothers with higher confidence in enforcing health-related behaviors are significantly more successful in preventing ECC, whereas low self-efficacy is associated with reliance on feeding as a caregiving strategy for comfort and soothing [19]. Additionally, biological determinants such as low birth weight and maternal smoking during pregnancy have been linked to adverse caries trajectories, suggesting that ECC reflects broader intrauterine and early-life environmental influences [20].

In Libya, the healthcare system has faced significant challenges due to recent political and economic instability, resulting in limited preventive dental services and low oral health awareness among the population. No studies have investigated the relationship between bottle-feeding practices and ECC in the Brack Al-Shatti region of Libya. Accordingly, the present study addresses this knowledge gap regarding how local feeding practices and maternal behaviors contribute to oral health outcomes. Therefore, this study aims to: (1) estimate the prevalence of Early Childhood Caries (ECC), (2) examine its association with bottle-feeding practices, and (3) identify maternal behaviors associated with increased caries risk among children in the Brack Al-Shatti municipality.

Methodology

Study Design: A cross-sectional study was conducted to examine the association between bottle-feeding practices, maternal behaviors, and (ECC) among children in Brack Al-Shatti, Libya.

Study Population and Sampling: The study population consisted of mothers with children aged 1 to 6 years residing in Brack Al-Shatti municipality, Libya. A convenience sampling technique was used to recruit participants from three primary healthcare centers, two private dental clinics, and selected households through community visits within the Brack Al-Shatti municipality. These healthcare facilities were selected based on their accessibility, high patient attendance, and willingness to participate in the study, in addition to the professional experience of the dental staff and the strategic locations of the private clinics, which attract patients from diverse geographic and socioeconomic backgrounds within the municipality. Eligible mother–child pairs attending these facilities during the study period were invited to participate consecutively until the required sample size was achieved. Additional participants were recruited through community household visits to improve population coverage and enhance the representation of different areas within the municipality.

Inclusion and Exclusion Criteria: Mothers were eligible if they provided informed consent and had children aged 1 to 6 years who had a history of bottle-feeding (formula-fed either exclusively or partially). The children with systemic diseases affecting oral health, craniofacial anomalies, or those who had received professional fluoride treatment within the previous six months were excluded. The mothers who were unable to complete the questionnaire due to language or cognitive barriers were also excluded.

Sample Size: The sample size was calculated using G* Power software (version 3.1). The sample size was calculated using G*Power (version 3.1), assuming an expected (ECC) prevalence of 40%, a 95% confidence level, and a 5% margin of error, the minimum required sample size was 138 participants. To reduce the risk of incomplete responses, 250 questionnaires were distributed, and 224 valid responses were ultimately included.

Data Collection Procedures: A structured, literature-based questionnaire was developed in Arabic and pre-tested to ensure clarity and feasibility. The questionnaire was structured into seven sections to capture comprehensive data on demographics, feeding patterns, and oral health status. The questionnaire consisted of 33 items distributed across seven

sections. The first section included six questions related to the baseline characteristics of the study populations of the mother and child. The second section comprised five questions addressing formula bottle feeding patterns, while the remaining sections included 22 questions covering maternal behaviors, oral hygiene practices, utilization of dental services, and oral health outcomes.

Participants included in the pilot study were excluded from the final analysis. The pilot study was conducted to assess the clarity and feasibility of the questionnaire. The internal consistency of the questionnaire was acceptable (Cronbach's alpha = 0.78). Data collection was carried out by a research team consisting of three trained researchers who received prior training on the interview protocol to ensure standardization of questioning techniques. Face-to-face interviews were conducted with the mothers, with each interview lasting approximately 15–20 minutes.

Diagnosis of (ECC):

The assessment of (ECC) was primarily conducted through visual oral examinations by dentists using dental mirrors under natural light conditions. While this field-based screening approach is common in epidemiological studies where full clinical or radiographic examination is not feasible, it may underestimate early non-cavitated lesions, such as white spot lesions and enamel discoloration. For children who had previously visited dental clinics, visual findings were complemented by their existing clinical records to accurately classify the caries as anterior, posterior, or generalized. Crucially, the maternal questionnaire was used exclusively to collect data on feeding practices, oral hygiene behaviors, and baseline characteristics of the study populations, ensuring that the diagnosis of dental caries relied solely on clinical evaluation rather than parental reports.

Ethical Consideration: The study received ethical approval from the Research Ethics Committee of the Faculty of Education at the University of Wadi Al-Shatti, Libya. All procedures strictly adhered to established ethical standards for scientific research. Prior to data collection, informed consent was obtained from all participants, who were assured of full confidentiality. Furthermore, participants were informed that all collected information would be used exclusively for scientific research purposes.

Statistical Analysis: Data were processed and analyzed using the Statistical Package for the Social Sciences (SPSS), version 26.0. The statistical treatment included descriptive statistics, where frequencies and percentages were used to describe categorical variables, while means and standard deviations were used for continuous variables. Inferential statistics employed the Chi-square test to examine associations between categorical variables, independent t-tests and One-way Analysis of Variance (ANOVA) to compare means, and Binary Logistic Regression analysis to identify independent risk factors associated with dental caries. Variables with $p < 0.05$ in bivariate analysis, along with clinically relevant variables identified in the literature, were included in the multivariable logistic regression model.

A probability value (P-value) of less than 0.05 was considered statistically significant for all tests.

Result

Early Childhood Caries and Baseline Characteristics of the Study Population: The study population comprised 224 mother–child pairs, with an overall (ECC) prevalence of 55.4% (n=124), as shown in table 1. The demographic analysis showed that slightly more than half of the participants were male (51.8%), and the most frequent age group was 1–2 years (37.9%). Regarding maternal education, nearly half of the mothers had completed secondary education (49.6%), followed by university degrees (35.7%), postgraduate studies (8.0%), and preparatory education (6.7%).

Table 1: Baseline Characteristics of the Study Populations of participants (N = 224)

Variable	Category	(N/%)
(ECC)	Yes	124/55.4
	No	100/44.6
Child gender	Male	116/51.8
	Female	108/48.2
Child age	1–2 years	85/37.9
	3–4 years	62/27.7
	5–6 years	77/34.4
Maternal education	Preparatory	15/6.7
	Secondary	111/49.6
	University	80/35.7
	Postgraduate	18/8.0

Feeding Practices and Oral Hygiene: In terms of infant feeding practices, 52.7% of the children were primarily formula-fed, while 16.5% of mothers reported adding sugar or honey to the formula. Behavioral observations showed that nearly half of the mothers (46.4%) practiced pre-tasting or placing the feeding bottle in their own mouths before feeding. Regarding sleep-related habits, 48.7% of the children used a pacifier during sleep, and 32.1% were reported to sleep with a bottle in their mouths. Furthermore, oral hygiene practices were found to be suboptimal; specifically, only 47.8% of mothers cleaned the bottle before each feeding, and fewer than half (45.1%) performed oral cleaning for their child after feeding, as presented in table 2.

Table 2: Feeding practices and oral hygiene behaviors (N = 224)

Variable	Category	(N/%)
Formula feeding as main nutrition	Yes	118/52.7
	No	106/47.3
Adding sugar or honey to infant formula	Yes	37/16.5
	No	187/83.5
Maternal pre-tasting of bottle	Yes	104/46.4
	No	120/53.6
Pacifier use during sleep	Yes	109/48.7
	No	115/51.3
Cleaning bottle before feeding	Yes	107/47.8
	No	117/52.2
Cleaning child's mouth after feeding	Yes	101/45.1
	No	123/54.9
Child sleeps with bottle	Yes	72/32.1
	No	152/67.9

Dental Health Outcomes and Parental Perceptions: Regarding dental care utilization among children with (ECC), a significant majority (80.8%) had never visited a dentist, and 35.7% had received no treatment despite the presence of active caries. The reported age of (ECC) onset varied, with the highest frequency occurring between 3–4 years (22.3%), followed by 5–6 years (17.4%), and 1–2 years (15.6%), as presented in Table 3. Parental awareness of caries etiology was notably high; more than half of the parents correctly identified the association between caries and bottle feeding (52.7%), sleeping with a bottle (58.0%), and the addition of sugar to formula (56.7%). Furthermore, a substantial majority (75.9%) recognized that neglecting early treatment could lead to serious dental complications.

Factors Associated with Early Childhood Caries (ECC) and Clinical Characteristics

Table 3: Dental health outcomes and parental perceptions (N = 224)

Variable	Cat	(N/%)
Age of caries onset	1–2 years	35/15.6

	3–4 years	50/22.3
	5–6 years	39/17.4
	No caries	100/44.6
Type of caries	Anterior teeth	43/19.2
	Posterior teeth	47/21.0
	Generalized	34/15.2
	No caries	100/44.6
Dental visit due to caries	Yes	43/19.2
	No	181/80.8
Bottle feeding causes caries	Yes	118/52.7
	No	106/47.3
Sleeping with bottle causes caries	Yes	130/58.0
	No	94/42.0
Sugar increases caries risk	Yes	127/56.7
	No	97/43.3
Neglecting treatment leads to complications	Yes	170/75.9
	No	54/24.1

Cat, Category; **N**, number; **%**, Percentage.

The development of (ECC) within the study population was significantly influenced by several behavioral and demographic factors (Table 4). Statistical analysis using Chi-square tests revealed that child age was significantly associated with ECC (χ^2 = 12.004, p = 0.002), with the highest prevalence observed in the 5–6 years age group (41.9%). Furthermore, the age at which caries first appeared was a highly significant predictor (χ^2 = 224.0, p < 0.001), with 40.3% of children developing their first lesions between 3 and 4 years of age. Notably, 28.2% of the sample experienced an early onset of decay as early as 1–2 years.

Table 4: Factors Associated with (ECC) in the Study Population (N = 224)

F	Cat	(N /%)	χ^2	P-V
Child Age	1–2 y	35/28.2	12.004	0.002
	3–4 y	37/29.8		
	5–6 y	52/41.9		
Sugar or Honey in infant Formula	Yes	29/23.4	9.505	0.002
	No	95/76.6		
Maternal pre-tasting of bottle	Yes	69/55.6	9.486	0.002
	No	55/44.4		
Pacifier During Sleep	Yes	69/55.6	5.424	0.020
	No	55/44.4		
Bottle Cleaning	Yes	50/40.3	6.171	0.013
	No	74/59.7		
Mouth Cleaning	Yes	48/38.7	4.566	0.033
	No	76/61.3		
Sleeping with Bottle	Yes	50/40.3	8.521	0.004
	No	74/59.7		

F, Factor; **Cat**, Category; **N**, number; **χ^2**, Chi-Square; **P-V**, P-value; **Y**, years

Feeding habits played a paramount role in disease prevalence. Significant associations were found with adding sugar or honey to formula (χ^2 = 9.505, p = 0.002), sleeping with a bottle in the mouth (χ^2= 8.521, p = 0.004), and pacifier use during sleep (χ^2 = 5.424, p = 0.020). Furthermore, maternal behaviors, specifically pre-tasting the bottle (χ^2 = 9.486, p = 0.002), suggested a potential pathway for bacterial transmission. Conversely, protective hygiene practices, such as cleaning the bottle before feeds (p = 0.013) and cleaning the child's mouth after feeding (p = 0.033), were significantly linked to lower ECC risks.

Clinically, these factors culminated in distinct disease patterns (p < 0.001, Phi = 1.0). Posterior caries were the most prevalent (37.9%), followed closely by anterior involvement (34.7%), while 27.4% of children suffered from widespread caries. Interestingly, socio-demographic variables, including gender, residence, and maternal education, showed no significant association with ECC (p > 0.05), indicating that behavioral practices are the primary drivers of dental decay in this demographic.

The results of the logistic regression analysis highlight the significant scale of dental health challenges in the region. As indicated in table 5, out of the 224 mother–child pairs examined in Brack Al-Shatti municipality, 124 presented with at least one decayed, missing, or filled primary tooth. This equates to an overall (ECC) prevalence of 55.4% within the study population. Such a high prevalence reflects a substantial oral health burden in the region, emphasizing the critical need for immediate preventive strategies and community-based oral health programs.

Table 5: Prevalence of (ECC) among the Study Population (N=224)

Status	(N/%)
Caries Present (ECC)	124/55.4
Caries Free	100/44.6
Total	224/100.0

The final analysis included a cohort of 224 mother–child pairs. To identify factors associated with (ECC), a multivariable logistic regression model was employed. This approach allowed for the adjustment of potential confounders, ensuring a more precise determination of the specific factors significantly associated with the occurrence of caries within the study population.

Model fitness:

The multivariable logistic regression model demonstrated the model demonstrated good fit and acceptable explanatory power, and high statistical significance. According to the Omnibus test of model coefficients (χ2 = 62.503, df = 14, p < 0.001), the model was highly effective in predicting the occurrence of (ECC). The model's explanatory power was further evidenced by the Cox & Snell (0.243), Nagelkerke (0.326) and R2 values, suggesting that the included variables account for approximately 24.3% to 32.6% of the total variance in (ECC) cases. Most importantly, the Hosmer-Lemeshow goodness-of-fit test yielded a non-significant result (χ2 = 6.123, p = 0.633), confirming that the model's predictions are in close alignment with the observed data and that the model is adequately calibrated, as shown in table 6.

Table 6: Model summary and goodness-of-fit statistics for the logistic regression model

Statistic	Value
Sample size (N)	224
-2 Log Likelihood	245.451
Cox & Snell R^2	0.243
Nagelkerke R^2	0.326
Omnibus test χ^2 (df)	62.503 (14)
p-value	< 0.001
Hosmer–Lemeshow χ^2 (df)	6.123 (8)
Hosmer–Lemeshow p-value	0.633

Factors associated with early childhood caries:

The multivariable logistic regression analysis identified several key factors associated with (ECC). Among the dietary and behavioral risk factors, the addition of sugar or honey to formula was the strongest predictor, with children in this group being over three times more likely to develop (ECC) (AOR = 3.63, 95% CI: 1.42–9.27, p = 0.007). Similarly, significant associations were observed with maternal pre-tasting of bottle (AOR = 2.05, p = 0.025), the use of a

pacifier during sleep (AOR = 2.07, p = 0.024), and the habit of sleeping with a bottle in the mouth (AOR = 2.05, p = 0.048).

Conversely, oral hygiene practices demonstrated a significant protective effect. Specifically, cleaning the feeding bottle before use was associated with a 59% reduction in the odds of (ECC) (AOR = 0.41, 95% CI: 0.21–0.78, p = 0.006). Furthermore, the most substantial protective factor was cleaning the child's mouth after feeding, which reduced the likelihood of (ECC) by 66% (AOR = 0.34, 95% CI: 0.18–0.65, p = 0.001), as detailed in table 7.

Table 7: Multivariable logistic regression analysis of factors associated with early childhood caries

Variable	AOR (95% CI)	p-value
Adding sugar/honey to formula	3.63 (1.42–9.27)	0.007
Pacifier use during sleep	2.07 (1.10–3.89)	0.024
Maternal pre-tasting of bottle	2.05 (1.09–3.86)	0.025
Sleeping with bottle in mouth	2.05 (1.01–4.16)	0.048
Cleaning bottle before feeding	0.41 (0.21–0.78)	0.006
Cleaning mouth after feeding	0.34 (0.18–0.65)	0.001

AOR, Adjusted Odds Ratio; **CI. 95%**, Confidence Interval; **P-V**, P-value.

Model classification performanc: The predictive performance of the logistic regression model demonstrated, as illustrated in table 8. A robust overall classification accuracy of 75.9%. In terms of diagnostic precision, the model exhibited a high sensitivity, correctly identifying 81.5% of children with (ECC). Furthermore, the model showed a specificity of 69.0%, accurately classifying those without the condition. These results indicate that the model is particularly effective at capturing true cases of (ECC), providing a reliable framework for identifying at-risk children based on the studied associated factors.

Table 8: Classification performance of the logistic regression model

Observed outcome	Predicted: No (ECC)	Predicted: (ECC)	Percentage % correct
No (ECC)	69	31	69.0
(ECC)	23	101	81.5
Overall accuracy	—	—	75.9

Discussion

Early Childhood Caries (ECC) and its associated behavioral determinants among children in Brack Al-Shatti. The observed prevalence of 55.4% underscores ECC as a significant public health concern within this population. Although the highest prevalence was observed among children aged 5–6 years (41.9%), the most clinically significant finding was the notably early onset of the disease, with 40.3% of children developing their first carious lesions between 3 and 4 years of age, and nearly 28.2% affected as early as 1–2 years.

These findings are consistent with [8], who reported that 5-year-old children exhibit the highest susceptibility to dental caries, particularly within the posterior dentition. This pattern may be explained by the metabolic activity of cariogenic oral microbiota, which ferment dietary sugars and produce organic acids that reduce oral pH and initiate enamel demineralization. Moreover, the prolonged retention of fermentable carbohydrates within the pits and fissures of posterior teeth likely creates a favorable environment for sustained acidogenic activity and lesion progression.

The behavioral determinants identified in Brack Al-Shatti also parallel findings reported in other populations, including the socio-behavioral study conducted in Trinidad [21]. In particular, saliva-sharing practices between caregivers and children may facilitate the vertical transmission of cariogenic bacteria, a mechanism that aligns with the unifying conceptual model of environmental and maternal influences in ECC development proposed by [22]. Furthermore, maternal psychosocial factors and caregiving burden have been shown to significantly influence children's caries experience [19, 23].

These findings are consistent with previous studies conducted in similar settings across various developing countries [3]. Recent studies in similar contexts have also highlighted that social and background inequalities play a crucial role in the distribution of caries among preschool children [24, 25]. Where (ECC) prevalence typically ranges between 40% and 70% ([2, 3]. In this context, the present study contributes to the limited evidence from North African populations, highlighting the role of modifiable maternal behaviors in (ECC) development.

Global epidemiological data further confirm the widespread burden of (ECC), with a recent systematic review and meta-analysis estimating that nearly half of preschool children worldwide are affected by this condition, although substantial regional variations exist [26]. These observations highlight that (ECC) continues to represent a persistent global health challenge despite advances in preventive dental care.

The relatively high prevalence identified in the present study likely reflects the combined influence of behavioral, environmental, and socioeconomic factors. Limited awareness of appropriate oral health practices [27], frequent consumption of sugar containing foods and beverages, and restricted access to preventive dental services may collectively contribute to the observed burden of disease. Previous studies have consistently emphasized that (ECC) is strongly influenced by dietary behaviors and lifestyle patterns established during early childhood [6, 27].

Dietary habits emerged as one of the most important determinants of (ECC) in this study. In particular, the addition of sugar or honey to infant formula was significantly associated with an increased risk of (ECC) [6], with affected children showing children exposed to added sugar or honey had significantly higher odds of developing (ECC) (AOR = 3.63; 95% CI: 1.42-9.27). This finding is consistent with the well-established biological mechanism underlying dental caries, whereby frequent exposure to fermentable carbohydrates promotes the proliferation of cariogenic microorganisms, leading to acid production and subsequent enamel demineralization [28, 29].

Beyond dietary composition, feeding patterns and timing also appeared to play a crucial role in the development of (ECC). Night-time feeding using bottles or pacifiers was associated with an increased likelihood of dental caries. During sleep, salivary flow decreases substantially, reducing the natural buffering capacity of saliva and allowing sugars to remain in prolonged contact with tooth surfaces [12, 14, 15]. Similar results have been reported in previous studies, including the case-control study conducted by [29], which identified night-time bottle feeding as a significant predictor of caries development in young children.

Caregiver behaviors also emerged as an important factor associated with (ECC) risk. In the present study, saliva-sharing practices between mothers and children, such as maternal pre-tasting of bottle to check its temperature or taste before giving it to the child, were significantly associated with increased odds of (ECC). These behaviors may facilitate the vertical transmission of cariogenic bacteria from caregivers to children, a mechanism that has been well

documented in microbiological and epidemiological studies [8, 10].

Socioeconomic characteristics also played a notable role in the occurrence of (ECC). Children whose mothers had lower educational levels were more likely to experience dental caries compared with those whose mothers had higher levels of education. Maternal education is widely recognized as a key determinant of health literacy and may influence parental knowledge related to oral hygiene practices, feeding behaviors, and preventive dental care [18]. These findings reinforce the growing body of evidence suggesting that (ECC) is not solely a biological condition but also a socially mediated disease shaped by socioeconomic disparities.

The results of this study are broadly consistent with findings reported in several regional and international investigations. For instance, a cross-sectional study conducted in Saudi Arabia reported high caries prevalence of 95% among the participants. Statistical analysis indicated that dietary habits and the frequency of dental visits were significant predictors of caries experience, whereas demographic variables such as gender, age, and birth order, along with oral hygiene behaviors, did not demonstrate a significant association [30].

Similarly, a comparative study conducted in Bangladesh reported significantly higher (ECC) prevalence among bottle-fed children compared with breastfed children, emphasizing the importance of feeding patterns and parental knowledge in shaping early oral health outcomes [31].

Additional evidence supporting the influence of feeding practices on (ECC) was reported in another clinical study which found that breastfed children had lower decayed, missing, and filled teeth (dmft) scores compared with children who were formula-fed or received mixed feeding. The authors suggested that breastfeeding may offer biological and immunological advantages that contribute to healthier oral environments during infancy [32].

Interestingly, in the present study, formula feeding itself did not remain a significant risk factor after adjustment for behavioral variables. This finding suggests that the behavioral context surrounding feeding including feeding frequency, timing, and associated oral hygiene practices may play a more critical role in (ECC) development than the feeding method alone. Similar observations were reported by [11], who emphasized that inappropriate feeding behaviors, rather than the type of milk consumed, are the primary drivers of (ECC) progression.

Encouragingly, several protective behaviors were also identified. Cleaning the child's mouth after feeding and maintaining appropriate hygiene of feeding bottles were both associated with significantly lower odds of dental (ECC). Early oral hygiene practices are widely recognized as essential preventive measures, particularly during the period of primary tooth eruption.

Overall, the findings of the present study reinforce the multifactorial nature of early childhood caries. (ECC) appears to result from the complex interaction of biological, behavioral, and socioeconomic factors, including dietary habits, caregiver practices, oral hygiene behaviors, and maternal education. Similar conclusions have been drawn in several epidemiological studies examining the determinants of (ECC) in young children [6, 27].

From a public health perspective, these findings highlight the need for preventive strategies that extend beyond clinical dental care. Educational programs targeting parents and caregivers may play a critical role in improving feeding practices, reducing children's exposure to added sugars, and promoting early oral hygiene behaviors. Evidence from community-based health promotion interventions suggests that enhancing parental awareness can significantly contribute to the prevention of (ECC) among preschool children [33] Finally, future research should consider longitudinal study designs to better understand the causal relationship between maternal feeding practices and the development of Early Childhood Caries (ECC) over time. Such studies should adopt a life-course perspective, accounting for the complex interactions between dietary behaviors, parenting practices, and cultural influences on children's eating behaviors [34, 35]. Furthermore, future investigations should incorporate radiographic assessments, such as bitewing radiographs, to supplement visual-tactile inspections. This methodology would significantly enhance diagnostic sensitivity by detecting proximal lesions that may remain clinically occult during conventional visual screenings, thereby providing a more comprehensive and precise estimation of ECC prevalence and its clinical severity.

Study Limitations

Several limitations should be considered when interpreting the findings of this study. First, the use of convenience sampling may limit the representativeness of the sample and the generalizability of the results to the wider Libyan population. Second, data related to feeding practices and oral hygiene behaviors relied on maternal recall and self-reporting, which may introduce recall bias or social desirability bias. Third, despite clinical examination by qualified dentists, caries diagnosis relied exclusively on visual inspection using dental mirrors and natural light, without radiographic confirmation. This approach may have resulted in an underestimation of early non-cavitated enamel lesions. Nevertheless, field-based visual examination remains a widely accepted protocol in large-scale epidemiological surveys where comprehensive clinical settings are not feasible. Fourth, the cross-sectional design of the study precludes the establishment of causal relationships.

Conclusions and Recommendations

ECC is highly prevalent among preschool children in Brack Al-Shatti, Libya, affecting more than half of the study population. The disease is significantly associated with modifiable maternal behaviors, particularly adding sugar or honey to formula, pre-tasting the bottle, and nocturnal bottle-feeding. Protective factors include simple hygiene practices: cleaning bottles before use and cleaning the child's mouth after feeding. Effective prevention strategies should focus on parental education, promotion of healthy feeding practices, and early oral hygiene interventions integrated into existing maternal and child health services.

Integrate oral health counseling into prenatal and postnatal healthcare services to improve parental awareness of early childhood caries prevention. Incorporate routine oral health screening into childhood immunization and well-child care programs to facilitate early detection and referral. Develop culturally appropriate visual educational materials targeting mothers with lower educational attainment to improve oral health literacy. Implement public health campaigns discouraging the addition of sugar or honey to infant formula, reducing nighttime bottle-feeding and sleeping with a bottle, and promoting oral hygiene practices after feeding. Educate mothers and caregivers about the risks associated with saliva-sharing behaviors, including pre-tasting feeding bottles. Promote adherence to international recommendations advocating the first dental examination by the age of one year. Provide training for nurses, pediatricians, and primary healthcare providers in basic oral health screening and parental counseling.

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