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Country profile of the epidemiology and clinical management of early childhood caries, volume II

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Published in
Frontiers in Public Health
Frontiers in Pediatrics

ISSN 1664-8714
ISBN 978-2-8325-2760-3
DOI 10.3389/978-2-8325-2760-3

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Country profile of the epidemiology and clinical management of early childhood caries, volume II

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Citation

Folayan, M. O., Ramos-Gomez, F., Tantawi, M. E., Sabbah, W., eds. (2023). *Country profile of the epidemiology and clinical management of early childhood caries, volume II*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-2760-3

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frontiers | Frontiers in Public Health

TYPE Editorial
PUBLISHED 06 June 2023
DOI 10.3389/fpubh.2023.1201899

OPEN ACCESS

EDITED AND REVIEWED BY
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RECEIVED 07 April 2023
ACCEPTED 08 May 2023
PUBLISHED 06 June 2023

CITATION
Folayan MO, Ramos-Gomez F, Sabbah W and El Tantawi M (2023) Editorial: Country profile of the epidemiology and clinical management of early childhood caries, volume II.
Front. Public Health 11:1201899.
doi: 10.3389/fpubh.2023.1201899

Editorial: Country profile of the epidemiology and clinical management of early childhood caries, volume II

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KEYWORDS

inequality, elimination, dental caries, inequity, collaboration, human right

Editorial on the Research Topic
Country profile of the epidemiology and clinical management of early childhood caries, volume II

Early childhood caries (ECC) is a non-communicable disease of global public health importance. It affects more than 530 million children all over the world. ECC prevalence is high in some countries and low in others with little explanations for the observed disparities. For example, in this Research Topic, Chouchene et al. highlighted that the prevalence of ECC was 20% for 3–5-year-olds in Tunisia; Guan et al. highlighted that the prevalence was to 63.1% for 4–5-year-old in Guizhou Province, China, while Liu et al. highlighted that the prevalence was 74.3% in 3–5-year-olds in Xiangyun, China; and Şengül et al. showed the prevalence was 73.3% for 4–5-year-olds in Turkey.

There seems to be consensus, however, that ECC is a disease of inequality with a heavier burden in lower-income countries and among children from lower socioeconomic backgrounds. Yet, the global profile of ECC is not so distinct and cannot be stratified completely by country income profile. For example, sub-Saharan Africa is one of the poorest regions in the world (1). However, in this region, Gambia, which a low-income country, has one of the lowest levels of ECC prevalence in the world while the Central African Republic, the Democratic Republic of Congo and Gabon which have the same income level as Gambia, have one of the highest levels of prevalence of ECC in the world (2). Similarly, Nigeria, a low-middle-income country, has the second lowest prevalence of ECC in children younger than 36-months-old and the second lowest prevalence of ECC in children 36–71 months old after Denmark (3).

Our understanding of the factors driving inequity in ECC distribution may have been limited by the theoretical lens by which we used to study ECC. Studies on the social and structural drivers of ECC are limited and so are studies that use the human right approach. Most studies on ECC explore individual and household factors. Further investigation is needed into studies that explore the impact of food and food policies on the risk of ECC as highlighted by Amalia et al.. A study by Albrecht showed a link between soil fertility and epidemiology of caries in the US. This study noted that *soils with a high capacity for protein production, because of their high mineral fertility, are the soils that have also grown better teeth* (4). Studies of the land (sustainable development goal 15), food and dietary diversity may improve understanding of ECC and how to proceed to eliminate this public health threat. As identified in this Research Topic, Wang et al. showed that dietary diversity and vegetable meals are associated with lower risk of ECC but grain diet is associated with higher ECC risk. The study of land and food may help improve our understanding of culture and its impact on oral health. Culture may be a better tool to understand the distribution of ECC than country income levels.

Studies of health systems and how they can support the control of ECC are also important. Integrating ECC management into primary health care and pediatric healthcare delivery systems in every country can improve children's access to oral healthcare. In this Research Topic, Shmueli et al. highlighted that collaborating with a wide range of healthcare workers to deliver sustainable oral healthcare tailored to the needs of local communities will be required to promoting oral and dental health in early childhood in Israel. Prior to this issue highlighted in this Research Topic, other authors had highlighted the need to establish a collaborative partnership between oral health care providers and community-based oral health workers is needed to to reach hard-to-reach populations (5); and supporting interprofessional education and collaborative practice between oral health, medical and other pediatric primary care providers is needed (6).

The study of ECC may also need new methodologies. Of interest is the use of single question self-measure as an indicator of ECC. Experts are skeptical about the validity of single-item measures to measure cognitive and affective outcomes. Yet, single-item measures can provide valid and reliable assessment of important phenomena just like their multi-item counterparts (7). Single item measures allow the conduct of shorter surveys, reduce research costs and improve the quality of research participants' engagement leading to greater survey effectiveness. Single item measures may also be more suited to certain populations (8). In this Research Topic, Imes et al. demonstrated how maternal assessment of oral health using a single-item measure was indicative of caries and untreated caries.

In effect, governments, global actors and research stakeholders need to do more to reduce the ECC burden. We can collectively do more if we continue to show evidence on "why" the prevalence of ECC continue to be high, and "how" to reduce this prevalence and mitigate its impact. Hopefully, the generation of new evidence to drive a collective global response for the ECC can help us reach a point where the elimination of untreated ECC becomes a possibility. The elimination of untreated ECC is a worthy target considering its significant impact on children' growth, development, quality of life, and wellbeing.

Author contributions

MF conceptualized the Research Topic, wrote the first draft of the manuscript, and developed the final version of the manuscript. FR-G, WS, and ME edited the manuscript and agreed to the final version of the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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ORIGINAL RESEARCH
published: 30 September 2021
doi: 10.3389/fpubh.2021.747371

Dental Caries and Associated Factors in 3–5-Year-Old Children in Guizhou Province, China: An Epidemiological Survey (2015–2016)

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OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *26 July 2021*
Accepted: *30 August 2021*
Published: *30 September 2021*

Citation:
Guan M, Nada OA, Wu J-j, Sun J-l, Li N, Chen L-m and Dai T-m (2021) Dental Caries and Associated Factors in 3–5-Year-Old Children in Guizhou Province, China: An Epidemiological Survey (2015–2016). Front. Public Health 9:747371. doi: 10.3389/fpubh.2021.747371

Objective: This study aimed to explore the factors influencing dental caries among 3–5-year-old children in Guizhou Province and the interrelationship between these factors using structural equation modeling, while providing theoretical references to improve the prevention and control strategy.

Materials and Methods: A total of 1,291 children aged 3–5 years in Guizhou Province were selected by a multistage stratified and whole group random sampling to examine the caries prevalence in whole-mouth deciduous teeth crowns, and parents were surveyed with questionnaires to analyze the caries-related factors. IBM SPSS Statistics v 23.0 software (IBM, Armonk, NY, USA) was used for statistical analysis.

Results: The caries prevalence of children aged 3–5 years in Guizhou Province was 63.1%, the mean decayed-missing-filled teeth was 3.32, the caries filling rate was 0.5%, and there was no statistically significant difference between urban and rural areas and among genders in each age group; results of logistic regression analysis showed that the caries risk increased with the following factors: age, brushing frequency <2 times per day when parents did not take their children to the dentist, and with parents poor evaluation of the oral condition of their children. The higher the education of the parent, the lower the risk of children suffering from caries in deciduous teeth.

Conclusions: With an overall poor situation about oral hygiene habits, oral healthcare attitude of the parents, and behavior transformation, the prevalence of dental caries in the deciduous teeth of children aged 3–5 years in Guizhou Province is high, and their caries status was severe, with more than 99% of the caries cases that were untreated. Therefore, prevention and treatment measures of caries in preschool children need strengthening through the improvement of public awareness and the enhancement of the management of oral health habits of their children.

Keywords: early childhood caries, associated factors, epidemiological survey, pre-school children, design efficiency deff

INTRODUCTION

Dental caries is one of the most common chronic diseases among children in the world, particularly in developing countries during the past decades (1, 2). Early childhood caries (ECC) is defined as the presence of decayed, missing, and filled tooth surfaces in any deciduous dentition occurring in a child younger than 71 months, which is an oral disease that is influenced by several factors, such as socioeconomic factors, dietary factors, oral health behaviors, and biological factors (3–7). Although the rapid economic development in China in the last decade has changed the oral health condition of the residents, survey results in some regions still revealed that the caries prevalence in preschool children is high (8–10). Guizhou Province is located in an economically underdeveloped area with a concentration of ethnic minorities in western China. Through the implementation of national economic stimulation policies such as "Western Development," "One Belt and One Road," and "Poverty Alleviation," Guizhou Province has been ranked among the top in the country in terms of economic growth rates for several years where the economic situation and living conditions of the residents have improved. In the context of changing socioeconomic factors, the changes in the prevalence and influencing factors of ECC in Guizhou Province citizens deserve attention. In this study, a sample of children aged 3–5 years in 12 kindergartens belonging to two districts (Huichuan District, Zunyi City, and Xixiu District, Anshun City) and two counties (Zunyi County, Zunyi City, and Hezhang County, Bijie Region) in the Guizhou Province was surveyed for their oral health status. Moreover, influencing factors associated with ECC were analyzed to provide a reference for oral health policies referencing the oral prevention measures and treatment strategies in Guizhou Province.

MATERIALS AND METHODS

Object of This Investigation

This study was conducted in Guizhou Province from October 2015 to May 2016 as a part of the Fourth National Oral Health Epidemiological Survey in China. This study was approved by the Dental Ethics Committee of the Chinese Society of Stomatology on July 9, 2014 (approval number: 2014-003). The survey population included children aged 3-, 4-, and 5-year-old [age was calculated according to the month of the survey], and according to the sample size formula, design efficiency (deff) = 4.5, with μ the confidence level and α set to 0.05. The estimated rate p was set to 66.0% according to the caries prevalence of 5-year-old children with deciduous teeth (according to the Third National Oral Health Epidemiological Survey), δ error margin was 10%, and the non-response rate was 20%.

The multistage stratified, cluster random sampling method was used, and two districts and two counties in Guizhou Province were randomly selected according to the population proportion using probability proportionate to size sampling method; then, three kindergartens were randomly selected from each district (county), totaling 12 kindergartens. Among the selected kindergartens, 1,291 subjects were selected by random sampling method from eligible children aged 3, 4, and 5 years using the cluster sampling method. Kindergartens with insufficient sample sizes were filled from neighboring kindergartens.

Survey Content and Methods

Oral Examination

The examination was conducted by the dentist, who administered them inside the kindergartens that provided a quiet room. Participants took the sitting position during examination under the artificial light of the dental chair. Written informed consent was obtained from the legal guardians of participants before the survey. Referring to the 5th edition of Basic Methods of Oral Health Survey of WHO and the Fourth National Oral Health Epidemiological Survey Program, the caries status of the crowns of 20 deciduous teeth in the oral cavity of children aged 3–5 years was examined by visual examination combined with probing under artificial light with a dental mirror and a WHO periodontal probe. Caries prevalence was recorded as decayed-missing-filled teeth (dmft) $>$ 0. The DMFT/dmft index was recorded according to WHO guidelines.

Questionnaire Survey

The questionnaires were obtained from the Fourth National Oral Health Epidemiological Survey. It was completed by one-on-one on-site questioning the parents of children by questionnaire investigators at the agreed time and place. The questionnaires included general information (name, age, gender, residence, and survey dates), attitudes and behaviors, and other related situations. The oral health attitude survey had six questions, of which 2 points were given for favorable attitude, 1 point for neutral, and 0 points for indifferent attitude.

Quality Control of Inspection and Questionnaire Personnel

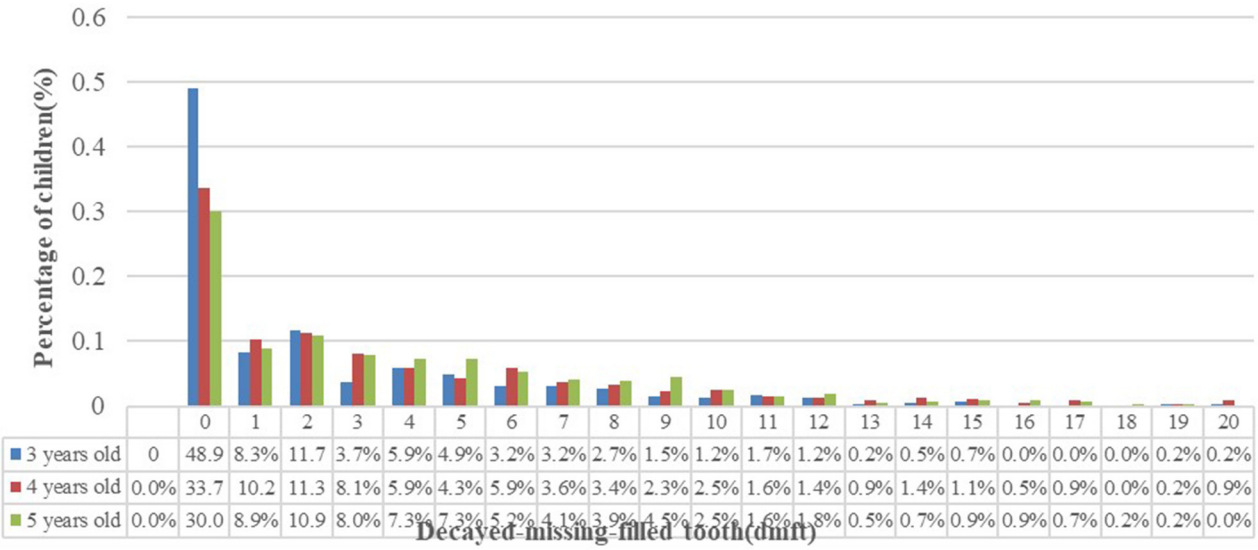
The oral examiners were all dentists with more than 3 years of clinical work experience, who received theoretical and clinical operation training before the survey, with a standard consistency test Kappa value of caries examination at 0.82–0.92. During the on-site examination, the respondents were randomly selected according to the 5% reexamination rate and were reexamined by another examiner to calculate the Kappa value $\geq$ 0.8. The questionnaire personnel also received training and were subjected to standard consistency tests after the training, and the questionnaire answers all had a compliance rate of 95% or more.

Statistical Analysis

IBM SPSS Statistics v 23.0 software (IBM, Armonk, NY, USA) was used for statistical analysis. The filling rate and the significant caries index (SiC) were calculated. Quantitative variables were compared using t-test or ANOVA, while qualitative variables, such as factors related to caries in deciduous *teeth*, were compared through chi-squared test and multivariable logistic

TABLE 1 | Dental caries status of 3- to 5-year-old children in Guizhou Province.

Item	Number	The prevalence (%) of caries	*P*-value	The mean dmft	*P*-value	Significant caries index (SiC)	*P*-value	Caries filling rate (%)	*P*-value
Residence									
Urban	645	65.1	0.125	3.54	0.049	7.98	0.404	0.5	0.909
Rural	646	61.0		3.09		8.28		0.6	
Gender									
Male	639	62.1	0.496	3.34	0.849	8.32	0.238	0.2	0.092
Female	652	64.0		3.30		7.90		0.9	
Age									
3 (years)	410	51.2	0.000	2.44	0.000	6.51	0.152	0.2	0.556
4 (years)	442	66.5		3.62		8.76		0.5	
5 (years)	439	70.6		3.83		8.68		0.9	
Total	1,291	63.1		3.32		8.11		0.5	



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3 years old	0	48.9	8.3%	11.7	3.7%	5.9%	4.9%	3.2%	3.2%	2.7%	1.5%	1.2%	1.7%	1.2%	0.2%	0.5%	0.7%	0.0%	0.0%	0.0%	0.2%	0.2%
4 years old	0.0%	33.7	10.2	11.3	8.1%	5.9%	4.3%	5.9%	3.6%	3.4%	2.3%	2.5%	1.6%	1.4%	0.9%	1.4%	1.1%	0.5%	0.9%	0.0%	0.2%	0.9%
5 years old	0.0%	30.0	8.9%	10.9	8.0%	7.3%	7.3%	5.2%	4.1%	3.9%	4.5%	2.5%	1.6%	1.8%	0.5%	0.7%	0.9%	0.9%	0.7%	0.2%	0.2%	0.0%

FIGURE 1 | Distribution of the mean decayed-missing-filled teeth (dmft) frequency in deciduous teeth in children aged 3–5 years in Guizhou Province.

regression (LR) analysis. The level of statistical testing was set at 0.05.

Strengthening the Reporting of Observational Studies in Epidemiology Guidelines

This study adheres to the STROBE guidelines.

RESULTS

Oral Examination

The caries prevalence, dmft, SiC, and caries filling ratio of 1,291 children aged 3–5 years in Guizhou Province are shown in **Table 1**, and the differences between the urban and rural areas and among genders were not found to be statistically significant ($p > 0.05$).

The frequency distribution of average caries in deciduous teeth is shown in **Figure 1**, with the majority of caries in two teeth, accounting for 11.7, 11.3, and 10.9% in the groups of children aged 3, 4, and 5 years, respectively, in all the examined children. The distribution of the number of participants gradually decreases with the increase.

The distribution of ECC (see **Figure 2**) showed that the most frequent caries sites were in the descending order that are as follows: the maxillary deciduous incisors, mandibular deciduous molars, and the maxillary deciduous molars. The children with age groups 3 and 4 years had the two maxillary deciduous incisors as the most frequently carious teeth. Moreover, the caries frequency in the deciduous molars increased gradually with age advancement, where the group of children aged 5 years had the highest caries prevalence in mandibular deciduous molars.

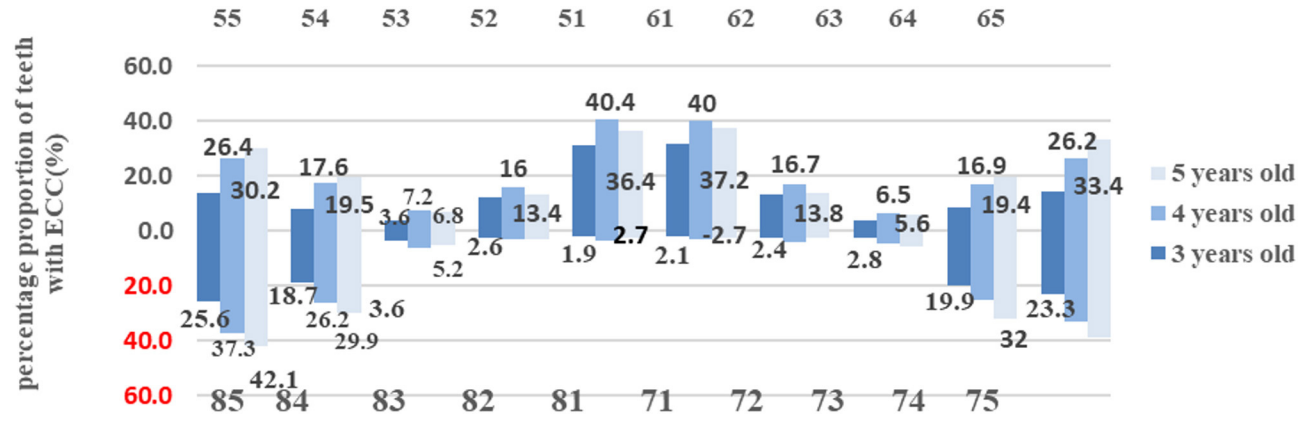


FIGURE 2 | The distribution of primary caries in each tooth position in children aged 3–5 years in Guizhou Province.

Analysis of Caries-Related Factors

In the results of bivariate analysis related to caries (see **Table 2**), there were statistically significant differences ($p < 0.05$) between the brushing frequency per day, if the child had a toothache history in the past 12 months, if the parents took the child to the dentist, the parent evaluation of the oral condition of the child, the education of parents, and the advancement in age, and if the child had caries.

The factors that were statistically significant in the aforementioned analysis included in the LR model and analyzed by the Forward LR method and the results suggested that the caries prevalence increased with the advancement of ages of children; with the risk factors being the brushing frequency of <2 times a day and parents not taking their children to visit a dentist. Moreover, the worse the parents evaluation of the oral cavity of their children, the higher the caries prevalence. Likewise, the higher the education of parents, the lower the deciduous teeth caries prevalence of children. The results are shown in **Table 3**.

DISCUSSION

The results of this study showed that the caries prevalence and the mean dmft of ECC in children aged 3–5 years in Guizhou Province (63.1%, 3.32) were comparable to the national average (62.5%, 3.35). The caries filling rate was only 0.5% with most caries not effectively treated. The difference between the urban and rural areas was not found to be significant, which may be related to the small economic disparity between the urban and rural areas based on administrative divisions randomly selected in Guizhou, where the overall economy is not developed (11). Compared with the prevalence rate of 50.3% (dmft = 1.92) among 5-year-old children in the Third Oral Epidemiological Survey in 2005, both caries prevalence and severity are on the rise, and this phenomenon also appears in the eastern regions of China such as Jiangsu Province and Guangdong Province (12), central regions such as Henan Province, and the western regions such as Sichuan Province (13). However, the trend of change of caries in deciduous teeth during the decade of 2005–2015 in Beijing faced a rapid increase where the rate of caries was curbed after intervention (14). Moreover, the caries prevalence of 5-year-old children in Hong Kong showed a trend of change from the peak value of 63–51% during the 14 years of 1993–2017, and then a small increase to 55% (15). The experience of oral healthcare service programs for preschool children in Beijing and Hong Kong suggests that ECC can be reduced by effective caries prevention measures, but it is a slow and long-term process (15). The caries situation of the younger children in Guizhou Province has been more serious, and the prevention and treatment of caries in deciduous teeth should be granted attention from early childhood.

The results of caries frequency and caries location distribution showed that the majority entails three caries per child, and the affected teeth are mostly distributed symmetrically, with caries in bilateral molars increasing with age. Moreover, several reports concluded that the overall high caries prevalence prevailed in the upper anterior teeth and posterior teeth bilaterally (12, 16–20), with the main reasons being as follows: caries in anterior deciduous teeth may be related to their early eruption in the oral cavity, poor feeding habits, and failure to perform proper oral hygiene measures on time (21–23); whereas caries in molar teeth may be related to the deep fissures and fossae on the occlusal surfaces that are difficult to clean, resulting in lengthy plaque retention (24–26). Therefore, teeth with higher caries prevalence should be the key focus for caries prevention. According to research on caries prevention methods (27–34), the incidence of ECC can be effectively reduced through fluoride application intervention two times yearly and timely fissure sealing after the eruption of molars to protect teeth at a high caries risk in both the anterior and posterior regions.

In this study, results suggested that the ratio of children consuming sweets, sugary drinks, and sweet milk/yogurt once or more per day, in addition to regularly eating desserts or drinking sugary drinks before bedtime is lower than the national level. There was no statistical correlation between the habit of

TABLE 2 | A single-factor analysis of factors associated with early childhood caries (ECC) in children aged 3–5 years in Guizhou Province.

Investigation factors		Number of people inspected (*n*, %)	Number of people suffering from the disease	Prevalence (%)	χ^2 value	*P*-value
How the child is fed 6 months postnatally	Breastfed	827 (64.1)	535	64.7	4.11	0.128
	Artificially fed	319 (24.7)	186	58.3		
	Mixed feeding	145 (11.2)	93	64.1		
Desserts and sugar consumption	Daily ≥ 1 time	321 (24.9)	209	65.1	0.776	0.378
	Daily < 1 time	970 (75.1)	605	62.4		
Sugary drink:s consumption	Daily≥1 time	176(13.6)	119	67.6	1.82	0.177
	Daily < 1 time	1,115 (86.4)	695	62.3		
Consumption of dairy products: yogurt, milk powder, and milk tea	Daily ≥ 1 time	285 (22.1)	181	63.5	0.033	0.856
	Daily < 1 time	1,006 (77.9)	633	62.9		
Consumption of sweets or drinks before bed	Present	93 (7.3)	56	59.6	0.526	0.468
	Absent	1,197 (92.7)	758	63.3		
Age of brushing onset	≥2 years old	832 (64.4)	536	64.6	3.886	0.143
	<2 years old	41 (3.2)	29	70.7		
	Unknown	418 (32.4)	249	59.6		
Brushing frequency per day	≥2 times	233 (18.0)	166	71.2	8.192	0.004
	<2 times	1,058 (82.0)	648	61.2		
Fluoridated toothpaste	Present	58 (4.5)	37	63.8	0.434	0.805
	Absent	163 (12.6)	99	60.7		
	Unknown	1,070 (82.9)	678	63.4		
History of toothache in the last 12 months	Absent	1,053 (81.6)	618	58.7	49.223	0.000
	Occasionally	171 (13.2)	143	83.6		
	Often	28 (2.2)	25	89.3		
	Unknown	39 (3.0)	28	71.8		
Parents taking their children to the dentist	Present	163 (12.6)	135	82.8	31.299	0.000
	Absent	1,128 (87.4)	679	60.2		
Parents' assessment of their child's oral condition	Good	832 (64.5)	466	56.0	75.528	0.000
	Average	328 (25.4)	225	68.6		
	Poor	131 (10.1)	123	93.9		
Parents' oral awareness attitude	0–4 points	129 (10.0)	79	61.2	0.237	0.888
	5–7 points	182 (14.1)	114	62.6		
	8–12 points	980 (75.9)	621	63.4		
The level of parental oral education	0–2 points	213 (16.5)	127	59.6	1.673	0.433
	3–5 points	735 (56.9)	473	64.4		
	6–8 points	343 (26.6)	214	62.4		
Household income	≥50,000 yuan	861 (66.7)	552	64.1	1.246	0.264
	>50,000 yuan	430 (33.3)	262	60.9		
Parental education	≤9 years	888 (68.8)	570	64.2	8.281	0.016
	10–15 years	292 (22.6)	188	64.4		
	≥16 years	111 (8.6)	56	50.5		

eating sweets or drinking sugary drinks at least once a day and the habit of eating sweets and drinking sugary drinks before bedtime, which we speculate may be related to the diet structure in Guizhou Province where the preference of population is more inclined to spicy and sour foods because Guizhou Province is a non-sucrose-producing area and the per capita sucrose consumption thereby measures at an overall lower level than China (35).

TABLE 3 | Logistics regression analysis of 1,291 children aged 3–5 years in Guizhou Province.

Variable		*β*-value	Wald chi-squared	*P*-value	OR	95% CI
Age groups	3-year-old group					
	4-year-old group	0.511	7.437	0.006	1.666	1.154 ~ 2.405
	5-year-old group	0.714	14.622	0.000	2.043	1.417 ~ 2.947
Daily brushing frequency	≥2 times					
	<2 times	0.446	6.485	0.011	1.563	1.108 ~ 2.204
Parents rate their children's oral condition	Good					
	Average	0.522	8.816	0.003	1.686	1.194 ~ 2.380
	Poor	2.880	22.962	0.000	17.806	5.483 ~ 57.820
Parent's education	≤9 years					
	12–15 years	−0.031	0.030	0.863	0.969	0.681 ~ 1.380
	≥16 years	−0.662	6.800	0.009	0.516	0.314 ~ 0.848
Parents taking their children to the dentist	Present					
	Unknown	0.550	4.249	0.039	1.733	1.027 ~ 2.923

Some scholars believe that brushing <2 times a day may lead to caries (36). However, it was found in the results of this study that the proportion of children with caries who brushed teeth two times or more a day was higher than those who brushed teeth <2 times a day, indicating that perhaps a higher brushing frequency per day does not equate to good oral hygiene, but perhaps mastering a correct brushing technique could, in theory, be the variable relevant to effectively improving oral hygiene of children (37, 38). Simultaneously, we speculate that an increase in the brushing frequency may be a behavioral change resulting after caries since it has been reported that children with caries display a significant improvement in their brushing habits after having received dental treatment (39, 40).

The education of parents influences the prevalence of ECC of children (41–44), where the results of our study also confirm that the higher the level of parental education was, the lower the prevalence of early childhood caries. Moreover, it has been suggested that the lower levels of parental education can be associated with a decreased financial ability which contributes to compromised overall access to dental resources, namely, decreased opportunities for dental checkups and dental visits (45). It has also been presented that oral health education is strongly related to socioeconomic status, which plays a key role in the prevention of ECC (46). It is, therefore the case that parents with higher levels of education are more likely to have oral health education and are thereby more capable of control and prevent ECC through enhanced child supervision and guidance that include improved oral health and dietary habits. Therefore, the parent evaluation of the oral condition of their children and whether or not they take their children to the dentist are directly related to ECC, concluding that besides dentists, parental education and their mastery of oral healthcare methods (especially correct brushing methods) play a crucial role in controlling ECC.

In addition to behavior and perception, the results of our survey were consistent with the national survey results by displaying that the majority of parents (75.9%) portray positive attitudes toward oral health. However, in our survey, the positive attitude of parents did not lead to a corresponding decrease in the ECC prevalence of children, and there was no correlation between the parental oral education level and the caries situation of children. Although the gross national product of Guizhou Province has grown rapidly in the recent years and even though this rapid economic growth has changed lifestyles and habits of the people, the positive attitude of parents did not lead to changes in the oral health habits, indicating that the transition from the knowledge and positive attitudes to implementation is a lengthy process, thereby delaying the display of positive behavioral changes in both the parents and their children in Guizhou Province.

This survey is a cross-sectional sample survey, and the questionnaire is thereby subject to few limitations. However, it can still roughly explain the overall oral health situation, namely, oral hygiene and dietary habits, awareness of oral healthcare of the parents, among children aged 3–5 years in Guizhou Province in a specific period.

The prevalence of ECC in Guizhou Province is not optimistic that should be addressed by effective measures to prevent and control.

Effective measures need to be taken to educate children to master oral healthcare methods (such as correct brushing methods). Measures are also needed to enhance parental guidance of young children (especially those with a lower education level) and regularly monitor the oral health of young children to achieve early caries detection and thereby early treatment. Moreover, it is important to actively adopt caries prevention measures through topical fluoride applications and fissure sealants to effectively control the occurrence of ECC.

CONCLUSIONS

This study finds a high ECC prevalence among children aged 3–5 years living in Guizhou Province, China. Although the prevalence of ECC in Guizhou Province matched other regions in China in 2005, it is below the WHO target of 50% caries-free by the year 2000 for 5-year-old children and this despite the undoubted

increase in the overall wealth in the past 10 years of the Province. Age, brushing frequency per day, history of toothache in the last 12 months, parent assessment of the oral condition of their child, and positive oral health attitude of parents were the significant factors for the occurrence of ECC in 3- to 5-year-old preschool children in Guizhou Province, China. As children often follow the oral health behavior of their parents, interventions should be designed to educate families and change their attitudes toward oral healthcare.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

MG and ON conceived the study, supervised the experiments, and drafted the manuscript. J-jW and J-lS evaluated data and prepared the manuscript. NL analyzed the data and revised the manuscript. T-mD analyzed the data and performed the data collection. L-mC conceived the study, designed the data evaluation, and prepared the manuscript. All authors contributed to the article and approved the submitted version.

FUNDING

This work was part of the Public Science and Technology Research Funds Project (2015)—the Fourth National Oral Health Survey (201502002), and supported by the Program of Oral Health Epidemiological Survey in Guizhou Province (gzwjkj2019-1-173).

ACKNOWLEDGMENTS

The authors would thank the children participants and their parents/grandparents, in addition to the staff who participated in the survey. Technical assistance was provided by the Guizhou Center for Disease Control and Prevention and the School of Materials and Architectural Engineering in Guizhou Normal University.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The handling editor declared a shared affiliation, though no other collaboration, with one of the authors ON at the time of the review.

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frontiers in Public Health

ORIGINAL RESEARCH
published: 26 November 2021
doi: 10.3389/fpubh.2021.725501

Early Childhood Caries in 4- to 5-Year-Old Children in Erzurum, Turkey

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Introduction: Early childhood caries is tooth decay seen in children under 72 months old. It is associated with multiple predisposing factors and has a negative impact on quality of life. In this study, our aim was to assess the oral health conditions and prevalence of early childhood caries (ECC) in children in the city of Erzurum, Turkey.

Materials and Methods: This cross-sectional epidemiological study was conducted in Atatürk University, Faculty of Dentistry, Pediatric Dentistry Department/Erzurum-Turkey, in the 2015–2016 academic year. A total of 1,156 children (588 girls and 568 boys), with mean age of 4.9 ± 0.3 years (min 4, max 5) were included in the study. Restorative index (RI), deft, significant caries index (SiC), SiC10, treatment needs, number of lost primary teeth per 100 children, care index, and prevalence of carious primary teeth were evaluated. Data were analyzed by Chi-square test and Mann–Whitney U test ($p < 0.05$).

Results: A total of 73.3% prevalence of ECC was observed in preschool children with a mean deft score of 3.9±4 and an increase in ECC with age. RI was 2.2%, SiC was 8.5, SiC10 was 12.3, caries treatment needs was 93.5%, care index was 2.1%, and number of lost primary teeth per 100 children was 0.9 tooth.

Conclusion: High level of ECC indicates the necessity of starting an oral health education program for mothers and dental screening of children, and the demand for improving oral and dental services.

Keywords: early childhood caries, deft, SiC, SiC10, restorative index, treatment needs, care index, children

OPEN ACCESS

Edited by:
Morenike Oluwatoyin Folayan, Obafemi Awolowo University, Nigeria

Reviewed by:
Bathsheba Turton, Boston University, United States
Peter Milgrom, University of Washington, United States

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *09 July 2021*
Accepted: *21 October 2021*
Published: *26 November 2021*

Citation:
Şengül F, Urvasızoğlu G, Derelioğlu S, Seddik T, Çelikel P and Baş A (2021) Early Childhood Caries in 4- to 5-Year-Old Children in Erzurum, Turkey. Front. Public Health 9:725501. doi: 10.3389/fpubh.2021.725501

INTRODUCTION

Early childhood caries is defined as the presence of one or more decayed, missing, or filled tooth surfaces in any primary tooth of children under 72 months old (1). Recently, early childhood caries (ECC) has increased rapidly worldwide, becoming an important public health problem especially in underdeveloped and developing societies. The great impact of ECC on the quality of life of children due to early tooth loss, malnutrition, and delayed growth and development, has been demonstrated in many studies (2–4). Moreover, efforts to prevent ECC have not achieved satisfactory results. Results of health surveys conducted in Turkey on 0- to 6-year-old children in 2010, 2015, and 2019 showed that 7.8, 9.3, and 6.4%, respectively, of them had oral and dental health problems (5–7). Recent oral health training and fluoride application campaign launched by Turkish Ministry of Health caused a slowdown in the increasing rate of oral and dental health problems. This study includes data from the first year of the campaign of the Ministry of Health.

In societies regarded as developing countries, such as Turkey, ECC is common because of the presence of various predisposing factors such as misconceptions about infant feeding, non-nutritive suckling habits, obesity, poor oral hygiene of mother and child, educational and socioeconomic status of the family, insufficient fluoride intake, and insufficient parental knowledge of the oral hygiene of infants (8–12). In two epidemiological studies conducted after 2010 in two different cities in Turkey (Izmir in the West and Erzurum in the East) with different sociodemographic structures, the prevalence of caries at the age of 6 was 44.8 and 76.6%, respectively (13, 14).

In 2014, the Ministry of Health in Turkey started general oral health screening programs in kindergartens and primary schools in an effort to prevent dental caries, which is considered as a widespread public health problem in Turkey. During these programs, visual presentations for oral hygiene training were followed by the application of fluoride varnishes.

Data in this study were obtained from the above-mentioned oral health screening conducted in Erzurum city by the Ministry of Health in cooperation with the Faculty of Dentistry of Atatürk University. In this study, we aimed to assess ECC prevalence in children in the city of Erzurum, Turkey, as well as the prevalence of other oral health conditions.

MATERIALS AND METHODS

This study was conducted by the Department of Pediatric Dentistry, Faculty of Dentistry, Atatürk University in accordance with the provisions of Ministry of Health Clinical Research Regulations, and had written approval from the Faculty of Medicine Research Ethics Committee (session No.03/2021 resolution # 31). In this descriptive cross-sectional study, we evaluated archived data from the oral health screening project, which was jointly carried out by the Faculty of Dentistry, Atatürk University, and the Ministry of Health, in the 2015–2016 academic year. The archived data covered 19,807 preschool and primary school children aged between 4 and 12 years in all 263 schools in Erzurum city. According to Turkish Statistical Institute (TUIK), a total of 26,866 children aged 4–12 years old were living in Erzurum around the time the data were collected; among these children, all preschoolers were included in our study (15).

Inclusion Criteria

Day care center, kindergarten, and first-grade children under the age of 72 months were included in this study; their data were extracted from the entire database of the oral health screening program; other children were excluded. The study included children attending public and private schools, representing students from low, middle, and high-income families.

Data Collection Tool

Study data were collected with examination forms developed by the researchers. The examination forms were prepared in order to record the dental caries status of the participants.

Researchers

This study was carried out by three faculty members from the department of pediatric dentistry and one member from the oral and maxillofacial surgery department.

Before beginning the study, examiners were trained and evaluated at the Department of Pediatric Dentistry, Faculty of Dentistry, University of Atatürk by one of the authors (SD), who is an experienced pediatric dentist. Kappa statistic was used to compare intra- and inter-examiner agreements of the measured deft index scores in 40 children. Kappa statistic values, comparing the deft scores measured by each of the three examiners to the deft scores measured by SD, were 0.93, 0.74, and 0.91. Intra-examiner reliability, assessed in the same children with 10-day intervals, was high, and the Kappa statistic score was 0.95, 0.82, and 0.94 for the three examiners.

Following visual presentations on oral and dental health given at the schools of the participants, oral examinations of the children were performed, and results were recorded. Parents were informed about the treatment needs of their children with formal letters delivered by post. After the oral examination and recording process had been completed, varnishes containing 5% sodium fluoride (NaF) were applied to the teeth of the children.

Oral Examination

School administrations were notified that children should brush their teeth prior to the examination. The examinations were performed in school classrooms using flat mouth mirrors, WHO periodontal probes, dental gauze rolls, containers for dirty tools, rubber gloves, single-use surgical masks, hand sanitizers, paper towels, and pen lights. First, the examining dentists explained the examination procedure to children one by one. Then, the children were examined seated in a high-back seat facing the examining dentist.

Study Size

The study population included a total of 1,156 children (568 boys and 588 girls), 4–5 years old, in the city of Erzurum. Sample size was calculated as 1,112 using Epi Info^{TM}6 (with 99% confidence interval, 5% standard error, and 73.3% prevalence). We tried to reach the whole population, and 1,156 children whose families were willing to participate in the study were included. Students who were absent on the day of the oral examination ($n = 57$) were evaluated in their schools the following week. Thus, this research can be generalized to children aged 4–5 years living in Erzurum.

Indices Used

In this study, the following indices were evaluated: caries prevalence in primary teeth, number of decayed, extracted due to caries, or filled teeth (deft), significant caries index (SiC, the mean deft of 1/3 of the study group with the highest caries score), SiC10 index (the mean deft of children with 10% highest deft scores), number of missing (extracted) primary teeth per 100 children (the sum of extracted primary teeth divided by the number of children and multiplied by 100), $caries\ treatment\ needs = \frac{decayed\ teeth}{deft} \times 100\%$, $care\ index = \frac{filled\ teeth}{deft} \times 100\%$, and restorative index ($RI = \frac{decayed\ teeth}{decayed\ teeth + filled\ teeth} \times 100\%$) (16, 17).

The number of missing primary teeth per 100 children was modified from another index (number of missing permanent teeth per 100 children) that was previously used for permanent dentition (18).

Statistical Analysis

All statistical evaluations were carried out using Statistical Package for Social Sciences version 26 (SPSS Inc., Chicago IL, United States). Descriptive statistics were used to determine the sociodemographic and clinical status of included children. Kolmogorov–Smirnov test indicated that the distribution of deft and index scores did not follow a normal distribution. Therefore, Pearson Chi-square test (nominal data) was performed for enumeration data, and Mann–Whitney U test (two groups) was performed for continuous data. The level of statistical significance was set at $p < 0.05$.

RESULTS

Out of the 1,156 research participants, 568 (49.1%) were boys and 588 (50.9%) were girls, with a mean age of 4.9 ± 0.3 years. A homogeneous distribution was observed between the groups in terms of age and sex ($p = 0.303$).

The prevalence of dental decay was 73.3% (**Table 1**). Total study population mean deft score was 3.9 ± 4. SiC score for the total population was 8.5, and SiC10 score was 12.3. Caries prevalence, deft, SiC, and SiC10 scores of 4-year-old children were lower than those of 5-year-olds ($p < 0.05$). Although there was no significant difference in caries prevalence between the sexes ($p > 0.05$), deft, SiC, and SiC10 scores of the girls were significantly lower than those of the boys ($p < 0.05$).

The distribution of deft frequency is given in **Figure 1** ("deft = 0" score was excluded). The most frequent deft values were 2, 1, and 4 scores (15.9, 14.8, and 10.8%, respectively). The distribution of the number of carious primary teeth per 100 children, caries treatment needs, care index, and RI according to age and sex is illustrated in **Table 2**. There were no significant differences between age and sex in these indices ($p > 0.05$).

DISCUSSION

Early childhood caries is one of the preventable chronic diseases that are progressing internationally in recent years. According to The Global Burden of Disease Study-2017, ∼530 million children were estimated to have untreated primary teeth caries (19). It is a serious public health problem caused by the interaction among cariogenic bacteria, carbohydrates, improper nutrition conditions, and a number of social factors (20–22). ECC has a negative impact on the well-being, learning skills, and growth and development of children. In short, it affects their quality of life (23–25). Therefore, oral and dental health should also be evaluated within the scope of general health protection programs. Since many families cannot afford costly advanced ECC treatments conducted under general anesthesia or sedation, ECC also adversely affects the families by imposing a heavy economic burden (26). This burden is huge, and immediate measures are needed to promote the oral health

TABLE 1 | Deciduous caries status of different age and sex ($n = 1,156$).

Variables	Categories	Caries prevalence no. of surveyed (No. of cases with dental caries)	Caries prevalence (%)	p-value (X^2 test)	deft mean ± SD	p-value (Mann-Whitney U)	SiC mean ± SD	p-value (Mann-Whitney U)	SiC10 mean ± SD	p-value (Mann-Whitney U)
Age (year)	4	91 (49)	53.8	<0.001	2.1 ± 3	<0.001	5.4 ± 3.2	<0.001	9.6 ± 2.2	0.002
	5	1065 (768)	74.9		4 ± 4		8.8 ± 3		12.5 ± 2.3	
Sex	Boys	588 (424)	72.1	0.364	4.2 ± 4.2	0.014	9.2 ± 3.1	<0.001	13.1 ± 2.6	0.002
	Girls	568 (423)	74.5		3.6 ± 3.7		8 ± 2.8		11.6 ± 1.7	
Total	-	1156 (847)	73.3	-	3.9 ± 4	-	8.5 ± 3.1	-	12.3 ± 2.3	-

deft, the number of decayed, extracted due to caries, or filled teeth; SiC, significant caries index; SiC10, significant caries index of the 10% of children with the highest deft scores; SD, standard deviation.

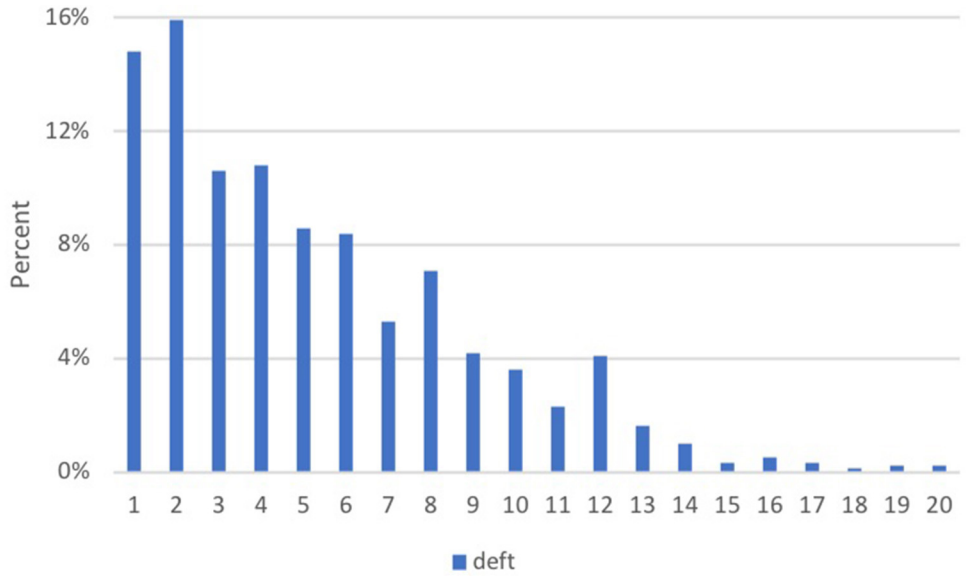

FIGURE 1 | Frequency distribution of the number of decayed, extracted due to caries, or filled teeth (deft) in 1,156 children aged 4 to 5 in Erzurum community in Turkey for the 2015–2016 academic year.

TABLE 2 | The distribution of different indices of 1,156 children by age and sex.

Age (year)	Sex	Carious primary teeth per 100 children (teeth)	Caries treatment needs (%)	Care index (%)	RI (%)
4	Boys	0.8	91.7	2.1	2.2
	Girls	0.1	97.9	1	1.1
5	Boys	1	93.2	2.4	2.5
	Girls	0.9	93.7	1.9	2
Total		0.9	93.5	2.1	2.2
p-value (X^2 test)	0.386	0.799	0.659	0.85	

RI, restorative index.

of children worldwide. Providing the community with oral healthcare services could be achieved with government policies; these policies may address several structural factors predisposing to ECC. Countries have developed their own plans and projects to intervene against ECC (27).

Because of increasing demand for dental treatments in pediatric patients in recent years in Turkey, the Ministry of Health launched countrywide oral and dental health screening programs in 2014. Within the scope of this program, not only condition assessment was made, but also educational seminars for children and teachers on oral hygiene measures and caries prevention were organized, and 5% NaF varnishes were applied to children. This study covered a part of this large project, which was conducted in Erzurum and its surroundings, and was jointly run by Atatürk University Faculty of Dentistry and the Ministry of Health.

This is not the first study of the researchers on ECC in the province of Erzurum. They had also performed a less comprehensive study in Erzurum in 2002 and 2013 that included similar age groups (8, 14). In this section, we will compare data from Erzurum province to data from Turkey and other countries.

Studies that evaluated caries prevalence showed that caries increased proportionally with age (28, 29). In our study, the mean value of caries prevalence was 73.3% for children aged between 4 and 5 years, raising serious concern about the status of permanent teeth in these children.

The higher scores obtained in this study, compared to our previous study which was conducted on a smaller population (63% in 4-year-old and 64.4% in 5-year-old children), (14) indicate an increase in the prevalence of ECC over time. Furthermore, we think that the results of this study are more generalizable, since it has been carried out on a larger population. Regardless, these data clearly indicate that the future of oral and general health status of these children is not promising.

According to the WHO, ECC prevalence by continents is: Africa 30%, Americas 48%, Asia 52%, Europe 43%, and Oceania 82%. Considering the 48% global ECC prevalence, the prevalence of 73% found in our study is quite high (30). However, our study is limited within the Erzurum province. According to

the 2011 data from the Ministry of Development with regard to socioeconomic development status, Erzurum ranked 59th among 81 cities in Turkey. As reported in the 2017 urban development index by the Ministry of Industry and Technology, Erzurum province ranked 5th out of six levels, indicating lower urban development index (31). Hence, we believe that the high prevalence of ECC found in our study is linked to low-income levels.

The ratio of available dental workforce to dental caries prevalence makes it unrealistic to suggest providing surgical or conventional restorative treatments to millions of children suffering from ECC in low-income countries. New intervention protocols that are highly effective, easy to deliver, and require fewer sensitive techniques and dental equipment are needed, especially in countries with high ECC prevalence and low dentist/population ratios.

In such low income countries, taking into consideration the lack of dental workforce and high ECC prevalence, recommending the provision of conventional dental treatment to millions of children is impractical. Novel and effective treatment protocols that can be easily fulfilled with less equipment and simple methods are required in countries with high ECC prevalence and low dentist/population ratios (32). Similar to the situation remarked by Chen et al. (32) in their review, only 6 pediatric dentists and 12 research assistants have led the efforts against ECC in Erzurum where the pediatric dentist/population ratio is 1/11,300 for children aged 0–14 years.

In our study, higher index values found in 4- to 5-year-old children, with caries treatment needs value of 93.5%, deft score of 3.9, and SiC score of 8.5, revealed that caries-preventive measures for this population were insufficient. In a study carried out on 552 kindergarten children with mean age of 4.4 $\pm$ 0.7 years in Bucharest, Romania, the deft and SiC indices were 9.11 and 12.6, respectively (33). Although this study had a higher mean score for age, which was 4.9 years, our deft score was lower but with a similar SiC score.

Mothupi et al. (34) reported caries prevalence of 48.7%, deft and SiC indices of 2.4 and 6.4, respectively, in children aged between 4 and 5 years in South Africa. In another study, Hoffmeister et al. (35) reported a deft score of 2.5 and a SiC value of 6 for 4-year-old children in Chile. Those in our findings were higher than these values.

With the help of results obtained in our study, the need for implementation of minimally invasive approaches, such as atraumatic restorative treatment, and non-surgical approaches, such as the Hall Technique and silver diamine fluoride application, and the need for educating the public on ECC, including how to improve nutrition status and oral hygiene, were emphasized once more (36). The high prevalence of caries in our study indicates the indifference of our society to oral health of infants and young children. Moreover, although efforts were made to prevent ECC by the Ministry of Health, such as semiannual dental field screenings, fluoride varnish applications, and distribution of toothpastes and toothbrushes, measures for tackling ECC are still insufficient. Children with very high prevalence of caries needed comprehensive dental rehabilitation.

CONCLUSION

This study evaluated 4- to 5-year-old children living in Erzurum, Turkey, regardless of their socioeconomic status and nutritional habits, and found very high caries prevalence. There will be a need for future studies in order to evaluate risk factors, such as socioeconomic status and nutritional and oral hygiene habits, that increase the prevalence of caries in our population.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

This study was conducted by the Department of Pediatric Dentistry, Faculty of Dentistry, Atatürk University in regard to the provisions of Ministry of Health Clinical Researches Regulations and also in accordance with the Faculty of Medicine Research Ethics Committee's written approval (Session No. 03/2021 resolution # 31). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

FŞ and GU: scanning archive data, examination of patients, and manuscript preparation. SD: study design, scanning archive data, and manuscript preparation. TS: examination of patients and manuscript preparation. PÇ and AB: statistical analyses and manuscript preparation. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 24 December 2021
doi: 10.3389/fpubh.2021.751733

Guardian Reports of Children's Sub-optimal Oral Health Are Associated With Clinically Determined Early Childhood Caries, Unrestored Caries Lesions, and History of Toothaches

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: 01 August 2021
Accepted: 06 December 2021
Published: 24 December 2021

Citation:
Imes EP, Ginnis J, Shrestha P, Simancas-Pallares MA and Divaris K (2021) Guardian Reports of Children's Sub-optimal Oral Health Are Associated With Clinically Determined Early Childhood Caries, Unrestored Caries Lesions, and History of Toothaches. Front. Public Health 9:751733. doi: 10.3389/fpubh.2021.751733

Background: Parents'/guardians' perceptions of their children's oral health are useful proxies of their clinically determined caries status and are known to influence dental care-seeking behavior. In this study, we sought to examine (1) the social and behavioral correlates of fair/poor child oral health reported by guardians and (2) quantify the association of these reports with the prevalence of early childhood caries (ECC), unrestored caries lesions and toothaches.

Methods: We used guardian-reported child oral health information (dichotomized as fair/poor vs. excellent/very good/good) obtained *via* a parent questionnaire that was completed for $n = 7{,}965$ participants (mean age = 52 months; range = 36-71 months) of a community-based, cross-sectional epidemiologic study of early childhood oral health in North Carolina between 2016 and 2019. Social, demographic, oral health-related behavioral data, and reports on children's history of toothaches (excluding teething) were collected in the same questionnaire. Unrestored ECC (i.e., caries lesions) was measured *via* clinical examinations in a subset of $n = 6{,}328$ children and was defined as the presence of one or more tooth surfaces with an ICDAS ≥ 3 caries lesion. Analyses relied on descriptive and bivariate methods, and multivariate modeling with average marginal effect (A.M.E.) estimation accounting for the clustered nature of the data. Estimates of association [prevalence ratios (PR) and adjusted marginal effects (AME) with 95% confidence intervals (CI)] were obtained *via* multilevel generalized linear models using Stata's *svy* function and accounting for the clustered nature of the data.

Results: The prevalence of fair/poor oral health in this sample was 15%–it increased monotonically with children's age, was inversely associated with parents' educational attainment, and was higher among Hispanics (21%) and African Americans (15%) compared to non-Hispanic whites (11%). Brushing less than twice a day, not having

a dental home, and frequently consuming sugar-containing snacks and beverages were significantly associated with worse reports ($P < 0.0005$). Children with fair/poor reported oral health were twice as likely to have unrestored caries lesions [prevalence ratio (PR) = 2.0; 95% confidence interval (CI) = 1.8-2.1] and 3.5 times as likely to have experienced toothaches [PR = 3.5; 95% CI = 3.1-3.9] compared to those with better reported oral health.

Conclusions: Guardian reports of their children's oral health are valuable indicators of clinical and public health-important child oral health status. Those with fair/poor guardian-reported child oral health have distinguishing characteristics spanning socio-demographics, oral-health related practices, diet, and presence of a dental home.

Keywords: parents, subjective oral health, children, dental caries, pediatric dentistry

INTRODUCTION

Early childhood caries (ECC) is a world-wide clinical and public health problem; it affects an estimated 600 million children and remains largely untreated (1). Globally, the mean ECC prevalence has been estimated to be 24% for children younger than 36 months and 57% for children aged 36-71 months. Furthermore, a significant association has been shown between higher economic growth and higher ECC prevalence at the individual country level (2). Though dental caries physically impacts children with possible manifestations including pain and infection, it also has an impact on a child's quality of life. Studies have linked dental caries with school absences, poor school performance, difficulty eating, trouble sleeping, and difficulty paying attention in class (3, 4).

Remarkably, despite its recognized multilevel consequences (5) and major advances in the science and practice of dentistry, the prevalence of ECC has not followed the declines observed among adults. In fact, besides being on the increase in some parts of the world, ECC is characterized by marked disparities, with children in families from socially disadvantaged or racial/ethnic minority backgrounds experiencing a disproportionate burden of disease (6). Taken together, these issues strongly suggest that additional, concerted efforts by multiple stakeholders (7, 8) are needed to tackle this severe early childhood disease.

Young children's health and care-seeking are largely determined by their family environment (9). Children's oral health care-related visits, oral health-related behaviors, attitudes, values, and habits are strongly influenced by their caregivers (10). For example, guardian's health literacy may determine their young children's optimal (i.e., preventive) vs. sub-optimal (i.e., problem-initiated) entry into the dental care system (11, 12), as well as future dental care-associated expenditures (13). Other studies have directly linked mothers' and children's dental caries status (14). Clearly, the road to improved children's oral health includes a focus on families and identifying means to empower parents and communities to better care for children's oral health (15). Adult family members shape the behavioral landscape underlying their young children's oral health; thus, it is logical to empirically study their specific roles, influencing factors, and areas for potential intervention.

Guardians' perceptions of their young children's oral health are useful proxies of their clinically determined dental needs (16–18) and crucially, they are known to influence dental care–seeking behaviors (11, 19, 20). Of note, guardian-reported child oral health was found to be the most informative element in one recent machine learning based ECC screening application (21). Recent reports examining parental perceptions of young children's oral health in diverse settings (22–26) demonstrate the value and practical utility of understanding the agreement between self-reports and actual clinical status or treatment needs, as well as factors influencing them. Studies among community samples (i.e., not actively dental care-seeking populations), preschool-age children (i.e., those whose oral health-related behaviors and care is entirely determined by their family environment), and diverse (i.e., multi-ethnic) populations are warranted.

The overarching motivation for this study was to add to the knowledge base of the association between guardians' reports of young children's oral health and children's clinically determined oral health status, examining factors influencing and potentially modifying these associations in a large, community-based sample of preschool-age children. This has not been previously done in a large, multi-ethnic, community-based sample of preschool-age children. Specifically, we sought to (1) examine the social and behavioral correlates of fair/poor guardian-reported child oral health, and (2) quantify the association of these reports with the prevalence of ECC, unrestored caries lesions and reported history of toothaches. We therefore hypothesize that an association exists between parental perception of a child's oral health and their clinically determined oral health status. Additionally, that those with fair/poor guardian-reported child oral health will have distinguishing characteristics spanning socio-demographics, oral-health related practices, diet, and presence of a dental home. Ultimately, if guardian reports prove valuable and informative for their children's oral health status,

Abbreviations: ECC, early childhood caries; ICDAS, International Caries Detection and Assessment System; dmfs, the number of decayed, missing, and filled primary tooth surfaces due to caries; ds, the number of decayed primary tooth surfaces; PR, prevalence ratio; CI, confidence interval; A.M.E., average marginal effect.

they may aid screening efforts to identify members of the population who are most in need of care.

METHODS

Study Population

We used clinical and questionnaire data obtained in the ZOE 2.0 pediatric oral health study, a community-based cross-sectional epidemiologic study of childhood oral health in North Carolina (NC), United States (27, 28). Between 2016 and 2019, the investigators enrolled 8,059 children ages 36-71 months attending public preschools (Head Start) in 86 out of 100 NC counties. Head Start is a comprehensive program that provides education and healthcare services to low-income families, who are also eligible for public insurance. During the study period, there were ∼20,000 children enrolled in the Head Start system in North Carolina; 13,089 children were invited to participate. Children's guardians provided written informed consent to participate in this IRB-approved study (UNC-Chapel Hill #14-1992) and completed a written questionnaire about their children's oral health. This questionnaire was available in both English and Spanish language. Comprehensive clinical examinations took place in children's preschool centers typically within 2 months of enrollment. In this study 8,059 3-5 year-old children were enrolled and all their parents/legal guardians returned the questionnaire. Furthermore, 6,470 (80%) had clinical examinations, and 6,328 of those yielded usable clinical and questionnaire data. Detailed information about the study population, sample size considerations, procedures, and the clinical examination protocol have been previously reported (27, 29).

Measures and Variables

The questionnaire for the guardians included 15 items covering 5 domains of information: socio-demographics (i.e., gender, race/ethnicity, parents' level of education), oral health-related practices (i.e., frequency of brushing, use of fluoridated toothpaste, adult involvement in tooth brushing), diet (e.g., daily frequency of sugar-containing snacks and beverages), presence of a dental home, and guardian-reported child oral health status including proxy-reported health and history of toothaches (not due to teething). As defined by the American Academy of Pediatric Dentistry (AAPD), dental home is understood as a continuous relationship between a dentist and patient. As described here, having a dental home has proven to provide better health outcomes for children, especially those at higher risk for ECC or periodontal disease. To measure proxy-reported oral health, we used an item routinely used in the U.S. National Health and Nutrition Examination Survey (NHANES)—"how would you describe the condition of your child's mouth and teeth," that included five response options: excellent, very good, good, fair, and poor. In the present study we dichotomized item responses to distinguish between "negative" (i.e., fair/poor) and "positive" (i.e., good/very good/excellent) reports. Ninety-nine percent ($n = 7{,}965$) of participants answered this question and this group comprised the study's analytical sample. Answers to the question regarding history of toothaches not due to teething were also treated as a dichotomous response variable. In addition to individual questionnaire item responses on oral health behaviors–OHB (i.e., diet/feeding practices, oral hygiene practices and presence of a dental home), we used a latent class analysis-derived membership variable "favorable vs. unfavorable OHB" that broadly segregates individual participants with oral health-promoting vs. deleterious oral health behaviors (30).

Clinical examinations were done by trained and calibrated dental examiners using modified visual International Caries Detection and Classification (ICDAS) criteria (31). Dental caries experience was recorded at the tooth surface-level and in this study was defined at the moderate/established caries lesion threshold (ICDAS $\geq$ 3) (32). Consequently, ECC cases were defined as children with decayed, missing, filled surface (dmfs) index $\geq$ 1 (i.e., at least one primary tooth surface with caries experience) and those with unrestored caries lesions had decayed surfaces index (ds) $\geq$ 1 (i.e., at least one caries-affected and not restored primary tooth surface). Of note, for the purposes of this study, we considered the presence of unrestored, ICDAS $\geq$ 3 caries lesions, to represent "unrestored disease."

Analytical Approach

We sought to determine the association of the dichotomized reports of oral health with the prevalence of ECC, unrestored caries lesions, and history of toothaches. We also examined correlates of fair/poor guardian-reported child oral health through responses derived from the questionnaire. For initial data description, we relied on descriptive and bivariate tabular and visual methods of presentation. There data were clustered in nature: specifically, children were enrolled in 260 different preschool centers (primary clusters) and within 34 different preschool programs (higher level clusters). We employed statistical methods to account for this study design feature. Bivariate comparisons (i.e., Pearson chi-square) and estimates of association [prevalence ratios (PR) and 95% confidence intervals (CI)] were obtained using Stata's *svy* function and Taylor-linearized variances. To obtain covariate-adjusted estimates of association of fair/poor oral health reports with clinical measures of disease (ECC and unrestored caries) and reported toothaches, we used multi-level generalized linear models (log-binomial models) including random-effect terms for the two-level nested clustered design and fixed-effect terms for children's age in months, race/ethnicity, and parents' education level. Interpretation of these model results was based on marginal effects estimation (33) and reporting of average marginal effects (A.M.E.) expressed in absolute percentage points (p.p.) increase in the prevalence of ECC, unrestored caries lesions, and toothaches. Analyses were done using Stata/MP version 17.0 (StataCorp LLC, Texas, US) and JMP Pro 16.0 (SAS Institute Inc., Cary, NC).

RESULTS

Participating children ($n = 7{,}965$) had mean age of 52 months and were of diverse racial/ethnic composition (**Table 1**), with 48% being non-Hispanic Blacks (African Americans), 20% Hispanic, and 18% non-Hispanic whites. The demographic

TABLE 1 | Sociodemographic information of the ZOE 2.0 study participants, overall and among those with clinical information for early childhood caries (ECC).

	All participants*	w/ECC information
	n (column %)	*n* (column %)
Entire sample	7,965 (100)	6,328 (100)
Gender		
Boy	3,955 (50)	3,155 (50)
Girl	4,008 (50)	3,173 (50)
Age at enrollment (years)		
3	2,537 (32)	1,967 (31)
4	4,183 (53)	3,334 (53)
5	1,245 (16)	1,027 (16)
(months), mean (SD)	52 (7.5)	52 (7.4)
Race/ethnicity		
Non-hispanic black	3,755 (48)	3,003 (48)
Hispanic	1,585 (20)	1,268 (20)
Non-hispanic white	1,422 (18)	1,122 (18)
>1 race	836 (11)	654 (10)
AI/AN/Asian/NH/PI/Other	285 (4)	219 (4)
Guardian's education		
Some elementary	367 (5)	317 (5)
Some high school	1,110 (14)	861 (14)
High school/GED diploma	2,941 (38)	2,338 (38)
Some technical/college education	2,243 (29)	1,783 (29)
College or more	1,118 (14)	885 (14)

**94 participants (1.2% of the entire study population) were excluded from presentation and analysis due to missing information in the reported child oral health status questionnaire item.*

ECC, early childhood caries; AI, American Indian; AN, Alaskan Native; NH, native Hawaiian, PI, Pacific Islander.

composition of these participants remained the same for the subset with ECC clinical information (n = 6,328). The prevalence of fair/poor reported oral health in this sample of children was 15%. The frequency of fair/poor reports increased monotonically with children's age, was inversely associated with their guardians' educational attainment, and was higher among Hispanics (21%) and African Americans (15%) compared to their non-Hispanic white counterparts (11%). The associations of fair/poor reported child oral health with race/ethnicity and education persisted within and across strata of children's age.

Unfavorable patterns of child oral health-related behaviors were associated with higher prevalence of fair/poor reports (**Table 2**). Specific behaviors underlying this association included brushing less than twice a day, not having a dental home, and frequently consuming sugar-containing snacks (all with $P < 0.0005$). In contrast, we found no important associations with adult involvement in tooth brushing and use of a fluoride-containing toothpaste.

In bivariate comparisons, we found that children with fair/poor reported oral health had worse clinically determined oral health (**Table 3**). For example, they were twice as likely to have unrestored disease [prevalence ratio (PR) = 2.0; 95% confidence interval (CI) = 1.8-2.1] and 3.5 times as likely to have experienced toothaches [PR = 3.5; 95% CI = 3.1-3.9] compared to those with better reported oral health. After adjusting for children's age and race/ethnicity and guardian's education in multivariate analyses, these associations remained statistically significant and were of substantial magnitude. Sub-optimal (i.e., fair/poor) reported oral health was associated with absolute percentage point (p.p.) increases in ECC: +44 p.p., unrestored caries lesions: +26 p.p., and history of tooth aches: +15 p.p.

DISCUSSION

This study sought to quantify the association between parental perception of children's oral health and their clinically determined dental needs. The findings provide support for the use of proxy reports, specifically guardian-provided assessments in investigations and monitoring of early childhood oral health at the population level. Child oral health status reports based on a single questionnaire item were found to be strongly indicative of clinically determined measures of ECC, including unrestored caries lesions and history of toothaches. These associations were robust to adjustments for children's and parents' sociodemographic characteristics. Importantly, these findings were generated from a large, community-based sample of preschool-age children, and not a clinic-ascertained convenience sample that might overrepresent a dental care-seeking subset of this population. Taken together, these data affirm the value of proxy-reported measures of child oral health and their concordance with clinical and public health-important oral disease endpoints.

We also sought to explore correlates of suboptimal (fair/poor) guardian-reported child oral health. Indeed, reports of sub-optimal (i.e., fair/poor) child oral health were significantly more prevalent among population subgroups known to experience disproportionate levels of dental disease—ethnic minorities and children in families with low levels of education. This is consistent with previous findings and may be due to dental care seeking attitudes (e.g., inconsistent dental care) or values (e.g., perception of primary teeth not being important). This association has emerged in both preschool-age and school-age populations. For example, Talekar et al. analyzed national data in the United States found worse reported oral health among preschool-age children whose parents had lower educational attainment (16). A more recent study (34) confirmed that lower parental education was associated with higher rates of decay in their children.

Strikingly, sub-optimal reports were almost twice as common among Hispanic participants compared to their non-Hispanic white counterparts, mirroring earlier reports of oral health disparities experienced by this population group (35, 36). This finding must be interpreted with caution, as Spanish speakers may differentially report child oral health problems—in an earlier study among a younger (6-23-month-old) child population in NC we found a lower rate of 'child oral health-related problems'

TABLE 2 | Guardian-reported child oral health-related behavior information in the ZOE 2.0 study sample, overall and stratified by child reported oral health status.

		Reported child oral health status		
	All participants*	**Excellent/very good/good**	**Fair/poor**	
	***n* (column %)**	***n* (row %)**	***n* (row %)**	***P***
Entire sample	7,965 (100)	6,734 (85)	1,231 (15)	
Pattern of modifiable child oral health-related behaviors†				<0.0005
Favorable	5,883 (74)	5,131 (87)	752 (13)	
Unfavorable	2,078 (26)	1,600 (77)	478 (23)	
Tooth brushing frequency				<0.0005
Twice a day or more	4,940 (62)	4,293 (87)	647 (13)	
Less than twice a day	3,011 (38)	2,431 (81)	580 (19)	
Adult involvement in tooth brushing				0.172
Yes	4,777 (60)	4,015 (84)	762 (16)	
No	3,180 (40)	2,711 (85)	469 (15)	
Use of fluoridated toothpaste				0.155
Yes	6,073 (77)	5,162 (85)	911 (15)	
No	848 (11)	713 (84)	135 (16)	
I do not know	980 (12)	804 (82)	176 (18)	
Child has a dental home				<0.0005
Yes	6,544 (84)	5,699 (87)	845 (13)	
No	1,267 (16)	907 (72)	360 (28)	
Between-meal sugar-containing snacks and beverages daily consumption				<0.0005
≥2	5,713 (72)	4,757 (83)	956 (17)	
<2	2,235 (28)	1,962 (88)	273 (12)	

**94 participants (1.2% of the entire study population) were excluded from presentation and analysis due to missing information in the reported child oral health status questionnaire item.*
†Derived from latent class analysis of responses to 6 modifiable oral health behavior questionnaire items, as reported by Simancas-Pallares et al. (30).

TABLE 3 | Clinical and guardian-reported measures of child oral health in the ZOE 2.0 study sample, and associations with reported child oral health status.

	All participants*	**Child oral health status**			
		Excellent/very good/good	**Fair/poor**		
	***n* (column %)**	***n* (row %)**	***n* (row %)**	***PR (95% CI)*‡**	***adjusted A.M.E.*‖**
ECC status†					
Yes	3,407 (54)	2,571 (75)	836 (25)	1.8 (1.7-1.9)	+42 p.p. (37-47)
No	2,921 (46)	2,797 (96)	124 (4)	ref.	ref.
Unrestored disease† status					
Yes	2,269 (36)	1,682 (74)	587 (26)	2.0 (1.8-2.1)	+26 p.p. (21-30)
No	4,059 (64)	3,686 (91)	373 (9)	ref.	ref.
History of tooth aches, not from teething					
Yes	958 (12)	586 (61)	372 (39)	3.5 (3.1-3.9)	+15 p.p. (14-17)
No/I do not know	6,930 (88)	6,082 (88)	848 (12)	ref.	ref.

**Participants with clinical information only are included in ECC and unrestored disease comparisons, whereas all participants with non-missing questionnaire information are included in the toothache history comparison.*
†Defined at the ICDAS≥3 caries lesion detection threshold.
‡Prevalence ratio and 95% confidence intervals estimated with an unadjusted log-binomial model accounting for the complex study design using Stata's svy function.
‖Adjusted average marginal effect (expressed in percentage points) of the association of reported child oral health status, with ECC, unrestored disease and history of toothaches, estimated from an adjusted multilevel generalized linear model including terms for features of study design, as well as children's age, race/ethnicity, and guardian's education.
ECC, early childhood caries; PR, prevalence ratio; CI, confidence interval; A.M.E., average marginal effect.

among children in Spanish-speaking families compared to their English-speaking counterparts (37). Low health literacy (24) and social desirability bias (38), among other reasons, could diminish the validity of guardians' child oral health reports. Nevertheless, this study's findings are concordant with previous reports suggesting considerable association between guardian reports and objective measures of childhood dental disease (16–18, 23, 39).

The monotonic increase of fair/poor reported child oral health status with children's age is expected, as ECC experience, severity, and associated problems also increase in the same manner at the population-level. It is possible that parents perceive visual changes in their children's teeth (i.e., the formation of cavities), signs and symptoms of tooth pain or sensitivity, or they are informed by a health professional that dental problems exist. The associations with sub-optimal child oral health-related behaviors and practices, such as infrequent brushing, lack of a dental home, and frequent consumption of sugar-containing snacks and beverages are demonstrative of the important role these, arguably modifiable, behavioral risk factors play in the development of ECC at the person-level (40). Emphasis is currently placed by multiple stakeholders on all children establishing a dental home in the first 12 months of life (41). Introduction of a dental home is believed to provide better health care outcomes for children, especially those at higher risk of developing ECC. Children introduced to a dental home at an early age receive effective preventative care (42). These children are also less likely to need emergency dental care, which is emotionally and financially burdensome (43, 44).

From a public health standpoint, the estimated associations of 44 percentage points higher prevalence of ECC, 26 percentage points higher prevalence of unrestored disease, and 15 percentage points higher prevalence of history of toothaches, are noteworthy—it would be justifiable to use population-wide screening strategies using single-item guardians' reports to identify segments of the child population that might need targeted or intensified comprehensive dental care. This may be especially important for largely non-dental care-seeking segments of the population wherein clinical information is lacking, or where access to dental care services is difficult. This strategy may also offer cost and time advantages and reduce study participants' information burden.

The study's findings must be viewed while acknowledging several limitations. First and foremost, questionnaire and clinical data were obtained practically contemporaneously—this limits any potential for causal inference (i.e., guardians' reports being predictive of clinical disease or toothaches), but these identified associations can be validly interpreted in the context of screening. Second, it is possible that some guardians' perceptions were influenced by dental care received by their children—even if presenting with no current clinical problems, guardians' perceptions of oral health may be lowered due to the history of recent and potentially extensive dental care. Notwithstanding this speculative scenario, the group of children with ECC experience include both those with restored and unrestored disease and identifying both groups is of public health significance, i.e., for monitoring disease experience. Finally, these results emanate from a single state in the U.S., and from a low-income, high-risk child population attending public preschools; while this population may not be representative of the general preschool-age population in other U.S. states or countries, or those in more affluent strata, we believe that the findings regarding guardians' reports are generally transferable across samples and populations.

CONCLUSIONS

In this cross-sectional study among a multi-ethnic, community-based sample of preschool-age children, we found strong associations between guardian-reported child oral health status, and ECC, including unrestored caries lesions, and history of toothaches. Fair/poor child oral health reports were associated with lower guardian education and were higher among racial/ethnic minorities compared to non-Hispanic whites. We conclude that guardian reports of their children's oral health are valuable indicators of clinical and public health-important child oral disease endpoints.

DATA AVAILABILITY STATEMENT

The datasets analyzed in this study can be found online in the Carolina Digital Repository as "ZOE 2.0: A community-based, epidemiologic study of early childhood oral health" at: https://doi.org/10.17615/8yjy-w790 (accessed 1 August 2021).

ETHICS STATEMENT

The study was reviewed and approved by the Institutional Review Board of the University of North Carolina-Chapel Hill. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

EI, JG, PS, MS-P, and KD made substantial contributions to the conceptualization of the work, data collection, data analysis, co-wrote sections of the paper, read, and approved the final version of the manuscript. All authors have agreed both to be personally accountable for each author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated.

FUNDING

This study was funded by a grant from the National Institutes of Health/National Institute of Dental and Craniofacial Research U01-DE025046 (PI: KD). The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

ACKNOWLEDGMENTS

The authors would like to thank all study participants, staff, community partners, and volunteers for their contributions.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers in Public Health

ORIGINAL RESEARCH
published: 25 February 2022
doi: 10.3389/fpubh.2022.821128

Early Childhood Caries Prevalence and Associated Risk Factors in Monastir, Tunisia: A Cross-Sectional Study

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OPEN ACCESS

Edited by:
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Reviewed by:
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Al-Quds University, Palestine
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King Saud University, Saudi Arabia

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Specialty section:
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

Received: *23 November 2021*
Accepted: *31 January 2022*
Published: *25 February 2022*

Citation:
Chouchene F, Masmoudi F, Baaziz A, Maatouk F and Ghedira H (2022) Early Childhood Caries Prevalence and Associated Risk Factors in Monastir, Tunisia: A Cross-Sectional Study. Front. Public Health 10:821128. doi: 10.3389/fpubh.2022.821128

Purpose: The present study aimed to investigate the prevalence and risk factors of ECC among preschool children in Monastir, Tunisia.

Methods: The survey was designed as a cross-sectional study carried out between February and April 2021 in the main region of Monastir, Tunisia. A total of 381 preschool children were randomly selected using a three-stage clustered sampling technique from 10 daycares. The dental caries were diagnosed using WHO recommendations and a questionnaire in Arabic language was used to record personnel profile of the enrolled children. The chi-square test was used in bivariate analyses to assess the association between ECC and risk factors. Variables showing significant associations were included in multiple logistic regression models.

Results: The prevalence of ECC was 20% and the mean dmft score was 0.89 ± 0.24. The prevalence of ECC increased at the age of 48–59 months ([OR] 2.602; 95%CI: 1.122–2.302), the age of 60–71 months ([OR] 2.845; 95% CI: 1.128–2.072), in children with nocturnal feeding ([OR] 2,417; 95% CI: 1.340–4,358), who take sugary drinks in the bottle ([OR] 1.104; 95% CI: 1.667–2.826), stopped breast or bottle feeding after the age of 18 months ([OR] 2.417; 95% CI: 1.340–4.358), do not brush their teeth properly ([OR] 1.435; 95% CI: 1.207–2.915), had visited a dentist ([OR] 2.444; 95% CI: 2.072–1.108), and decreased in children with a more highly educated parents ([OR] 0.797; 95%CI: 0.171–0.650).

Conclusion: Given the relatively high prevalence of ECC in Tunisia, it is important to review public dental health policies and develop effective strategies to encourage changes in behavior related to the oral health of children to prevent the spread and worsening of this disease.

Keywords: early childhood caries, prevalence, caries risk factors, Tunisia, epidemiological study

INTRODUCTION

Early childhood caries (ECC) has become a significant health problem among children and infant. The American Academy of Pediatric Dentistry defined ECC as the presence of one or more carious (non-cavitad or cavitaded lesions), missing (due to caries), or filled tooth surfaces in one or more primary teeth in children aged 71 months or younger (1–3).

According to a systematic with meta-analysis published in 2021, ECC is considered as a global health problem, affecting about almost half, of preschool children. Sixty-four reports of 67 countries (published between 1992 and 2019) which covered 29 countries/59018 children showed that the ECC prevalence varied widely, and there was more variance attributable between-country differences rather than continent or change over time (4).

The prevalence by continent was Africa: 30 [19, 45]; Americas: 48 [42, 54]; Asia: 52 [43, 61]; Europe: 43 [24, 66]; and Oceania: 82 [73, 89]. Africa had a lower prevalence than the global pooled prevalence, whereas Asia, Oceania, and North and Central America showed a prevalence above the global estimate. Europe and America were within the global estimate. However, there was a lack of certainty as to the accuracy of the result, as many countries (and regions) were not represented such as Tunisia (4).

To describe ECC different terminologies were used such as; rampant caries, prolonged nursing habit caries, nursing bottle caries, nursing caries, baby bottle tooth decay, baby bottle caries, and milk bottle syndrome (5).

The terminologies of ECC reflect its multifactorial characteristics (6). In addition to the simultaneous interaction of factors including susceptible tooth surface/host, cariogenic microorganisms, and carbohydrates, epidemiological studies have documented transfer of cariogenic microorganisms from mother to her children, low socioeconomic status, gestational age, weight at birth, insufficient child oral health-care, unbalanced bottle-feeding, and bad brushing behaviors as ECC risk factors (5, 7).

ECC which is considered as a significant health issue reported among young children, may be associated with other health conditions, ranging from local pain, abscesses, to more severe problems leading to difficulty in chewing, malnutrition, and gastrointestinal disorders (8).

Further, left untreated, ECC may considerably influence the child quality of life, his self-esteem, his socializing and learning abilities (6, 9).

To optimize the chances of young children to stay free of early dental caries, it is mandatory to initiate preventive programs soon or after primary tooth eruption (9, 10).

Despite being preventable, ECC has remained relatively unexplored in many countries including Tunisia. Little work has been done on determining the prevalence of ECC among Tunisian preschool children and only a few studies have been published. According to Chamli et al. (11), the prevalence of ECC in Sousse, Tunisia was 45%. While in the study conducted by Maatouk et al. (12) the prevalence of dental caries among preschool children aged 3–5 years reported in the same region of Monastir in 2002 was 36%. Monitoring the prevalence of ECC in Tunisia is a key element in planning services and determining progress toward controlling this commonest dental disease in children. This study aimed to investigate the prevalence and risk factors of ECC among preschool children aged 3–5 years in Monastir, Tunisia.

MATERIALS AND METHODS

Study Design and Sample

The present study was designed as a cross-sectional survey carried out between February and April 2021 in the main region of Monastir Tunisia.

Before initiation of the study, the sample size was calculated assuming a prevalence of ECC of about 45% (11) with a margin of error of 5% and a 95% of confidence level. Accordingly, a sample size of 381 was sought. To select the children, a three-stage cluster sampling technique was followed. This technique consisted first of selecting the district which was stratified into two urban and rural areas, then over the 35 preschools stratified by district, 10 were randomly selected. Finally, three kindergarten classes representing children aged 3, 4, and 5 were randomly selected from each kindergarten.

In the present study, only healthy children who do not have history of any diseases under 6 years of age (3–5 years) in primary dentition attending the previously selected kindergarten present at the time of the study and whose parents signed an informed consent were included.

Children in mixed teeth, absent during the dental examination and/or whose parents did not consent to their participation were excluded.

Questionnaire

To record personnel profile of the children, a questionnaire in Arabic language was designed by the investigator according to the guidelines of the American Academy of Pediatric Dentistry (13, 14).

The questionnaire included information about; sociodemographic characteristics of the enrolled preschool children (gender, age, family size, birth order, family annual income, family health insurance, parent's age, and education level).

Children's gestational age, dietary behaviors (history of feeding, frequency of sweet and soft drinks consumption), oral hygiene behaviors (start of tooth brushing, daily brushing frequency, tooth brushing methods, parental supervision, using fluoride toothpaste), history of dental visit.

The questionnaire was distributed in each selected school with a covering letter for informed consent to all the children, and collected 2 week later after being completed by the parents. Responses were anonymous and participation was voluntary.

The investigator reviewed the questionnaires for appropriateness and children who fulfilled the inclusion criteria were examined.

Clinical Examination

Using non-invasive technique and knee-to-knee posture in the kindergarten classes, the enrolled children underwent an oral examination which was performed by the same pediatric dentist

(F.C). Two subjects from each school were re-examined on the same day as their initial dental examination to ensure the reproducibility of the application of diagnostic criteria between children. The intra-examiner agreement was 90%. No x-rays were performed. All the children were examined visually under natural light and. The dental caries were diagnosed using the World Health Organization (WHO) recommendations for oral health surveys (15). The "dmft index" by calculating the number of decayed (d), missing teeth (m), filled teeth (f), teeth (t) or surfaces (s), was used to assess the ECC.

In case of no evidence of treated or untreated clinical caries, the tooth was considered as sound.

A tooth was considered carious when there was an evident sign of cavity in a pit or fissure. A tooth with a temporary filling, or sealed but also decayed was recorded as carious. A tooth was considered filled when one or more permanent restorations were present and there was no caries. For missing teeth it was very important to differentiate those absent following the evolution of carious lesion from those lost due to physiological exfoliation (15).

Ethical Consideration

The Preventive Dentistry Committee and the Faculty of Dental Medicine of Monastir approved the study. Permissions were obtained by the investigator from the Regional Delegation of the Ministry of Family and Child Welfare (Monastir, Tunisia) to visit the preschools establishments and to be able to examine the children. Informed consent of all the selected children's parents was obtained before the clinical examination.

Statistical Analysis

The statistical analysis was performed using SPSS version 22.0 (IBM Corp., Windows, Armonk, NY, USA). To facilitate statistical analyses, some of the original variable were combined by the authors. Children age was grouped into; 36–47, 48–59, and 60–71 months. Parents education was categorized as; none/primary school, middle, high school, and university. Family income was grouped into: low, middle, and upper income according to the parents parents employments. Age stopped breast or bottle feeding was categorized as <12, 12–18, and >18 months. Tooth brushing methods were grouped intà; no particular method, vertical, horizontal tooth brushing and roll technique. The prevalence and mean dmft score were calculated to determine the extent of ECC in the study population. To measure the level of intra-examiner agreement and the reproducibility of the application of diagnostic criteria for dental caries, Cohen's Kappa was used (15). Frequencies and descriptive statistics were generated.

Bivariate analyses were performed to assess the association between ECC and risk factors using the chi-square test. Variables that showed significant associations were included in multiple logistic regression models. A $p \leq 0.05$ was considered as statistically significant.

RESULTS

A total of 381 preschool children aged between 36 and 71 months with a mean age of 48 ± 9 months were included in the present survey. Of the participants, 49.9% were female and 50.1% were male. The ECC prevalence was 20% ($n = 76$) and the mean "dmft score" was 0.89 ± 0.24.

The prevalence of ECC and associated socioeconomic factors are shown in **Table 1**.

About 67.9% of caries-free children parents went to the university and 50.2% of them were issued from high socio-economic level. Univariate analyses showed a statistically significant relationship between ECC, children's age ($p < 0.001$) and parents' educational level ($p = 0.041$) (**Table 1**).

Table 2 shows the association of ECC with feeding history and dietary variables. Half of ECC-children took sugary drinks in bottle at night and 44.7% of them were breastfed for more than 18 months. Results showed a statistically significant association was found between ECC and the following variables; nocturnal feeding ($p = 0.003$), sugary drinks in bottle at night ($p = 0.020$), water in bottle during the day or the night ($p = 0.030$), and age stopped breast or bottle feeding ($p = 0.027$) (**Table 2**).

There was a significant association between ECC prevalence, age of start tooth brushing ($p = 0.008$), tooth brushing frequency and methods ($p = 0.041$, $p = 0.009$), and parental supervision during the tooth brushing ($p = 0.017$) as reported in **Table 3**.

A statistically significant association was found between ECC and history of dental visits ($p < 0.001$). Variables identified as being statistically significant in univariate analysis were entered into logistic regression models as shown in **Table 4**.

Table 4 summarizes risk factors associated with ECC in multiple logistic regression analysis. Age of 48–59 months (odds ratio [OR] 2.602; 95% CI: 1.122–2.302), and age of 60–71 months (OR 2.845; 95% CI: 1.128–2.072) were significantly associated with greater odds of having ECC. Children with more highly educated parents were less likely to have ECC (OR 0.797; 95% CI: 0.171–0.650). Further, children with nocturnal feeding (OR 2,417; 95% CI: 1.340–4,358), who take sugary drinks in the bottle (OR 1.104; 95% CI: 1.667–2.826) and stopped breast or bottle feeding after the age of 18 months (OR 2.417; 95% CI: 1.340–4.358) were more likely to present ECC. Additionally, children who do not brush their teeth properly (OR 1.435; 95% CI: 1.207–2.915) and had visited a dentist (OR 2.444; 95% CI: 2.072–1.108) were more likely to present ECC, and no association was found with start tooth brushing age, daily brushing frequency and parental supervision.

DISCUSSION

In the present study, the prevalence of ECC among 3–5 years preschool children living in Monastir, Tunisia was 20% with a mean dmft score of 0.89 ± 0.24.

Even though dental caries remains a serious and important health problem among children, ECC is still relatively unexplored in Tunisia; only a few studies were conducted among preschool Tunisian children. According to Chamli et al. (11), the prevalence of ECC in Sousse Tunisia was 45% which was higher than the

TABLE 1 | Prevalence of ECC and associated socioeconomic factors ($N = 381$).

Variables	*N*	%	Caries groups		*p*-value
			Caries-free N (%)	ECC N (%)	
Gender					
Girl	190	50.1	155 (50,8)	35 (46.1)	0.457
Boy	191	49.9	150 (49.2)	41 (53.9)	
Age (months)					
36–47	101	26.5	60 (19.6)	41 (53.9)	**<0.001***
48–59	136	35.7	112 (36.7)	24 (31.6)	
60–71	144	37.8	133 (3.6)	11 (14.4)	
Gestational age					
Full-term	358	94	285 (93.4)	73 (96.1)	0.291
Premature birth	23	6	20 (6.6)	3 (3.9)	
Family size					
One child	174	45.6	142 (46.6)	32 (42.1)	0.352
More than one child	207	54.4	164 (79.2)	43 (20.8)	
Birth order					
1	171	44.9	141 (46.2)	30 (39.5)	0.330
2	137	36	107 (35.1)	30 (39.5)	
3	63	16.5	51 (16.7)	12 (15.8)	
4	9	2.4	5 (1.6)	4 (5.3)	
5	1	0.3	1 (0.3)	00 (00)	
Mother's age					
20–30	90	23.6	72 (23.6)	18 (23.7)	0.270
31–40	257	67.5	205 (67.2)	52 (68.4)	
>41	34	8.9	28 (9.2)	6 (7.9)	
Father's age					
20–30	29	7.6	25 (8.2)	4 (5.3)	0.070
31–40	212	55.6	200 (65.6)	12 (15.8)	
>41	140	36.8	80 (26.2)	60 (78.9)	
Parents educational level					
None/primary school	15	3.9	12 (4)	3 (3.9)	**0.041***
Middle school	32	8.4	26 (8.5)	6 (7.9)	
High school	87	22.8	60 (19.7)	27 (35.5)	
University	247	64.8	207 (67.9)	40 (52.6)	
Family annual income					
Low income	128	33.5	98 (32.1)	30 (39.5)	0.316
Middle income	65	17.1	54 (17.7)	11 (14.5)	
Upper income	188	49.3	153 (50.2)	35 (46.1)	
Parent's marital status					
Married	372	97.6	300 (98.4)	72 (94.7)	0.060
Divorced	1	0.3	00 (00)	1 (0.3)	
Widowed	8	2.1	5 (1.6)	3 (3.9)	
Family health insurance					
Yes	361	94.8	290 (95.1)	71 (93.4)	0.367
No	20	5.2	15 (4.9)	5 (6.6)	

*$p \leq 0.05$.
Chi-square test.

prevalence reported in the present survey; while in the study conducted by Maatouk et al. (12) the prevalence of dental caries among preschool children aged 3–5 years reported in the same region of Monastir in 2002 was 36%, which revealed a slight decrease in the dmft score over the past 20 years. These changes may be attributed to evolution in ECC associated risk factors

TABLE 2 | Prevalence of ECC and associated feeding history/dietary habits ($N = 381$).

Variables	*N*	%	Caries groups		*p*-value
			Caries-free N (%)	ECC N (%)	
Feeding history					
Feeding type					
Breast only	136	35.7	108 (35.4)	28 (36.8)	0.995
Breast and bottle	204	53.5	164 (53.8)	40 (52.6)	
Bottle only	41	10.8	33 (10.8)	8 (10.5)	
Nocturnal feeding					
No	66	17.3	44 (14.4)	22 (28.9)	**0.003***
Yes	315	8.7	261 (85.6)	54 (71.1)	
Sugary drinks in bottle at night					
Yes	173	45.4	137 (44.9)	36 (47.4)	**0.020***
No	208	54.6	168 (55.1)	40 (52.6)	
Water in bottle (day/night)					
Yes	105	27.6	91 (29.8)	14 (18.4)	**0.030***
No	276	72.4	214 (70.2)	62 (81.6)	
Age stopped breast-feeding/bottle					
<12 months	113	29.7	86 (28.2)	27 (35.5)	**0.027***
12–18 months	94	24.7	79 (25.9)	15 (19.8)	
>18 months	174	54.6	140 (45.9)	34 (44.7)	
Current dietary habits					
Frequency of sweet and soft drinks consumption					
Never	29	7.6	25 (8.2)	4 (3.3)	0.519
Once a day	208	54.6	170 (55.7)	38 (50)	
Twice a day	102	26.8	78 (25.6)	24 (31.6)	
More than twice a day	42	11	32 (10.5)	10 (13.2)	

*$p \leq 0.05$.
Chi-square test.

over the time, the disparities of the studies samples and the fact that the studies were conducted in subgroups of the population. Although the number of children examined can be considered adequate, the low number of cavities reported in our study may be due to the parent's behavior and awareness of the importance of dental prevention.

According to a systematic review aiming to review the determinants of dental caries in children residing in the Middle East and North Africa (MENA) region, results including 94,491 participants in 14 countries, showed that the prevalence of ECC ranged between 3 and 57% (16). This wide variation between countries suggest that the distribution of ECC is not homogeneous and could be explained by genetic factors, ethnicity, and differences in socio-economic status (4).

In Casablanca, Morocco, the prevalence of ECC and severe-ECC were 74.2 and 47.3%, respectively (17). Results of this study suggests also that ECC negatively impacts the life quality of Moroccan Children in addition to their parents.

A previous narrative review by Tinanoff et al. based on 72 articles estimated a prevalence of ECC, across countries, of between 17% in France and 98% in Australia (18).

Recently published studies have shown that ECC was more widespread and frequent in countries that are underdeveloped and/or less developed, as well as among minorities living in well-developed countries (19).

According to some recent studies, the increasing tendency toward ECC may be associated with a rapid decline in the standard of living, a therapeutic approach in the resolution of the disease and certain demographic, psychosocial and behavioral characteristics specific to the region, which could modify the biological basis of the disease still insufficiently studied (19–22).

The fact that other published studies did not use the WHO criteria, included other diagnostic criteria, target population or examiner calibration may explain the decreased prevalence of ECC reported in our study (11, 12).

Due to the differences in the studies design, and other variables, comparing the present study findings to previous global and national studies was difficult.

The interaction of different etiological factors concurrently present initiate dental caries development. The known factors are essentially, the presence of cariogenic microorganisms, fermentable carbohydrates (substrate), and susceptible tooth surface/host.

TABLE 3 | Prevalence of ECC and oral hygiene behaviors/dental history ($N = 381$).

Variables	*N*	%	Caries groups		*p*-value
			Caries-free N (%)	ECC N (%)	
Start tooth brushing					
≤3 years	71	18.6	51 (16.7)	20 (26.3)	**0.008***
>3 years	310	81.4	254 (83.3)	56 (73.7)	
Daily brushing frequency					
No or irregular	9	2.4	7 (2.3)	2 (2.6)	**0.041***
Once a day	208	54.6	170 (55.7)	38 (50)	
Twice a day	127	33.3	101 (33.1)	26 (34.2)	
More than twice a day	37	9.8	27 (8.8)	10 (13.2)	
Tooth brushing methods					
No particular method	102	26.7	88 (28.9)	14 (18.4)	**0.009***
Vertical tooth brushing	145	38	112 (36.7)	33 (43.4)	
Roll technique	23	6	12 (3.9)	11 (14.5)	
Horizontal tooth brushing	111	29.1	93 (30.5)	18 (23.7)	
Parental supervision					
Yes	109	28.6	83 (27.2)	26 (34.2)	**0.017***
No	272	71.4	222 (72.8)	50 (65.8)	
Fluoride toothpaste					
Yes	147	61.4	116 (38)	31 (40.8)	0.376
No	234	38.6	189 (62)	45(59.2)	
History of dental visit					
Yes	49	12.8	23 (7.5)	26 (34.2)	**<0.001***
No	332	87.2	282 (92.5)	50 (65.8)	

*$p \leq 0.05$.
Chi-square test.

TABLE 4 | Factors associated with ECC in multiple logistic regression analysis.

Variable	OR	95% CI		X^2	*P-value*
		Lower	Upper		
Age (months)					<0.001
Age 1	2.602	1.122	2.302	42.117	<0.001
Age 2	2.845	1.128	2.072	34.379	<0.001
Parents educational level (reference, none/or primary school)	0.797	0.171	0.650	15.630	0.040
Nocturnal feeding (reference, no)	2,417	1.340	4,358	13.350	0.003
Sugary drinks in bottle at night (reference, no)	1.104	1.667	2.826	12.817	0.009
Water in bottle (day/night) (reference, no)	0.531	0.283	0.997	3.971	0.064
Age stopped breast-feeding/bottle (reference, >18 months)	2.417	1.340	4.358	40.336	0.003
Start tooth brushing (reference, ≤3 years)	0.836	0.504	1.385	10.230	0.440
Daily brushing frequency (reference, no or irregular)	0.503	0.069	1.684	3.189	0.503
Tooth brushing methods (reference, no particular method)	1.435	1.207	2.915	15.430	0.015
Parental supervision (reference, no)	1.385	0.809	1.369	4.801	0.061
History of dental visit (reference, no)	2.444	1.108	2.072	44.494	<0.001

Age code: 36–47 months (0, 0); 48–59 months (1, 0); 60–71 months (0, 2).
SE, Standard error; OR, Odds ratio; CI, Confidence interval; X^2, Chi-square test value.

In association to these well-demonstrate factors, a multitude of risk factors associated with ECC have been also reported the last decade.

In fact, epidemiological studies have documented other associated risk factors such as transfer of microbes from mother to child, low socioeconomic status, minority status, and low birth

weight. In the developed countries, about 1–12% of children younger than 6 years experience ECC (21, 23).

Feeding, cariogenic food, child oral health-care and cleaning behaviors have been associated with ECC among children.

In the present study, children with nocturnal feeding, who take sugary drinks in the bottle and stopped breast or bottle feeding after the age of 18 months, are more likely to experience dental caries.

Regarding breast tor bottle feeding factors, some studies have reported that nighttime (20), long periods of breastfeeding and bottle feeding after the age of 18 months (24) were risk factors of ECC, while other studies have reported that nighttime feeding (breast and bottle feeding) after 12 months of age increased the risk of developing dental caries (25).

Although breastfeeding for at least 24 months is strongly recommended (26), when it is done on demand or especially at night with an associated high sugary diet and a late introduction of brushing, it can contribute toward high ECC (27).

In Tunisia, a study carried out among pediatricians showed that the majority of them recommend breastfeeding for at least 2 years and showed that 84% of them did not believe that nighttime breastfeeding is a risk factor for ECC, which may explain the implication of this factor in the development of caries lesions in the present study (28).

Additionally, it has been shown that during sleep, salivary flow decreases significantly thereby reducing the liquid carbohydrates clearance from the oral cavity, acting as a determining factor in the initiation of dental caries. It is therefore very important to reduce night-time breastfeeding, and sugary drinks in the bottle as much as possible and provide dentist early visit for examination and preventive advice concerning feeding practices (29).

However, in children who take water in their bottles, the prevalence of ECC was lower, which can be explained by the washing effect of the water or by the level of fluorides contained in the bottled water consumed by Tunisians. A same result was also reported in a study conducted by Al and Marshad et al. in Riyadh, Saudi Arabia (20).

In the present study, a statistically significant associations were reported between ECC prevalence, age of start tooth brushing, tooth brushing frequency and methods and parental supervision during the tooth brushing which was in accordance with numerous other studies carried out in different countries (11, 20, 22, 24, 25, 30).

According to a systematic review performed to assess the effect of tooth brushing frequency, individuals who report brushing their teeth infrequently have an increased risk of developing new carious lesions than those brushing more frequently, and this effect of brushing was more pronounced in primary than in permanent dentition (31).

Additionally, parents play an important role in their children's oral hygiene practices. According to a cross-sectional survey performed in Japan, lack of parental supervision was considered as a risk factor for dental caries in 6- to 7-year-old children (32).

Several studies (31, 33, 34), have reported a wide range, 9–72%, of young children, aged 1–5 years, brushing their teeth without their parents assistance. According to Zeedyk et al. (35) when young children are left on their own to brush their teeth, active tooth brushing may takes only an average of 10 s.

Parental supervision is not only about ensuring effective plaque removal through appropriate brushing technique, but also about supervising the amount of toothpaste used by children while brushing to reduce the incidence of fluorosis (33).

As reported in other studies a significant decrease of ECC was reported in children with a more highly educated parents (22, 36, 37).

In these studies it was reported that maternal education significantly influences attitudes toward children's oral health and that mothers play an important role in the development of children's dental health behavior (22, 36, 37). Moreover, parental practice such as feeding style and general parenting style can be relevant (32). According to a study conducted in Ohio, USA, permissive parenting style was more associated with dental caries than authoritative parenting style (38).

Results of the present study showed a statistically significant association between ECC and history of dental visits ($P < 0.001$) and children who visited a dentist during their infancy had a higher ECC prevalence. This is consistent with previous reports of an association between dentist visit and ECC in children (20, 39). This might reflect the fact that most children see the dentist only for an existing dental problem and not for prevention or control, and that parents in Tunisia believe that children do not need to be taken to the dentist unless they have a dental problem or pain caused by a carious lesion (20).

It is very important to highlight the significance of assessing the prevalence of dental caries in primary dentition, because according to recent research carious lesions in primary dentition may be used as a risk indicator for predicting not only dental caries but also enamel defects in their permanent successors (10, 40).

Since only a few studies about ECC have been conducted in Tunisia, the present results are considered as important but must be interpreted considering some limitations of the study. The sample size was slightly reduced, and only children enrolled in preschools were examined so the results may not be generalizable to children of the same age group not enrolled in preschools. In addition, as the caregiver data were retrospective, the possibility of some response bias could not be excluded. Nonetheless, the same findings may help to develop better prevention strategies.

Oral health programs should be established in Tunisia, focusing mainly on mothers, preschool teachers as well as young children.

It is also very important to start screening for ECC from early age; from the eruption of the first primary tooth or at the latest at the age of 1 year. To support oral health programs for children, health workers need to collect multiple epidemiological data through other surveys carried out in different regions of the country.

Awareness plays a very important role in the prevention of caries disease, which is why it is essential to sensitize health workers, in particular pediatricians, doctors, nurses and midwives, to the diagnosis, to prevention and treatment of childcare centers. The prevention of ECC in young children

should begin with providing preventive dental care (application of fluoride varnishes/gel, crack sealants).

Parents, especially mothers, must be sensitized and educated in order to be able to help reducing the prevalence of ECC and this especially through the recognition of the first signs of ECC, good nutrition, supervision of tooth brushing, and cautious use sources of fluoride in high carious risk children. It is also important to underline the role of oral health promotion and prevention programs during pregnancy among future mothers. There is also a need to incorporate oral health education and motivation interventions in the pre and postnatal care programs in the Tunisian hospitals and public clinics (41).

CONCLUSION

Findings of the present study demonstrate that dental caries in preschool children remain a serious oral health problem in Monastir. Parents educational level, poor oral hygiene, risky dietary, feeding behavior, and visits of a dental service, were associated with a higher risk of dental caries. It is therefore important to acknowledge that this risk may be reduced since all the described factors could be modified by improving Tunisian public health strategies, developing preventive strategies for primary dentition, providing health education for a large public and promoting the role of dentists in oral health promotion and prevention.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The study was reviewed and approved by the Preventive Dentistry Committee and the Regional Delegation of the Ministry of Family and Child Welfare (Monastir, Tunisia). Written informed consent to participate in this study was provided by the participants' legal guardian.

AUTHOR CONTRIBUTIONS

FC conceived the idea, collected the data, and wrote the article. FC, FMas, and AB analyzed the data. FMaa and HG provided comprehensive judgement and assisted in editing the final version of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

ACKNOWLEDGMENTS

The authors would like to thank the children who participated in the study, the staff of primary schools and the staff of the Department of Pediatric Dentistry who assisted in the project.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 16 August 2022
DOI 10.3389/fpubh.2022.959125

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

RECEIVED 01 June 2022
ACCEPTED 13 July 2022
PUBLISHED 16 August 2022

CITATION
Liu M, Song Q, Xu X and Lai G (2022) Early childhood caries prevalence and associated factors among preschoolers aged 3–5 years in Xiangyun, China: A cross-sectional study. *Front. Public Health* 10:959125. doi: 10.3389/fpubh.2022.959125

Early childhood caries prevalence and associated factors among preschoolers aged 3–5 years in Xiangyun, China: A cross-sectional study

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Purpose: This study aimed to investigate the early childhood caries (ECC) prevalence among preschoolers aged 3-5 years in Xiangyun of Yunnan, China and explore the factors associated with the prevalence.

Materials and methods: A cross-sectional survey including 3-5-year-old children was conducted in Xiangyun County, China, between September and November 2020. According to the dental examination standard of the WHO 2013 criteria, the presence of ECC was recorded. Besides the dental examination for children, their parents completed questionnaires about caries-related factors, including demographic variables, family socioeconomic status, feeding, and oral health-related habits, parental dental knowledge, and the condition of dental service utilization. SPSS Statistics 25.0 (IBM, Chicago, IL, USA) was used for data analysis. Statistical significance was set at $p < 0.05$.

Results: The ECC prevalence among a sample of 1,280 children aged 3–5 years consisting of 665 boys and 615 girls in this study, was 74.3%, and the mean decayed-missing-filled teeth (dmft) was 4.9 ± 5.0. There were no statistically significant differences in the ECC prevalence between the sexes and among different ethnic groups. Children with different dietary and oral hygiene habits showed no significantly different prevalence of ECC. Logistic regression analysis showed that the most significantly associated factors were older age, lower family income, and worse parental perception of children's oral health status.

Conclusion: The ECC prevalence among 3–5-year-old preschool children in Xiangyun was higher than the average national ECC prevalence in China. This study implies that more attention should be given to children's caries

prevention from early childhood; oral health education and promotion should be intensified to reduce the ECC prevalence and improve the oral health status of children in Xiangyun.

KEYWORDS

early childhood caries, dental caries, prevalence, preschool children, epidemiological study, associated factors

Introduction

Dental caries is the most common non-communicable disease among children (1). Early childhood caries (ECC) is characterized by the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a child under the age of six (2). ECC can result in a high risk of pain or discomfort, abscesses, caries risk in permanent dentition, impact children's oral health-related quality of life, and bring an economic burden to society (1).

Despite being preventable, ECC still has a high prevalence among children around the globe. A recent systematic review reported a combined ECC prevalence of 48% worldwide based on various studies concerned with the ECC prevalence that used the WHO criteria (3). Additionally, data abstracted from 72 worldwide studies between 1998 and 2018 revealed that the mean caries prevalence for 1-year-olds was 17% and significantly increased to 36% in 2-year-olds (4). According to the 4th Chinese National Oral Health Survey, the mean caries prevalence in 5-year-old children has increased from 66 to 70.9% in the past decade, suggesting ECC in Chinese children is still a problem worthy of attention (5).

ECC is a complex multifactorial risk disease. The etiology of ECC includes cariogenic microorganisms and dietary and host determinants, which are influenced by multiple behavioral, sociological, and environmental factors, such as parental oral-health knowledge, family income, and dental utilization (6, 7). Effective ECC management requires caries risk-based prevention approaches and policies (8). Thus, monitoring the prevalence of ECC and exploring associated factors is essential for planning services and policies to control the disease and promote children's oral health.

Previously, some regions of China have reported the ECC prevalence and associated factors (9–16). However, because China is a vast country with a large population that is composed of 56 ethnic groups, 55 minorities, and the dominant Han group, different regions in China have significant dietary and cultural differences, which may influence children's oral health status. Moreover, along with the rapid economic development in China, inequalities in children's health have occurred (17). Until now, the epidemiological data on the ECC prevalence in children from remote and rural areas of Southwest China are rare. Therefore, this study aimed to investigate the ECC prevalence in 3–5-year old children in Xiangyun of Yunnan, a region located in Southwest China that has several minorities and eliminated poverty in 2018 (18) and explore factors related to the prevalence, including demographics, family socioeconomic status, feeding, and oral health-related habits, parental dental knowledge, and the condition of dental service utilization. We hope that this study can provide useful basic information for establishing public oral-health-related policies and interventions by the local government.

Materials and methods

Study design and sample

This cross-sectional study was conducted between September and November 2020 in Xiangcheng Town, Xiangyun County, China. Before the study initiation, the sample size was calculated using Power Analysis & Sample Size (PASS) software 16.0 with a 95% confidence interval, 5% standard error, 62.5% prevalence (the average caries prevalence of Chinese children aged 3-5 years in 2015) (5), and a 20% non-response rate. The minimum required sample size was 473. In coordination with the 2020 National Oral Health Comprehensive Intervention Program for children's teeth fluoridization in China, this study used a two-stage stratified cluster sampling method. Xiangcheng Town, Xiangyun County, was divided into four geographical regions (eastern, southern, western, and northern). According to the kindergartens' size, one or two kindergartens were selected from each region. All the children from each kindergarten were selected using the following inclusion and exclusion criteria.

The inclusion and exclusion criteria of the present study were applicable for both children who participated in the study and their legal guardians/parents. Children in a designated range of age (3–5years) had to attend the class on the survey day and could cooperate with the examiner. Children's parents/guardians were able to understand the study and be willing to sign the informed consent. The exclusion criteria were: the legal guardian's failure to understand this survey; the presence of systemic diseases or mental disorders in the children.

The Ethics Committee of the People's Hospital of Xiangyun approved the survey protocol (No. 2020069). Written informed consents were obtained from the participants' legal guardians/parents before the survey.

Date collection

Clinical examination

The presence of ECC was determined using the WHO 2013 criteria (19). With working experience of more than 3 years, six dentists from the Department of Stomatology of the People's Hospital of Xiangyun received theoretical and clinical operation training before the survey. The test of intra-examiner and inter-examiner was conducted based on the methods recommended by WHO (19). Each dentist examined a group of volunteers (30 preschoolers) and re-examined each child on the second day. The mean Kappa values for both the intra-examiner and inter-examiner were over 0.85, which met the examination requirements (19).

On the scheduled day, children were examined in the kindergarten, sitting on chairs. The trained dentists examined children with a plane mouth mirror and a probe under artificial light. According to WHO guidelines, caries prevalence was recorded as decayed-missing-filled teeth (dmft) > 0 (19). No radiographs were taken.

Questionnaire survey

The questionnaire was in Chinese and modified based on the 4th Chinese National Oral Health Survey questions (5). These questionnaires were distributed and collected by teachers in each kindergarten who received unified training before the initiation of the field investigation. With the consent form, the parents or guardians were asked to complete the questionnaire

TABLE 1 Prevalence of ECC and socioeconomic factors ($N = 1280$).

Variables	N	%	Groups		*P*-value
			Caries-free (N/%)	ECC (N/%)	
Sex					
Male	665	52.0%	176 (26.5%)	489 (73.5%)	0.516
Female	615	48.0%	153 (24.9%)	462 (75.1%)	
Age (year)					
3	202	15.8%	71 (35.1%)	131 (64.9%)	<0.0001*
4	498	38.9%	142 (28.5%)	356 (71.5%)	
5	580	45.3%	116 (20.0%)	464 (80.0%)	
Ethnicity					
Han	1,004	78.4%	262 (26.1%)	742 (73.9%)	0.54
Others	276	21.6%	67 (24.3%)	209 (75.7%)	
Single child					
Yes	374	29.2%	99 (26.5%)	275 (73.5%)	0.686
No	906	70.8	230 (25.4%)	676 (74.6%)	
Primary caregiver					
Parents	1,075	84.0%	278 (25.9%)	797 (74.1%)	0.768
Others	205	16.0%	51 (24.9%)	154 (75.1%)	
Parental education level					
Middle school or below	457	35.7%	108 (23.6%)	349 (76.4%)	0.025*
High school	325	25.4%	75 (23.1%)	250 (76.9%)	
College	223	17.4%	56 (25.1%)	167 (74.9%)	
Undergraduate or above	275	21.5%	90 (32.7%)	185 (67.3%)	
Family income (Yuan, per month)					
<6,000 Yuan	679	53.0%	159 (23.4%)	520 (76.6%)	0.006*
≧6,000 and <12,000	354	27.7%	87 (24.6%)	267 (75.4%)	
≧12,000	247	19.3%	83 (33.6%)	164 (66.4%)	
Total	1,280	100%	329 (25.7%)	951 (74.3%)	

ECC, early childhood caries.
*Statistically significant at $P < 0.05$.

the day before the clinical examination of their children. The questionnaire contained the following information:

1. Demographics (children's age, gender, single child, primary caregiver).
2. Family socioeconomic status (parental education level, family income).
3. Feeding and oral health-related habits and dental service utilization (feeding type within six months after birth, bedtime bottle before children aged 3, frequency of consuming desserts, sweet drinks and candies or chocolates, habit of eating snacks without toothbrushing before bed, children's age of starting brushing teeth, frequency of brushing teeth, parental supervision for brushing teeth, the use of fluoride toothpaste, dental floss, history of dental visit, and the application of fluoride varnish).
4. Parental oral health awareness and knowledge (parents' perception of children's oral health status; the knowledge regarding the importance of oral health, the treatment necessity of decayed primary teeth, the protections to teeth, and too much consumption of sweets leading to tooth decay).

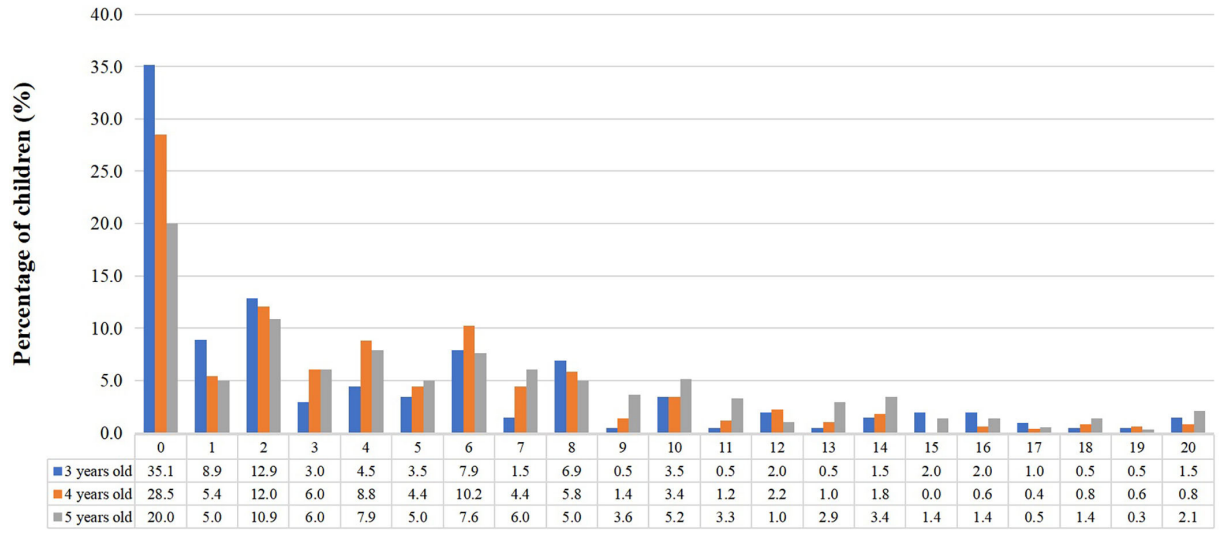
Data analysis

The presence or absence of ECC was the primary outcome variable. Categorical variables were expressed as numbers and percentages (%). Univariate analyses used the chi-square test to assess the differences between the ECC and caries-free groups. Variables showing significant associations were included in a logistic regression analysis model. All data were analyzed using SPSS Statistics 25.0 (IBM, Chicago, IL, USA). A p-value less than 0.05 indicated statistical significance. The average dmft score was exhibited in mean ± SD. The frequencies of dmft scores among different age groups were presented in a figure.

Results

Among 1,764 children aged 3–5 years attending class to receive fluoride varnish for their teeth, 1,293 children consisting of 673 boys and 620 girls participated in the dental examination with consent from parents or guardians. And their parents completed the questionnaire. There were no withdrawals in the study. However, due to insufficient data in the questionnaire, such as family income, 13 children were excluded. Finally, data of 1,280 children, comprised of 665 (52.0%) boys and 615 (48.0%) girls aged 3–5 years, were analyzed (Table 1). The mean age of this sample was 4.3 ± 0.7 years.

The statistical results showed that the ECC prevalence of this sample was 74.3%, and the mean dmft was 4.9 ± 5.0. The mean dmft in each age group was 4.1 ± 5.1 in children aged three years, 4.3 ± 4.5 in children aged four years, and 5.7 ± 5.2 in children aged 5 years. The frequency distribution of dmft is displayed in Figure 1. Among all the children with ECC, children with two decayed teeth were the most common. In 3-year-old children with ECC, children with one decayed tooth were the



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
3 years old	35.1	8.9	12.9	3.0	4.5	3.5	7.9	1.5	6.9	0.5	3.5	0.5	2.0	0.5	1.5	2.0	2.0	1.0	0.5	0.5	1.5
4 years old	28.5	5.4	12.0	6.0	8.8	4.4	10.2	4.4	5.8	1.4	3.4	1.2	2.2	1.0	1.8	0.0	0.6	0.4	0.8	0.6	0.8
5 years old	20.0	5.0	10.9	6.0	7.9	5.0	7.6	6.0	5.0	3.6	5.2	3.3	1.0	2.9	3.4	1.4	1.4	0.5	1.4	0.3	2.1

FIGURE 1
Frequency distribution of dmft among 3–5-year old children in Xiangyun, China.

second most common. On the contrary, in 4- and 5-year-old children with ECC, children with six decayed teeth were the second most common.

The ECC prevalence was 64.9% for 3-year-old children, 71.5% for 4-year-old children, and 80.0% for 5-year-old children, respectively. There were significant differences in the prevalence among age groups ($p < 0.0001$). Although the prevalence was slightly higher in girls (75.1%) than in boys (73.5%), the difference was statistically insignificant ($p = 0.516$). Han ethnic children showed a slightly lower prevalence than other ethnic children without significant differences (73.9 vs. 75.7%, $p = 0.54$). Similarly, single children showed no significant difference in ECC prevalence compared with non-single children (73.5 vs. 74.6%, $p = 0.686$).

Regarding the socioeconomic factors, children whose parents had an undergraduate degree or above showed significantly lower ECC prevalence (67.3%) than other children (76.4% for the parental education level of middle school degree or below, 76.9% for the parental education level of high school degree and 74.9% for the parental education level of college, respectively). The ECC prevalence in children from families with a monthly income of 12,000 Yuan and above was 66.4%, significantly lower than in other children ($p = 0.006$).

Table 2 shows that 561 (43.8%) children were breastfed within 6 months old and showed a slightly lower ECC prevalence (72%) than 719 (56.2%) children who had mixed-feeding or bottle-feeding without statistical significance ($p = 0.099$). Among all the children, 448 (35%) children experienced bedtime bottles before age 3; 425 (33.2%) children ate desserts at least once a day but showed a similar ECC prevalence (74.6%) to children who occasionally or never ate dessert (74.2%); 126 (9.8%) children consumed sweet drinks, and 326 (25.5%) ate candies/chocolates more than once a day. However, 897 (70.1%) children experienced consuming snacks before bed without toothbrushing. Regarding oral hygiene, 810 (63.3%) children started brushing their teeth at the age of 3 and even older; 652 (50.9%) children brushed their teeth twice a day, but they did not show lower ECC prevalence. Only 353 (27.6%) children used fluoride toothpaste, and 121 (9.5%) used dental floss. Additionally, 577 (45.1%) children had dental visit history and significantly higher ECC prevalence than the left 703 (54.9%) children (76.9 vs. 72.1%, $p = 0.049$).

As shown in Table 3, 773 (60.4%) parents believed that their children's oral health status was good, and their children exhibited a significantly lower ECC prevalence than others (68.4 vs. 83.2%, $p < 0.0001$). Besides, 289 (22.6%) children's parents were unsure whether decayed primary teeth needed treatment or believed primary teeth did not need treatment.

According to the logistic regression analysis (Table 4), the prevalence of ECC was significantly higher in children aged 5 years ($p < 0.0001$, OR 2.008; 95% CI: 1.390–2.902), those whose family income is lower than 12,000 Yuan ($p = 0.025$; OR 1.450; 95% CI: 1.047–2.007), and those whose parents think the child's oral health is poor ($p < 0.0001$, OR 2.227; 95% CI: 1.680–2.951).

Based on the results shown in Table 5, although parental education level was not associated with children's feeding type or sweet food consumption, it was significantly associated with the frequency of brushing teeth and parental supervision for brushing teeth ($p = 0.002$ and $p < 0.0001$). Among children whose parents had an undergraduate degree or above, 158 (57.5%) children brushed their teeth twice daily. Moreover, children whose parents had higher education levels tended to use fluoride toothpaste ($p < 0.0001$) and receive fluoride varnish ($p = 0.011$) and less likely to eat sacks without toothbrushing before bed ($p = 0.005$). Concerning the parents' dental knowledge, parents with higher education levels tended to know the necessity of treating decayed primary teeth ($p = 0.004$) and the correlation between teeth health and protections ($p = 0.001$).

As shown in Table 6, although children from higher-income families tended to brush their teeth twice a day ($p = 0.006$) and use fluoride toothpaste ($p = 0.029$), they were also likely to consume more desserts ($p < 0.0001$) and candies/chocolates ($p = 0.006$). While 42.1% of children whose family income was more than 12,000 Yuan per month consumed desserts at least once a day, the percentage was 27.8% among children whose family income was less than 6,000 Yuan per month.

Discussion

This study is the first cross-sectional investigation on the ECC prevalence among 3–5-year-old preschoolers in Xiangyun, China, which can fill the knowledge gap about ECC prevalence in China. The present study revealed that the caries prevalence and the mean dmft of ECC among children aged 3-5 years in Xiangyun (74.3%, 4.9) were much higher than the national average score (62.5%, 3.35) reported by the fourth national epidemiological survey (5). Moreover, the ECC prevalence in this sample is not only higher than results in recent surveys of relatively developed regions, such as Guangdong (68.3%) (12), Shanghai (between 29.38% and 50.25% among 3–5-year old children) (15), and Zhejiang (70.4%) (14), but also developing regions, such as Weifang (between 46.4 and 63.1% among 3–5-year old children) (16) and Guizhou (63.1%) in China (13). These results indicate that dental caries is a severe and urgent problem among children in Xiangyun, China.

A significant association between ECC prevalence and age existed in the present study. The reason may be that caries is a continuous and cumulative process, increasing with age in any population independent of gender, urbanization, and social status (20). In addition, the severity of caries occurrence may increase with the longer exposure time of the dentition to the etiologic factors of caries without proper intervention.

Socioeconomic status relating to family income and parental education level is a widely documented risk indicator for ECC

10.3389/fpubh.2022.959125

TABLE 2 Prevalence of ECC and feeding history, dietary habit, oral hygiene behaviors and dental history ($N = 1280$).

Variables	N	%	Groups		*P*-value
			Caries-free (N/%)	ECC (N/%)	
Feeding type within 6-month after birth					
Breast only	561	43.8%	157 (28.0%)	404 (72.0%)	0.099
Other types	719	56.2%	172 (23.9%)	547 (76.1%)	
Bedtime bottle before children aged 3					
Yes	448	35.0%	111 (24.8%)	337 (75.2%)	0.578
No	832	65.0%	218 (26.2%)	614 (73.8%)	
Frequency of consuming desserts					
At least once a day	425	33.2%	108 (25.4%)	317 (74.6%)	0.866
Occasionally or never	855	66.8%	221 (25.8%)	634 (74.2%)	
Frequency of consuming sweet drinks					
At least once a day	126	9.8%	32 (25.4%)	94 (74.6%)	0.934
Occasionally or never	1,154	90.2%	297 (25.7%)	857 (74.3%)	
Frequency of consuming candies or chocolates					
At least once a day	326	25.5%	84 (25.8%)	242 (74.2%)	0.976
Occasionally or never	954	74.5%	245 (25.7%)	709 (74.3%)	
Eating snacks without toothbrushing before bed					
Yes	897	70.1%	218 (24.3%)	679 (75.7%)	0.079
No	383	29.9%	111 (29.0%)	272 (71.0%)	
Start brushing teeth					
1-year-old and below	24	1.9%	6 (25.0%)	18 (75.0%)	0.742
2-year-old	446	34.8%	109 (24.4%)	337 (75.6%)	
3-year-old and above	810	63.3%	214 (26.4%)	596 (73.6%)	
Frequency of brushing teeth					
Twice per day or above	652	50.9%	165 (25.3%)	487 (74.7%)	0.904
Once a day	533	41.6%	138 (25.9%)	395 (74.1%)	
Occasionally or never	95	7.4%	26 (27.4%)	69 (72.6%)	
Parental supervision for brushing teeth					
Every time	146	11.4%	38 (26.0%)	108 (74.0%)	0.857
Occasionally	947	74.0%	246 (26.0%)	701 (74.0%)	
Never	187	14.6%	45 (24.1%)	142 (75.9%)	
Fluoride toothpaste					
Yes	353	27.6%	101 (28.6%)	252 (71.4%)	0.142
No	927	72.4%	228 (24.6%)	699 (75.4%)	
Dental floss					
Yes	121	9.5%	33 (27.3%)	88 (72.7%)	0.678
No	1,159	90.5%	296 (25.5%)	863 (74.5%)	
History of dental visit					
Yes	577	45.1%	133 (23.1%)	444 (76.9%)	0.049*
No	703	54.9%	196 (27.9%)	507(72.1%)	
Fluoride varnish					
Yes	420	32.8%	104 (24.8%)	316 (75.2%)	0.59
No	860	67.2%	225 (26.2%)	635 (73.8%)	
Total	1,280	100%	329 (25.7%)	951 (74.3%)	

ECC, early childhood caries.
*Statistically significant at $P < 0.05$.

TABLE 3 Prevalence of ECC and parental oral health awareness and attitude ($N = 1,280$).

Variables	N	%	Groups		*P*-value
			Caries-free (N/%)	ECC (N/%)	
Parents' perception of children's oral health status					
Good	773	60.4%	244 (31.6%)	529 (68.4%)	<0.0001*
Fair or poor	507	39.6%	85 (16.8%)	422 (83.2%)	
Oral health is important to life					
Yes	1230	96.1%	316 (25.7%)	914 (74.3%)	0.961
No	50	3.9%	13 (26.0%)	37 (74.0%)	
Decayed primary teeth do not require treatment					
Disagree	991	77.4%	259 (26.1%)	732 (73.9%)	0.512
Agree/ unknown	289	22.6%	70 (24.2%)	219 (75.8%)	
Teeth are born healthy or unhealthy, no correlation with the protections					
Disagree	1,139	89.0%	294 (25.8%)	845 (74.2%)	0.8
Agree/ unknown	141	11.0%	35 (24.8%)	106 (75.2%)	
Too much consumption of sweets can lead to tooth decay					
Known	1,233	96.3%	322 (26.1%)	911 (73.9%)	0.084
Unknown	47	3.7%	7 (14.9%)	40 (85.1%)	
Total	1,280	100%	329 (25.7%)	951 (74.3%)	

ECC, early childhood caries.
*Statistically significant at $P < 0.05$.

TABLE 4 Logistic regression analysis of factors associated with the ECC prevalence.

Variables		B	SE	Wald χ^2	P	OR
Age groups				15.087	0.001*	
	3-year-old					
	4-year-old	0.307	0.182	2.842	0.092	1.360 (0.951–1.943)
	5-year-old	0.697	0.188	13.794	<0.0001*	2.008 (1.390–2.902)
Parental education level	Undergraduate or above					
	College or below	0.130	0.141	0.848	0.357	1.138 (0.864-1.500)
Family income	≥12,000 Yuan					
	<12,000 Yuan	0.371	0.166	5.016	0.025*	1.450 (1.047–2.007)
Parental perceptions of children's oral health status	Good					
	Fair or poor	0.801	0.144	31.059	<0.0001*	2.227 (1.680–2.951)
History of dental visit	No					
	Yes	0.128	0.136	0.889	0.346	1.137 (0.871–1.484)

ECC, early childhood caries; B, regression coefficient; SE, standard error; Wald χ^2, a chi-square value; P, significant level; OR, odds ratios.
*Statistically significant at $P < 0.05$.

(4, 21, 22). In this study, the chi-square test and logistic regression analysis showed that lower family income was significantly associated with higher ECC prevalence, which was also demonstrated in children from Japan (23), America (24), Australia (25), Italy (26), and Mongolia (27). Although the logistic regression did not certify a significant relationship between lower parental education level and higher ECC prevalence, children tended to have higher prevalence when their parents had a lower education level in this study. Kato et al. (23) showed that higher caries prevalence was associated with lower levels of parental education among 3-year-old Japanese children. Cianetti (26) reported that a lower parental educational level was related to a higher presence of caries among an Italian population of children aged 4-14 years. However, no association between parental education and caries prevalence existed in a sample from Mongolia (27). The inconsistency of results among various studies may be due to the differences in study methodology, such as the study design, sample size,

TABLE 5 Parental education level and different variables ($N = 1,280$).

Variables	Parental education level				*P*-value
	Middle school or below	High school	College	Undergraduate or above	
Feeding type within 6-month					
Breast only	200 (43.8%)	142 (43.7%)	94 (42.2%)	125 (45.5%)	0.907
Other types	257 (56.2%)	183 (56.3%)	129 (57.8%)	150 (54.5%)	
Bedtime bottle before children aged 3					
Yes	170 (37.2%)	122 (37.5%)	73 (32.7%)	83 (30.2%)	0.158
No	287 (62.8%)	203 (62.5%)	150 (67.3%)	192 (69.8%)	
Frequency of consuming desserts					
At least once a day	151 (33.0%)	113 (34.8%)	61 (27.4%)	100 (36.4%)	0.169
Occasionally or never	306 (67.0%)	212 (65.2%)	162 (72.6%)	175 (63.6%)	
Frequency of consuming sweet drinks					
At least once a day	41 (9.0%)	37 (11.4%)	23 (10.3%)	25 (9.1%)	0.684
Occasionally or never	416 (91.0%)	288 (88.6%)	200 (89.7%)	250 (90.9%)	
Frequency of consuming candies or chocolates					
At least once a day	116 (25.4%)	91 (28.0%)	43 (19.3%)	76 (27.6%)	0.099
Occasionally or never	341 (74.6%)	234 (72.0%)	180 (80.7%)	199 (72.4%)	
Eating snacks without toothbrushing before bed					
Yes	346 (75.7%)	217 (66.8%)	157 (70.4%)	177 (64.4%)	0.005*
No	111 (24.3%)	108 (33.2%)	66 (29.6%)	98 (35.6%)	
Start brushing teeth					
1-year-old and below	8 (1.8%)	7 (2.2%)	3 (1.3%)	6 (2.2%)	0.791
2-year-old	147 (32.2%)	116 (35.7%)	81 (36.3%)	102 (37.1%)	
3-year-old and above	302 (66.1%)	202 (62.2%)	139 (62.3%)	167 (60.7%)	
Frequency of brushing teeth					
Twice per day or above	202 (44.2%)	167 (51.4%)	125 (56.1%)	158 (57.5%)	0.002*
Once a day	222 (48.6%)	126 (38.8%)	87 (39.0%)	98 (35.6%)	
Occasionally or never	33 (7.2%)	32 (9.8%)	11 (4.9%)	19 (6.9%)	
Parental supervision for brushing teeth					
Every time	42 (9.2%)	20 (6.2%)	31 (13.9%)	53 (19.3%)	<0.0001*
Occasionally	348 (76.1%)	245 (75.4%)	155 (69.5%)	199 (72.4%)	
Never	67 (14.7%)	60 (18.5%)	37 (16.6%)	23 (8.4%)	
Fluoride toothpaste					
Yes	115 (25.2%)	63 (19.4%)	76 (34.1%)	99 (36.0%)	<0.0001*
No	342 (74.8%)	262 (80.6%)	147 (65.9%)	176 (64.0.%)	
Dental floss					
Yes	43 (9.4%)	24 (7.4%)	24 (10.8%)	30 (10.9%)	0.431
No	414 (90.6%)	301 (92.6%)	199 (89.2%)	245 (89.1%)	
History of dental visit					
Yes	196 (42.9%)	147 (45.2%)	103 (46.2%)	131 (47.6%)	0.631
No	261 (57.1%)	178 (54.8%)	120 (53.8%)	144 (52.4%)	
Fluoride varnish					
Yes	128 (28.0%)	103 (31.7%)	82 (36.8%)	107 (38.9%)	0.011*
No	329 (72.0%)	222 (68.3%)	141 (63.2%)	168 (61.1%)	
Oral health is important to life					
Yes	434 (95.0%)	309 (95.1%)	217 (97.3%)	270 (98.2%)	0.089
No	23 (5.0%)	16 (4.9%)	6 (2.7%)	5 (1.8%)	

(Continued)

TABLE 5 Continued

Variables	Parental education level				*P*-value
	Middle school or below	High school	College	Undergraduate or above	
Decayed primary teeth do not require treatment					
Disagree	329 (72.0%)	257 (79.1%)	178 (79.8%)	227 (82.5%)	0.004*
Agree/unknown	128 (28.0%)	68 (20.9%)	45 (20.2%)	48 (17.5%)	
Teeth are born healthy or unhealthy, no correlation with the protections*					
Disagree	386 (84.5%)	294 (90.5%)	207 (92.8%)	252 (91.6%)	0.001*
Agree/ unknown	71 (15.5%)	31 (9.5%)	16 (7.2%)	23 (8.4%)	
Too much consumption of sweets can lead to tooth decay					
Known	439 (96.1%)	311 (95.7%)	218 (97.8%)	265 (96.4%)	0.625
Unknown	18 (3.9%)	14 (4.3%)	5 (2.2%)	10 (3.6%)	

*Statistically significant at $P < 0.05$.

the time of data collection, and the methods for assessing ECC (21, 28).

Socioeconomic factors may influence children's caries status through children's oral health behavior and parents' oral health knowledge and attitude (10). In this study, both higher parental education level and family income were related to the notably higher frequency of brushing teeth and parental supervision of brushing teeth, a higher proportion of children using fluoride toothpaste and receiving fluoride varnish, and better knowledge about whether decayed primary teeth need treatment and teeth need protections (Tables 4, 5). In general, parents with higher socioeconomic status will have much more opportunities to access health information, preferentially attend public dental services, and receive oral health advice (13, 21), which, in turn, can contribute to caries prevention for children. Nevertheless, high socioeconomic status did not correlate with good dietary habits for caries prevention in the present study. Furthermore, children from higher-income families consumed desserts and candies considerably more frequently. This may be because high family income influences oral health knowledge and attitude, but oral health knowledge and attitude fail to affect dietary behavior, which was also observed in a previous study (10).

A systematic review concluded that children exposed to a long duration of breastfeeding up to age 12 months had a reduced risk of caries (29). In this study, children being exclusively breastfed during the first half-year of life showed a relatively lower ECC prevalence without significance. On the contrary, some Chinese researchers reported that children exclusively/predominantly breastfed during the first half-year of life had a higher risk of ECC (12). The controversial results may be because, besides the feeding type, the existence and duration of nocturnal feeding can also affect children's caries status, which was not investigated in this study. Thus, in future studies, the feeding type and habits, such as nocturnal feeding, should be included to explore the associated factors of ECC.

Regular toothbrushing with a fluoridated paste is generally considered a fundamental self-care behavior for preventing caries and maintaining oral health (30, 31). According to a systematic review, children brushing their teeth less frequently have an increased risk of developing new carious lesions than those brushing more frequently, which was more pronounced in primary than permanent dentition (32). Additionally, parents play an important role in their children's oral health (33). Matsuyama (34) reported that lack of parental supervision was associated with children's unhealthy oral health behaviors and dental caries. However, neither children with higher frequent toothbrushing, using fluoride toothpaste, nor parental supervision showed significantly lower ECC prevalence in this study, which may be attributed to two reasons. First, 63.3% of the children started brushing their teeth at the age of 3 or above when decayed teeth had already existed in the oral cavity. Second, in addition to the brushing frequency, the brushing duration, method, and brushing effect have a cumulative effect on caries prevention (35), which was not included in the present study. Based on the current results, we did not know the actual oral hygiene status among the children, which may affect the exploration of the association between toothbrushing and caries occurrence.

The American Academy of Pediatric Dentistry (AAPD) recommends that the initial dental visit be scheduled within 6 months of the first primary tooth eruption but no later than 12 months of age (36, 37). Werneck et al. (38) investigated a sample of Portuguese-speaking immigrants in Toronto and found that a higher proportion of children with ECC than non-ECC children had not visited a dentist. Conversely, the study on preschool children in Monastir, Tunisia, showed a statistically significant association between higher ECC prevalence and history of dental visits (39), which was also observed among children in Southern Italy (40), Saudi preschool children in Riyadh (41) and children aged 3–5 years from

TABLE 6 Family income and different variables ($N = 1280$).

Variables	Family income (Yuan, per month)			*P*-value
	<6,000	≥6,000 <12000	≥12,000	
Feeding type within 6-month				
Breast only	306 (45.1%)	154 (43.5%)	101 (40.9%)	0.521
Other types	373 (54.9%)	200 (56.5%)	146 (59.1%)	
Bedtime bottle before children aged 3				
Yes	249 (36.7%)	119 (33.6%)	80 (32.4%)	0.392
No	430 (63.3%)	235 (66.4%)	167 (67.6%)	
Frequency of consuming desserts				
At least once a day	189 (27.8%)	132 (37.3%)	104 (42.1%)	<0.0001*
Occasionally or never	490 (72.2%)	222 (62.7%)	143 (57.9%)	
Frequency of consuming sweet drinks				
At least once a day	60 (8.8%)	35 (9.9%)	31 (12.6%)	0.245
Occasionally or never	619 (91.2%)	319 (90.1%)	216 (87.4%)	
Frequency of consuming candies or chocolates				
At least once a day	153 (22.5%)	92 (26.0%)	81 (32.8%)	0.006*
Occasionally or never	526 (77.5%)	262 (74.0%)	166 (67.2%)	
Eating snacks without toothbrushing before bed				
Yes	495 (72.9%)	238 (67.2%)	164 (66.4%)	0.062
No	184 (27.1%)	116 (32.8%)	83 (33.6%)	
Start brushing teeth				
1-year-old and below	11(1.6%)	6 (1.7%)	7 (2.8%)	0.13
2-year-old	226 (33.3%)	119 (33.6%)	101(40.9%)	
3-year-old and above	442 (65.1%)	229 (64.7%)	139 (56.3%)	
Frequency of brushing teeth				
Twice per day or above	314 (46.2%)	193 (54.5%)	145 (58.7%)	0.006*
Once a day	309 (45.5%)	135 (38.1%)	89 (36.0%)	
Occasionally or never	56 (8.2%)	26 (7.3%)	13 (5.3%)	
Parental supervision for brushing teeth				
Every time	54 (8.0%)	43 (12.1%)	49 (19.8%)	<0.0001*
Occasionally	507 (74.7%)	265 (74.9%)	175 (70.9%)	
Never	118 (17.4%)	46 (13.0%)	23 (9.3%)	
Fluoride toothpaste				
Yes	168 (24.7%)	103 (29.1%)	82 (33.2%)	0.029*
No	511 (75.3%)	251 (70.9%)	165 (66.8)	
Dental floss				
Yes	60 (8.8%)	35 (9.9%)	26 (10.5%)	0.701
No	619 (91.2%)	319 (90.1%)	221 (89.5%)	
History of dental visit				
Yes	287 (42.3%)	166 (46.9%)	124 (50.2%)	0.072
No	392 (57.7%)	188 (53.1%)	123 (49.8%)	
Fluoride varnish				
Yes	198 (29.2%)	125 (35.3)	97 (39.3%)	0.008*
No	481 (70.8%)	229 (64.7%)	150 (60.7%)	
Oral health is important to life				
Yes	648 (95.4%)	347 (98.0%)	235 (95.1%)	0.087
No	31 (4.6%)	7 (2.0%)	12 (4.9%)	

(Continued)

TABLE 6 Continued

Variables	Family income (Yuan, per month)			*P*-value
	<6,000	≥6,000 <12000	≥12,000	
Decayed primary teeth do not require treatment				
Disagree	492 (72.5%)	291 (82.2%)	208 (84.2%)	<0.0001*
Agree/ unknown	187 (27.5%)	63 (17.8%)	39 (15.8%)	
Teeth are born healthy or unhealthy, no correlation with the protections				
Disagree	586 (86.3%)	325 (91.8%)	228 (92.3%)	0.005*
Agree/ unknown	93 (13.7%)	29 (8.2%)	19 (7.7%)	
Too much consumption of sweets can lead to tooth decay				
Known	649 (95.6%)	343 (96.9%)	241 (97.6%)	0.291
Unknown	30 (4.4%)	11 (3.1%)	6 (2.4%)	

*Statistically significant at $P < 0.05$.

some regions of China (9, 12). In this study, despite the insignificant association evaluated by the logistic analysis, children with dental visit history tended to have a higher ECC prevalence. This might reflect that most children in many countries, including China, visit a dentist since they have already experienced a dental health problem, which is therapeutic rather than preventive (12). Therefore, visiting a dentist only when a problem is perceived rather than for preventive dental checkups could be one significant risk indicator for ECC (40).

According to the questionnaire survey, most parents had positive attitudes toward oral health care. They were aware of the importance of oral health, which, however, did not coordinate with the high prevalence of ECC. It is also worth noting that when parents thought their child's oral health was fair or poor, the ECC prevalence of their children was higher, indicating that parents might know their child's exact oral health status but did not make alterations. In future studies, we will explore the reasons for this phenomenon. Moreover, in view of this situation, increasing parental awareness of the seriousness of ECC treatment and its effect on oral health-related quality of life may help parents make behavioral alterations for improving children's oral health; preventive programs for ECC should involve children, as well as parents to lessen the disease burden.

In addition to the limitations mentioned above, this study does not allow the determination of the causal relationship between associated factors and the results due to the cross-sectional design. Moreover, as Xiangyun County has several towns, the study sample was drawn from the central town, Xiangcheng Town, which could lead to selection bias. Studies on the whole county's sample are needed in the future. Because we used the WHO criteria without radiographs for the examination, initial lesions have been neglected. Besides, potential response bias may exist as the data from parents were retrospective rather than prospective. Longitudinal studies in this field are necessary.

Conclusion

In this study, the ECC prevalence among 3–5-year-old preschool children in Xiangyun was 74.3%. The mean dmft score was 4.9 ± 5.0. Children's age of 5-year-old, family income lower than 12,000 Yuan, and worse parental perception of children's oral health are critical factors related to the higher caries prevalence in this sample. This study implies that more attention should be given to children's caries prevention from early childhood; public awareness of ECC should be increased through community initiatives, and parents should help their children to develop good eating and oral hygiene habits; oral health education and promotion should be intensified to reduce the ECC prevalence and improve the oral health status of children in Xiangyun.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of the People's Hospital of Xiangyun (No. 2020069). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

ML and QS wrote the manuscript. XX collected the data. GL conceived the idea, analyzed the data, and revised the manuscript. All authors read and approved the final version of the manuscript prior to submission.

Funding

This study received support from the Research Program of People's Hospital of Xiangyun Affiliated to Dali University (DX2020SF02).

Acknowledgments

The authors would like to thank the children and parents who participated in the study and the staff of preschools.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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frontiers | Frontiers in Public Health

TYPE Original Research
PUBLISHED 06 September 2022
DOI 10.3389/fpubh.2022.974419

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Children and Health, a section of the journal Frontiers in Public Health

RECEIVED 21 June 2022
ACCEPTED 15 August 2022
PUBLISHED 06 September 2022

CITATION
Wang X, Ma Z, Lei M, Zhao C, Lin X, Cao F and Shi H (2022) Association between early childhood caries and diet quality among Chinese children aged 2–5 years.
Front. Public Health 10:974419.
doi: 10.3389/fpubh.2022.974419

Association between early childhood caries and diet quality among Chinese children aged 2–5 years

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Background: Early childhood caries (ECC) is a major oral problem affecting the health and wellbeing of children worldwide. Diet quality is a better predictor of ECC risk than single foods or specific nutrients. The purposes of this study were to assess the associations between ECC and diet quality among 2- to 5-year-old Chinese children.

Methods: A total of 150 eligible children were included in this study. The decayed, missing, or filled surface (dmfs) score was recorded for each child by dental examination. All participants were divided into three groups based on their age and dmfs score [the caries-free group, the ECC group, and the severe early childhood caries (S-ECC) group]. Parents were invited to complete a questionnaire on the general characteristics and oral health behaviors of the participants. The information of 24-h dietary intake from each child was captured *via* a mobile APP. The Chinese diet balance index for preschool children (DBI_C) indicators score, high bound score (HBS), low bound score (LBS), and diet quality distance (DQD) score were calculated to assess the diet quality of study subjects. The associations of ECC with HBS, LBS, DQD score, and DBI_C indicators score were analyzed by Mann-Whitney U test and multivariable logistic regression analysis.

Results: In this study, 21, 31, and 98 children were diagnosed with caries-free, ECC, and S-ECC, respectively. Statistical analysis revealed that the risk of ECC and S-ECC were significantly increased with the DQD score (OR = 1.283 and 1.287, respectively), but both were not associated with HBS and LBS ($P > 0.05$). In the meantime, the risk of ECC and S-ECC were significantly increased with the Grains score (OR = 1.623 and 1.777, respectively), and significantly decreased with the Food diversity score (OR = 0.271 and 0.315, respectively). Moreover, the risk of S-ECC also significantly decreased with the Vegetables score (OR = 0.137).

Conclusion: Both ECC and S-ECC were associated with a high degree of dietary imbalance and grains intake as well as a low degree of food diversity among Chinese children aged 2–5 years. In addition, S-ECC was also associated with a low degree of vegetable intake.

KEYWORDS

early childhood caries, diet quality, Chinese diet balance index for preschool children, Chinese children aged 2–5 years, dietary imbalance

Introduction

Early childhood caries (ECC), one of the most widespread chronic diseases, has posed a threat to children's health worldwide. It is defined by the American Academy of Pediatric Dentistry as a child under 71 months of age with one or more decayed (with or without cavitation lesions), missing (due to caries), or filled tooth surfaces (dmfs) in any primary tooth (1). The Global Burden of Disease Study 2016 indicated that the incidence rate of deciduous tooth caries ranked fifth among the most prevalent diseases in the world (2). The Fourth National Oral Health Epidemiological Survey Report 2018 demonstrated that 50.8, 63.6, and 71.9% of Chinese children aged 3, 4, and 5 experienced ECC, respectively, while the therapeutic rates were only 1.5, 2.9, and 4.1%, respectively (3). If not addressed, ECC can not only affect children's growth, wellbeing, and quality of life (4) but can also have a negative impact on parents and socio-economics (5). Therefore, it is a challenging issue faced by pediatric dentists worldwide to prevent ECC.

ECC is a multifactorial disease, with common risk factors including cariogenic microorganisms, inappropriate feeding practices, frequent contact with fermentable carbohydrates, poor oral hygiene habits, and a series of social variables (6, 7). It has been well recognized that diets play a critical role in the etiopathogenesis of ECC (8). Among various foods, sucrose and processed or hydrolyzed starchy foods are considered to have a high cariogenic potential (9). All of these contain carbohydrates that can be fermented by cariogenic bacteria in the oral cavity, causing the saliva pH to drop to 5.5 or lower and thus facilitating the formation of caries (9). In parallel, other foods have been discussed for their anti-cariogenic effects, for instance, fresh vegetables and fruits, unrefined grains (whole grains), milk, and dairy products (10, 11).

Traditional nutritional epidemiology investigates the association between chronic diseases and diets through a single (or few) food or specific nutrient. However, the effects of and interaction with other potentially contributory groups on ECC may be missed out (8). Diet quality refers to the extent to which the types, quantities, and proportions of major foods and/or nutrients in the diet align with dietary guidelines or proven healthy dietary structures (12). In recent years, exploring the effects of overall diet quality on ECC has garnered attention from researchers due to it takes into account the complex synergistic effects between foods. At present, the tools utilized to assess the diet quality for children with ECC are primarily the Healthy Eating Index-2005 (HEI-2005) and its updated version, which are measures for assessing whether a group of foods conformity with the Dietary Guidelines for Americans (13–15). In 2015, Zaki et al. (16) claimed that Egyptian children aged 2–6 years with S-ECC had significantly lower HEI-2005 scores than children without caries. In 2017, Elif Inan-Eroglu et al. (17) reported that ECC patients accounted for a higher percentage of children with lower HEI-2010 scores. In 2020, Priyadarshini and Gurunathan (18) observed that Indian children with higher HEI-2005 scores were less prone to ECC. So far, HEI-2005 and its updated version have not been utilized to assess the diet quality among Chinese children aged 2–5 years. Considering the dietary habits vary across countries and regions, younger children differ from adults in recommended intake and nutritional requirements, in addition to having special physiological characteristics such as gradual growth in height and weight, limited chewing, and digestive ability (19, 20). The diet quality of subjects in the current research was assessed by adopting the Chinese diet balance index for preschool children (DBI_C), which consists of 10 food group indicators listed in the Balanced Diet Pagoda for Chinese Preschool Children, namely Grains, Vegetables, Fruits, Dairy, Beans, Animal foods, Cooking oil, Salt, Drinking water, and Food diversity (21).

Accurate description of foods and precise estimation of portion sizes are critical for assessing dietary intake. Traditional methods used in the past (e.g., multiple 24-h diets recall and food frequency questionnaires) are subject to inherent errors that could lead to inaccurate assessments, negatively impacting patients and research outcomes. Recently, along with the popularization of cameras and mobile phones, image-based methods integrating mobile device application technologies have been developed (22). All the foods consumed by the subject are captured as images *via* a mobile device and recorded as the primary sources of dietary intake, which follow the method for recording diet (22). Parents/guardians can supplement image details to reduce the food under-reporting and improve dietary

assessments' accuracy compared to traditional assessment methods alone (23). Therefore, a mobile phone APP based on the image-based method was used to acquire 24-h dietary intake information of the study participants.

The present study was conducted to investigate the associations of ECC and S-ECC with diet quality among Chinese children aged 2–5 years. We hypothesized that the risk of ECC and S-ECC is not associated with diet quality among Chinese children aged 2–5 years.

Materials and methods

Study population

A cross-sectional, analytical study design was carried out. One hundred and fifty healthy children were chosen by a convenience sampling method from the Department of Pediatric Dentistry at the Dental Hospital, Hebei Medical University, China, and three urban kindergartens in Shijiazhuang, China.

The eligibility criteria included children aged 2–5 who live with their parents/legal guardians, presence of primary dentition only.

Exclusion criteria were as follows: (1) Children with energy intake below 450 kcal/d or above 2,800 kcal/d (21); (2) Children whose height and weight are not within the normal range of the Reference Standards for Growth and Development of Children under 7 years old in China; (3) Children with any mental or systemic disease that affects oral health examination or dietary intake; (4) Children who took any antibiotics 2 weeks prior to this research.

Sample size estimation

The determination of sample size with the following assumptions: ECC prevalence of 62.5% was generated from The Fourth National Oral Health Epidemiological Survey Report 2018 (3). A margin of error was set to be 0.15 times the prevalence, which is 62.5% * 0.15 = 9%. Type I error = 5%. The confidence level was 95%. The required sample size calculated by PASS (Version 15) was 120. Assuming that the loss of follow-up was randomized, the loss of follow-up rate of 10% would require 134 cases. A total of 150 children were finally enrolled in the analysis.

Ethical considerations

This cross-sectional study was approved by the Ethics Committee of Dental Hospital, Hebei Medical University, China (No. [2018]028) and conducted in accordance with the principles of the Declaration of Helsinki. Parents/legal guardians of all eligible participants were informed about the research purpose, the health benefits, and potential hazards before the study commenced. They all provided written informed consent. All the data in this study were used for scientific research only. In addition, participants suffering from ECC or other oral diseases were offered the necessary advice and treatment.

Dental examinations

Dental examinations were carried out under field conditions by two trained and calibrated pediatric dentists. Duplicate clinical examinations were conducted to test the reliability of intra-examiner, with kappa values averaging 90 and 88% for the examiners themselves and between the two examiners, respectively. To ensure the accuracy of the examinations as much as possible, two caries diagnostic criteria have been employed: the International Caries Detection and Assessment System (ICDAS-II) (24) was used to assess early enamel caries without visible cavity formation. In the meantime, World Health Organization (WHO) criteria (25) were used to determine cavitated lesions in pits, fissures, and smooth surfaces.

For early enamel caries, after food residues and debris were removed, the decayed (with or without cavitation lesions), missing (due to caries), or filled surface (dmfs) score of children was determined through the visual examination using the sterile dental mirror and the portable air compressor under sufficient illumination. For cavitated lesions, the dmfs score was determined using the sterile dental mirror under sufficient illumination after cleaning and drying the teeth. And if necessary, a community periodontal index (CPI) probe was carried out to clean debris from the pits or fissures without significant axial force or excessive pressure. The 150 children were divided into three groups depending on their age and total dmfs score: the caries-free group consisted of 21 children (dmfs = 0), the ECC group consisted of 31 children [based on the definition by the American Academy of Pediatric Dentistry (1)], and the S-ECC group consisted of 98 children [based on the definition by the American Academy of Pediatric Dentistry (1)].

Questionnaire survey

Acquisition of the general characteristics and oral health behaviors of the study subjects were conducted using a questionnaire survey, which included questions pertaining to social demographics, infant feeding practices, and oral hygiene habits (Appendix 1).

Twenty-four hour dietary intake

The data on 24-h dietary intake (one workday when children eat regularly) were acquired using a mobile phone APP (Beijing Sihai Huachen Technology Co., Ltd.), which consists of the Children's Household Nutrition Management Micro-platform and Children's Nutrition Supervision Micro-platform. Firstly, twenty parents/legal guardians were randomly selected to test whether they could use this APP proficiently and correctly. According to the active feedback from the parents/legal guardians, no further explanation is deemed necessary for the use of this software.

The parents/legal guardians uploaded all the food consumed by children within 24 h (including snacks and beverages), in the form of images, onto the Children's Household Nutrition Management Micro-platform, in which they can also mark and supplement the information on food intake. The next day, the researchers acquired the details about food intake from the Children's Nutrition Supervision Micro-platform. All food items received were confirmed with the diet uploader by phone. We will request parents to make corrections or re-upload the food images if any errors are found at any time during the above period to ensure the accuracy and validity of the data obtained. In the meantime, if the parents uploaded diets as well as confirmed or corrected, we provided them with feedback on their child's dietary status as compensation. By calculating the score of each indicator in DBI_C, each child's dietary status was assessed and specific dietary recommendations were given.

Assessment of diet quality

Each food item acquired in the 24-h diet was transposed into the corresponding DBI_C indicators, and the score of each indicator was calculated (Appendix 2). The values of DBI_C indicators were determined by referring to Dietary Guidelines for Chinese preschool children (20) and Balanced Diet Pagoda for Chinese Preschool Children. A score closer to 0 means the intake of this food group is closer to the recommended intake at the corresponding age group.

According to the DBI_C score calculation method, the high bound score (HBS), low bound score (LBS), and diet quality distance (DQD) score were calculated, respectively. For these three indicators, a score closer to 0 means the dietary status is better. HBS is the absolute value of the sum of the positive score of DBI_C indicators, which reflects the degree of excessive dietary intake. Its score ranges from 0 to 36: 0 means no excessive intake; 1–7 means appropriate intake; 8–14, 15–22, and 23–36 means low, moderate, and high excessive intake, respectively. LBS is the absolute value of the sum of the negative score of DBI_C indicators, which reflects the degree of insufficient dietary intake. Its score ranges from 0 to 72: 0 means no insufficient intake; 1–14 means appropriate intake; 15–29, 30–43, and 44–72 means low, moderate, and high insufficient intake, respectively. DQD is the sum of the absolute value of the DBI_C indicators score, which comprehensively reflects the problem of dietary imbalance. Its score ranges from 0 to 84: 0 means that there is neither dietary insufficient nor excessive intake in the diet; 1–17 means appropriate, and 18–34, 35–50, and 51–84 means low, moderate, and high dietary imbalance, respectively.

Statistical analysis

The statistical description was presented as means and standard deviation (SD) for continuous variables conforming to normality, the median and quartile range for those with skewness, furthermore frequencies and percentages (%) for categorical variables.

Univariate analysis was conducted using appropriate tests (t-test, Pearson χ^2, Fisher exact test, and Mann-Whitney U-test) to evaluate associations of social demographics, infant feeding practices, and oral hygiene habits to ECC and S-ECC. Mann-Whitney U-test was utilized to compare the DBI_C indicators score, HBS, LBS, and DQD score between the study groups since the data distribution did not conform to normality and (or) heterogeneity of variance. All statistical tests were two-tailed with a statistical significance level of $P \leq 0.05$.

The above indicators that showed significant statistical differences (HBS, DQD score, Grains score, Vegetables score, and Food diversity score) were included in multivariable logistic regression models, that were constructed to assess the independent effect of these variables on ECC (Model 1) and S-ECC (Model 2). To understand whether potential confounders could affect OR, we adjusted for the following covariates: age and adult supervision of toothbrushing. HBS, DQD score, Grains score, Vegetables score, Food diversity score, and age were modeled as continuous variables. Adult supervision of toothbrushing was categorized as yes or no. The assumption of linearity between the continuous independent variables and the logit transformed values for the dependent variables were assessed by the Box-Tidwell test. Multicollinearity between independent variables was checked using the Variance Inflation Factor. The−2 log-likelihood ratio test was used to test the overall significance of the model. The goodness-of-fit of the models was assessed by the Hosmer-Lemeshow. P-value $\leq$ 0.05 was considered statistically significant.

The data were processed, analyzed, and plotted on SPSS (Version 26) and Graphpad Prism (Version 9).

TABLE 1 The general characteristics and oral health behaviors of study participants with the presence or absence of ECC and S-ECC.

Variable or practice	Caries-free	ECC	$\chi^2/t/z$	S-ECC	$\chi^2/t/z$
	n (%)	*n* (%)	P_1-value	*n* (%)	P_2-value
Age (years, mean ± SD)	3.191 ± 0.214	3.871 ± 0.152	$t = -2.668$ 0.010*	3.684 ± 0.087	$t = -2.333$ 0.021*
Gender					
Boy	11 (52.4)	13 (41.9)	$\chi^2 = 0.550$	47 (48.0)	$\chi^2 = 0.135$
Girl	10 (47.6)	18 (58.1)	0.458	51 (52.0)	0.713
Father's education level					
Junior high school or below	2 (9.5)	3 (9.6)	$z = -0.035$	12 (12.3)	$z = 1.476$
High school	4 (19.1)	6 (19.4)	0.972	35 (35.7)	0.140
University or above	15 (71.4)	22 (71.0)		51 (52.0)	
Mother's education level					
Junior high school or below	2 (9.5)	4 (12.9)	$z = -0.209$	16 (16.3)	$z = -1.618$
High school	3 (14.3)	4 (12.9)	0.834	27 (27.6)	0.106
University or above	16 (76.2)	23 (74.2)		55 (56.1)	
Sweets consumption					
Less than once a day or never	5 (23.8)	4 (12.9)	$z = -1.559$	15 (15.3)	$z = -1.754$
Once a day	9 (42.9)	10 (32.3)	0.119	29 (29.6)	0.079
More than once a day	7 (33.3)	17 (54.8)		54 (55.1)	
Wean from breastfeeding (months)					
<12	5 (23.8)	9 (29.0)	$z = -0.286$	19 (19.4)	$z = -1.508$
12–18	13 (61.9)	14 (45.2)	0.775	45 (45.9)	0.132
>18	3 (14.3)	8 (25.8)		34 (34.7)	
Start toothbrushing (months)					
<12	8 (38.1)	9 (29.0)	$z = -0.783$	26 (26.5)	$z = -1.092$
12–24	8 (38.1)	12 (38.7)	0.433	40 (40.8)	0.275
>24	5 (23.8)	10 (32.3)		32 (32.7)	
Adult supervision of toothbrushing					
No	4 (19.0)	17 (54.8)	$\chi^2 = 6.661$	43 (43.9)	$\chi^2 = 4.462$
Yes	17 (81.0)	14 (45.2)	0.010*	55 (56.1)	0.035*
Use of fluoride supplements					
No	8 (38.1)	16 (51.6)	$\chi^2 = 0.920$	47 (48.0)	$\chi^2 = 0.677$
Yes	13 (69.1)	15 (48.4)	0.377	51 (52.0)	0.411

P_1 The significance level for comparison of general characteristics and oral health behaviors between caries-free and ECC groups. P_2 The significance level for comparison of general characteristics and oral health behaviors between caries-free and S-ECC groups.
ECC, early childhood caries; S-ECC, severe early childhood caries.
*Significantly different at $P < 0.05$.

Results

General information

A total of 150 subjects aged 2–5 years meeting the study criteria were enrolled in our study and completed the program. Twenty-one of these individuals did not present with caries, 31 children were diagnosed with ECC, and 98 children were diagnosed with S-ECC. The general characteristics and oral health behaviors of study participants with the presence or absence of ECC and S-ECC are listed in Table 1. Subjects with ECC (3.871 ± 0.152) and S-ECC (3.684 ± 0.087) had higher age than those without caries (3.191 ± 0.214) ($P = 0.010$ and 0.021, respectively). A higher percentage of caries-free children (81%) were supervised to brush their teeth compared to children with ECC (45.2%) and S-ECC (56.1%) ($P = 0.010$ and 0.035, respectively). These differences were significant between the caries-free and the ECC groups as well as between the caries-free and the S-ECC groups ($P < 0.05$).

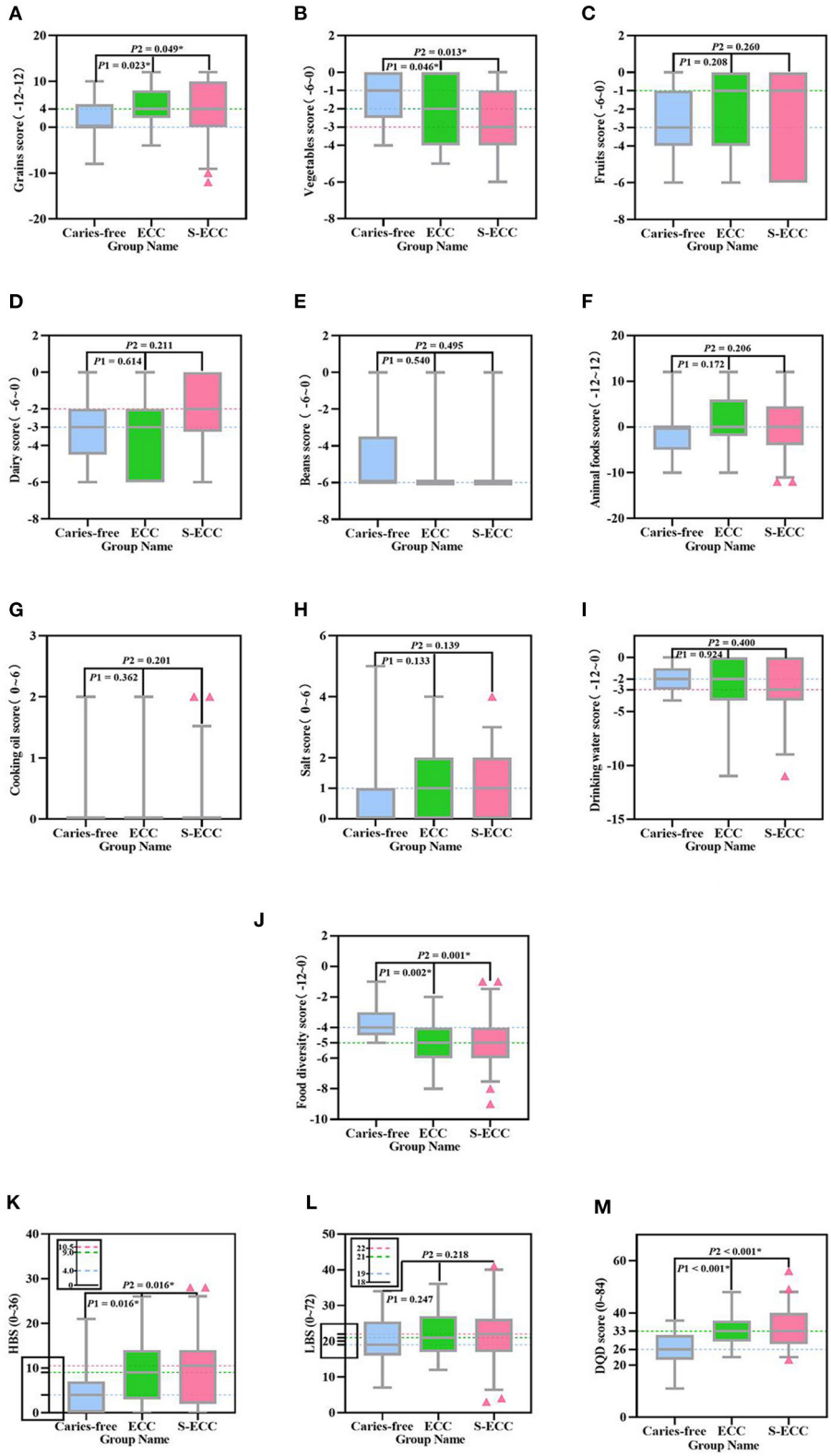

FIGURE 1
Distribution and comparison of DBI_C indicators scores, HBS, LBS, and DQD score among the three groups. The distribution and Comparison of **(A)** Grains score, **(B)** Vegetables score, **(C)** Fruits score, **(D)** Dairy score, **(E)** Beans score, **(F)** Animal foods score, **(G)** Cooking oil score, **(H)** Salt
(Continued)

FIGURE 1 (Continued)
score, **(I)** Drinking water score, **(J)** Food diversity score, **(K)** HBS, **(L)** LBS, and **(M)** DQD score in the caries-free group, the ECC group, and the S-ECC group. The blue, green, and red dashed lines correspond to the median scores of 13 indicators in the caries-free group, the ECC group, and the S-ECC group, respectively, with the dashed lines overlapping for those with the same value. *P*1 Represents the significance level for the comparison of 13 indicators scores between the caries-free and the ECC groups. *P*2 Represents the significance level for the comparison of 13 indicators scores between the caries-free and the S-ECC groups. *Represents significant differences ($P < 0.05$) between the groups. The y-axis data corresponding to HBS and LBS are displayed by local enlarged images. HBS, high bound score; LBS, low bound score; DQD, diet quality distance.

TABLE 2 Multivariable logistic regression analysis for the associated factor of ECC and S-ECC.

Variables	Model 1 (Outcome: ECC)	Model 2 (Outcome: S-ECC)
	OR (95% CI) *P*-value	OR (95% CI) *P*-value
HBS	1.066 (0.909–1.249)	1.043 (0.903–1.205)
	0.432	0.569
DQD score	1.283 (1.008–1.633)	1.287 (1.057–1.567)
	0.043*	0.012*
Grains score	1.623 (1.060–2.483)	1.777 (1.195–2.641)
	0.026*	0.004*
Vegetables score	0.699 (0.381–1.282)	0.137 (0.042–0.451)
	0.247	0.001*
Food diversity score	0.271 (0.095–0.779)	0.315 (0.130–0.763)
	0.015*	0.011*
Age	1.491 (0.325–6.846)	1.850 (0.347–9.867)
	0.607	0.471
Adult supervision of toothbrushing	0.336 (0.025–4.525)	0.454 (0.017–11.923)
	0.411	0.636

*Significantly different at $P < 0.05$.
ECC, early childhood caries; S-ECC, severe early childhood caries; OR, odds ratio; CI, confidence interval; HBS, high bound score; DQD, diet quality distance.

Distribution and comparison of scores

The mean scores of Grains and Salt among the studied children were both higher than 0 (Figures 1A,H), while the mean scores of Vegetables, Fruits, Dairy, Beans, Drinking water, and Food diversity were all lower than 0 (Figures 1B–E,I,J), only the mean scores of Animal foods and Cooking oil were equal to 0 (Figures 1F,G). The distribution and comparison of DBI_C indicators score, HBS, LBS, and DQD score between the study groups are listed in Figure 1. Comparing the mean scores of 10 indicators in DBI_C, it was manifested that subjects with ECC or S-ECC had higher Grains score ($P = 0.023$ and 0.049, respectively) in addition to Vegetables score ($P = 0.046$ and 0.013, respectively) and Food diversity score ($P = 0.002$ and 0.001, respectively) that were lower than those without caries (Figures 1A,B,J). Other than that, subjects with ECC or S-ECC had higher HBS (the *P*-value for both was 0.016) and DQD score (the *P*-value for both was <0.01) than did the subjects without caries (Figures 1K,M). These differences were significant between the caries-free and the ECC groups as well as between the caries-free and the S-ECC groups ($P < 0.05$).

Multivariable logistic regression analysis for the associated factor of ECC and S-ECC

Indicators that showed statistically significant differences in univariate analysis (HBS, DQD score, Grains score, Vegetables score, and Food diversity score) were entered into the multivariable logistic regression analysis to assess their independent effects on ECC and S-ECC. Following adjustment for covariates (age, adult supervision of toothbrushing), ECC was associated with DQD score ($P = 0.043$), Grains score ($P = 0.026$), and Food diversity score ($P = 0.015$), and not associated with HBS ($P = 0.432$) and Vegetables score ($P = 0.247$) (Model 1 in Table 2). In parallel, S-ECC was associated with DQD score ($P = 0.012$), Grains score ($P = 0.004$), Vegetables score ($P = 0.001$), and Food diversity score ($P = 0.011$), and not associated with HBS ($P = 0.569$) (Model 2 in Table 2). On the other hand, the risk of ECC significantly increased with DQD score (OR = 1.283, 95% CI = 1.008-1.633) and Grains score (OR = 1.623, 95% CI = 1.060–2.483), whereas it was significantly decreased with Food diversity score (OR = 0.271, 95% CI = 0.095–0.779). A similar results was found for S-ECC, that its risk significantly increased with DQD score (OR = 1.287, 95% CI = 1.057–1.567) and Grains score (OR = 1.777, 95% CI = 1.195–2.641), whereas it was significantly decreased with Vegetables score (OR = 0.137, 95% CI = 0.042–0.451) and Food diversity score (OR = 0.315, 95% CI = 0.130–0.763).

Discussion

To the best of our knowledge, this current study provides the first evidence on the association of diet quality, as measured by the DBI_C to ECC among 2- to 5-year-old Chinese children. The indicators in DBI_C are all food groups and do not involve nutrients, which avoids the tedious calculation of nutrient-based dietary quality assessment methods, and allows for simpler and faster diet quality analysis for individuals and groups (21). In

addition, the index adopts two-way scores, which can more intuitively reflect the problem and degree of dietary imbalance.

The main findings of this cross-sectional study were that those with ECC and S-ECC had a significantly higher degree of excessive dietary intake, dietary imbalance, and grains intake as well as a significantly lower degree of food diversity and vegetable intake than caries-free subjects. Multivariable logistic regression analysis revealed that the risk of ECC and S-ECC were significantly increased with the DQD score, but both were not associated with HBS and LBS. In the meantime, the risk of ECC and S-ECC were significantly increased with the Grains score and significantly decreased with the Food diversity score. Moreover, the risk of S-ECC also significantly decreased with the Vegetables score.

It is worth noting that the majority of participants in the present study had low-grade dietary imbalance, with both excessive and insufficient dietary intake. However, the mean scores of HBS, LBS, and DQD in the caries-free group were lower than those in the ECC group and the S-ECC group, which reflected that the caries-free children had higher diet quality and tended to follow healthy dietary recommendations. Similar results have been reported by Zaki et al. (16) and Priyadarshini et al. (18), both of whom found a significant association of a reduced likelihood of S-ECC with adherence to general healthy dietary guidelines among young children. The nutritional status of Chinese children has improved considerably with the rapid socio-economic development (26, 27). Nevertheless, it is still common for unbalanced dietary patterns among Chinese children (20, 28–30). In this study, only the mean intake of grains and salt for children aged 2–5 was higher than the recommended intake of Balanced Diet Pagoda for Chinese Preschool Children, while the mean intake of vegetables, fruits, dairy, beans, drinking water, and food diversity were below the recommended intake. The risk of ECC increased significantly with the degree of dietary imbalance. Dietary imbalances can lead to varying degrees of malnutrition, resulting in the hypofunction of salivary glands, altered salivary composition and reduced buffering capacity, and increased risk of ECC (31, 32). The level of diet quality in young children will affect the diet quality in school-age and even into adulthood (33) and is associated with the morbidity and mortality of chronic diseases from adulthood to old age (34, 35). Therefore, the problem of dietary imbalance in young children deserves great attention globally. Necessary intervention measures should be taken, such as strengthening nutrition and health awareness for guardians (36) and conducting interactive workshops for teachers and parents on nutrition education (37).

The mean scores of Grains were higher in children with ECC or S-ECC compared with those who did not present with caries. And the logistic regression models revealed that an increase in grains intake increased the probability of suffering from caries. It's a pity that DBI_C indicators do not strictly differentiate between refined grains and whole grains. However, grains consumption for Chinese residents was dominated by refined rice and flour as well as the intake of whole grains and coarse cereals were insufficient, as stated by the Scientific Research Report on Chinese Dietary Guidelines (38), which may indirectly indicate that the higher proportion of refined grains consumed compared to whole grains among Chinese children aged 2–5 years. Refined grains are lower in nutrients and minerals, dietary fiber content, polyunsaturated fatty acids, and phytochemicals, to a great extent attributable to loss of the outer bran layer and the endosperm of the grain being pounded during the most common way of refining (39), and starch accounts for the most proportion. Hancock et al. (40) claimed that the total time that plaque pH remained below a critical level of 5.5 when exposed to processed starch and sugar-containing foods was significantly higher compared to foods containing high concentrations of sucrose only, suggesting that an increased risk of caries was associated with the consumption of refined grains, particularly containing sucrose.

Moreover, this research which was conveying a significant difference in mean Vegetables score between the caries-free and ECC groups and between the caries-free and S-ECC groups, but logistic regression models showed it was an independent protective factor for S-ECC instead of ECC, indicating that S-ECC was significantly affected by vegetables intake with a stronger preventive effect than affected ECC. Vegetables are regarded to be of a protective role against caries for their fibrous nature and self-cleaning effects. Likewise, it stimulates saliva flow while chewing and meanwhile increases its acid-neutralizing power, which helps cleanse fermentable carbohydrates in the oral cavity (41, 42).

Children present with ECC or S-ECC had a higher mean Fruits score than children without caries. Still, the difference did not show statistical significance, which was inconsistent with the findings found by Zaki et al. (16), who concluded that caries experience was negatively associated with fruit intake. However, a few fruits, such as citrus fruits, are rich in organic acids (e.g., citric acids, malic acids, oxalic acids, and tartaric acids), which can decrease the saliva pH in the oral cavity, and excessive intake of such fruits may induce dental erosion and demineralization (11). In addition, the seasonal differences in the intake of fruits may also have an impact on the results.

Compared to the other two groups, children in the S-ECC group manifested the highest dairy intake, as demonstrated by their highest score, but the difference was not statistically significant. Although several studies have confirmed that milk and dairy products are abundant in nutrients, including proteins (e.g., casein and whey protein), minerals (e.g., calcium and phosphorus), and lipids (e.g., essential fatty acids and non-essential fatty acids) (43, 44), and yogurt and cheese also contain casein phosphopeptides (45, 46). *In vitro* demineralization/remineralization experiments also tend to indicate the low cariogenicity and potential caries-protective

roles of milk (43). However, a high percentage of commercial milk and dairy products contain sucrose and flavoring to upgrade and enrich the odor and taste of the products, which complicates the interpretation of research into cariogenicity. Moreover, yogurt and cheese are relatively viscous foods, which can provide a substrate for bacteria and may raise a higher risk of caries when the products containing more sucrose or flavoring are consumed without cleaning the teeth promptly.

In this study, children who did not present with caries had the highest Food diversity score than children diagnosed with ECC and S-ECC. Meanwhile, logistic regression models revealed that children with a higher degree of food diversity were less likely to suffer from caries. Food diversity has been confirmed to be positively related to dietary micronutrient intake (29), and it was considered an indicator of great value for the prediction of macronutrient or micronutrient adequacy in children (30, 47). However, If a child has a poorly balanced diet, deficiencies in calcium, iron, albumin, vitamin D, and protein-energy malnutrition may induce enamel hypoplasia/hypomineralization, roughening the enamel surface and prone to plaque accumulation, with can lead to post-eruptive caries (32, 48–50). A balanced diet with various foods is quite essential for young children as most micronutrients are derived from the daily diet.

Image-based methods offer a more comprehensive range of viable options for dietary assessment, which is easier to incorporate into participants' daily lives. Furthermore, it can instantly record the diet consumed by an individual without relying on memory for input, which has the advantage of being fast, more efficient, and more precise compared to traditional methods. Several meaningful and valuable results were obtained, but some limitations should be noted. First and foremost, in this cross-sectional study, the findings only can reflect associations and cannot establish a causal relationship. Secondly, the limited sample size included in this study is due to time factors. Thirdly, DBI_C is a scale based on food group indicators and cannot assess the specific nutrient intake of children and thereby cannot analyze the association between ECC and nutrients. Finally, the image-based method relies on images to assess food intake. And the complex and diverse food cultures make the Chinese diet one of the most complex dietary systems worldwide. In the case of some unlisted food varieties, it cannot be identified or analyzed.

Conclusion

Dietary imbalance is a serious health problem faced by this study sample. Both ECC and S-ECC were associated with a high degree of dietary imbalance and grains intake as well as a low degree of food diversity among Chinese children aged 2–5 years. Moreover, S-ECC was also associated with a low degree of vegetable intake. Nevertheless, large-scale prospective research is needed to validate these findings and to offer more information about the underlying causality and mechanism.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Ethics Committee of Dental Hospital, Hebei Medical University, in Shijiazhuang, China (Ethics approval code: [2018]028). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

HS conceived and designed the study. ZM, XL, ML, and CZ trained the data collectors. XW, ML, ZM, and CZ analyzed and reconciled the data. XW and FC drafted the first draft of the manuscript. HS reviewed and modified it to the final version. All authors contributed to manuscript revision, read, and approved the submitted version.

Funding

This research was supported by the Hebei Provincial Department of Finance: Government-funded specialty competence Building and Professional leader Training (Professional leader) (Grant No: 0300000062), the Project funded by the Hebei Provincial Department of Finance: Study on the Correlation of Caries Activity and Dietary Nutrition among Younger Children (Grant No: 361029). The funders did not influence any stage of this study.

Acknowledgments

We extend our gratitude to all the participants, coordinators, and administrators for their support and assistance during the study. In addition, we acknowledge the contribution of Ms. Xiaolin Zhang in collecting and analyzing data for this research. The first draft of this article was deposited on the preprint servers (51) on April 7, 2022. Link to original article: https://doi.org/10.21203/rs.3.rs-1503777/v1.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.974419/full#supplementary-material

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frontiers | Frontiers in Public Health

TYPE Policy Brief
PUBLISHED 28 September 2022
DOI 10.3389/fpubh.2022.984668

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Education and Promotion, a section of the journal Frontiers in Public Health

RECEIVED 02 July 2022
ACCEPTED 07 September 2022
PUBLISHED 28 September 2022

CITATION
Amalia R, Siregar FR, Alfian MF and Sandy LPA (2022) Regulations on nutrition in Indonesia and its relation to early childhood caries. *Front. Public Health* 10:984668. doi: 10.3389/fpubh.2022.984668

Regulations on nutrition in Indonesia and its relation to early childhood caries

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There is a close relationship between food and nutrition policies and oral health. The relationship between nutrition and dental problems has been widely discussed, including the major dental problem in children: early childhood caries (ECC). Health-oriented national policies are the main principles of public health welfare. This article is a policy brief that provide a review of the food and nutrition policies in Indonesia that may have a relationship with ECC. It is concluded that some policies support the efforts to prevent ECC however, other technical explanations are still needed for health workers and especially parents regarding its simple implementation in everyday life. Multisectoral approaches that includes health, nutrition and education are needed to address ECC.

KEYWORDS

nutrition, ECC, children, Indonesia, policy

Introduction

Early childhood caries (ECC) is the most common chronic infectious disease in children aged <71 months. The World Health Organization (WHO) has represented the ECC as a global problem since the prevalence is increasing rapidly in low and middle-income countries and particularly frequent or severe among children living in deprived communities (1). ECC occurs due to the demineralization of teeth caused by acids from dietary sugars metabolized by oral bacterial strains (1). Other risk factors are prolonged bottle feeding, frequent snacking and consumption of sugary drinks, inadequate tooth brushing, and lack fluoride and dental care (2). There was a significant association between ECC and malnutrition; a two-way relationship is postulated; malnutrition affects the occurrence of caries, and caries affects the occurrence of malnutrition in children (3, 4). Based on the 2018 Indonesia's Basic Health Research report, the prevalence of caries in primary teeth in children aged 3–4 is 81.5%, and aged 5 years is 90.2% (5).

Evidence suggests that food and nutrition which play a role in the growth and development of children also have impacts on the occurrence of ECC eventually (2). Thus, this policy brief offers a review of the opportunities in the existence of the food and nutrition policies to prevent and control early childhood caries (ECC) in Indonesia and discusses actions for decisions makers to decrease the prevalence of ECC through effective regulations.

Sections on policy options and implications

Existing foods and nutritions policy in Indonesia that potentially has a role in preventing and controlling ECC

Indonesia is the largest archipelagic country in the world and the most populous nation in Southeast Asia (6). Indonesia is a middle-income country with positive trends in economic growth, life expectancy, and increased food security from year to year (7). The Indonesian diet highly depends on one staple food (rice) and low meat and fat consumption, while consumption of food sources of fruit and vegetables is only half of the recommended daily intake and decreases over time (8). The following are six food and nutrition policies in Indonesia which have aim to ensure the growth and development and as well healthy eating of the children and considered have the potential to support ECC prevention efforts.

Ministerial Regulation on Health no. 51 of 2016 concerning nutritional supplementation product standards

The Nutritional Supplementation Policy aims to achieve nutritional adequacy for infants, toddlers, school-age children, women of childbearing age, pregnant women, and postpartum mothers as a vulnerable group (9). Nutritional supplementation is the addition of food or nutritional substances that are given in the form of additional food, basic added tablets, vitamin A capsules, and nutritional powder. Every nutritional supplementation product circulating in Indonesia must meet standards, including those regarding content, food additives, microbial and heavy metal contamination, processing, and package labeling. Nutritional fortification for children under the age of 5 contains at least 12 vitamins and four minerals: Vitamins A, B1, B2, B3, B6, B12, C, D3, E, and K1, folate, pantothenic acid, Iodine, iron, zinc, selenium, and maltodextrin.

This Regulation has a potential role in ECC prevention since several nutrients, including calcium, fluorine, phosphorus, vitamin A and vitamin D, have a significant function in the formation of tooth morphology, chemical composition, and tooth eruption pattern (10). A lack of these nutrients since maternal period can affect the resistance of teeth to caries. Increased maternal vitamin D and calcium intake reduce the risk of early childhood caries (10, 11).

Ministerial Regulation on Health no. 30 of 2013 concerning inclusion of information on sugar, salt, and fat content and health messages for processed foods and ready-to-eat foods

This policy aims to reduce the risk of non-communicable diseases, such as hypertension, stroke, diabetes, and heart attacks caused by excessive sugar, salt, and fat intake in processed or ready-to-eat foods (12). The sugar, salt, and fat content in question is the total sugar content, both monosaccharides, and disaccharides, total sodium in the form of mineral compounds with the main elements sodium and chloride, and total fat, namely the content of fatty acids expressed as triglycerides. Thus, the health message is that consuming more than 50 grams of sugar, more than 2,000 milligrams of sodium, or more than 67 grams of total fat per person per day places an individual at risk of non-communicable disease and keeps healthy. Concerning ECC, information on sugar content is very important since continuous consumption of high sugary foods and beverages, and lack of adequate fluoride levels can accelerate the occurrence of ECC (13). Consumption of cariogenic products more than three times per day, sweets more than once per week, and higher rates of soda pop increase the severity of dental caries in children (14).

Ministerial Regulation on Health no. 41 of 2014 concerning guidelines for balanced nutrition

This policy is intended to provide guidelines for daily food consumption and healthy behavior, including for children (15). This policy describes two visuals used to depict balanced nutrition: the balanced nutrition pyramid and my meal plate. The Balanced Nutrition Pyramide (BNP) has four successive layers from the bottom to the top; the layers grow smaller as one goes up the cone. Four layers mean that BNP is based on the principle of four pillars, namely:

a. Consumption of various foods in a balanced proportion and sufficient (not excessive) quantities that are carried out regularly.
b. Physical activity to balance the expenditure and intake of nutrients, which are the main body's energy resource.
c. Getting used to clean living behavior refers to maintaining cleanliness to avoid infectious diseases.
d. Monitoring indicators of the balance of nutrients in the body, known as body mass index (BMI).

These balanced nutrition guidelines are presented as a visual picture of a balanced nutrition pyramid that serves as a guide for daily consumption. Sugar, salt, and fat are found in the highest position on the pyramid, indicating that consumption of these foods should be limited to small quantities. For each food group, the recommended number of servings is written.

Concerning ECC, this Regulation can be a guide to keeping children's BMI at normal status. Research shows

that a BMI above or below normal is associated with caries (16). Consumption of various foods, especially fruits and vegetables, can also prevent caries. The guidelines for clean and healthy living in BNP are also important to be part of the ECC prevention measures. Since dental caries is a multifactorial disease, Toothbrushing is a fundamental self-care behavior for maintaining children's oral health (17).

Ministerial Regulation on Health no. 28 of 2019 concerning the recommended nutritional adequacy rate for the Indonesian people

The nutritional adequacy rate or recommended dietary allowance (RDA) is a value that indicates the average need for specific nutrients that must be met every day to maintain a healthy life for all people according to age group, gender, level of physical activity, and physiological conditions. RDA is used at the level of consumption, which includes adequate calories, protein, fat, carbohydrates, fiber, water, vitamins, and minerals. The average consumption level is 2,100 kcal daily to achieve optimal health status (18). The RDA is beneficial as a reference for nutritional labels, establishing balanced nutrition guidelines, and developing a quality index of food consumption which is also beneficial to become a guideline for parents. It will encourage parents to understand the composition of nutrients and identify which elements have the potential contributing factors to ECC.

Ministerial Regulation on Health no. 29 of 2019 concerning nutritional management in children with disease-related malnutrition

The central government and local governments are responsible for the implementation of countermeasures to nutritional problems for children due to disease in an integrated and sustainable manner. Diseases, as referred to in this Regulation, include diseases that cause children to be at risk of failure to grow, like malnutrition or congenital metabolic disorders (19). Handling cases is carried out by a team of health workers who each have competence in medicine, nutrition, midwifery, and nursing at a Community Health center or hospital and is carried out through diagnosis of causes and appropriate management of nutritional problems. Regarding ECC, this Regulation is a guide to preventing stunting conditions, which have a significant relationship with the incidence of ECC. Children who need nutritional status improvement will get special medical attention from a medical team that also has a potential role in implementing ECC preventive measures.

Regulation of the President of the Republic of Indonesia number 83 of 2017 concerning strategic food and nutrition policy

The implementation of strategic food and nutrition policies aims to improve the nutritional status of Indonesians (20). Efforts to improve community nutrition include: (a) promotion of and education about nutrition for the general public, (b) providing nutritional supplementation, (c) addressing health services and nutrition problems, (d) facilitating community empowerment in the field of food and nutrition, (e) providing social security that supports the improvement of food and nutrition and (f) implementing early childhood education programs. Coordination of food and nutrition development includes food and nutrition planning, strengthening of cross-sectoral roles, strengthening of civil registration in improving nutrition, involvement of stakeholders, and monitoring and evaluation. Nutritional status improvement targets selected groups such as pregnant women, babies, children under 5 years, low-income groups, and people with certain health risks. Healthy food promotion for personal consumption is an important part of community involvement to maintain the population's health, including preventing ECC indirectly.

Current situation challenges

Studies have found a link between a child's malnutrition AL status and ECC. The stunting and underweight rate in Indonesia is 24.4 and 17.0% for children under the age of five mostly come from low-income families; moreover, the prevalence of obesity is found in 3.8 % of children and is more common in children from wealthy families (21). This condition illustrates the incidence of malnutrition in all socioeconomic groups in Indonesia. Studies in Indonesia and other Asian countries showed that the status of dental caries and odontogenic infections in primary teeth was most common in underweight children and children with stunting (22). One study showed that in primary dentition, dental caries was significantly and inversely related to weight-for-age, height-for-age, and BMI-for-age (23). Obese children are more prone to dental caries (24). A sedentary lifestyle in obese children tends to encourage consuming snacks between meals, which can lead to caries (25).

One challenging condition is the Indonesian people's diet pattern, which is high in carbohydrates (5). Carbohydrates are mostly consumed in the form of rice, which has a fairly large Glycaemic Index (GI) content (5). One study showed that foods with a higher GI might increase the risk of dental caries (26). Another challenge is the increasing rate of high sugar food and beverages consumed by children in recent years in Indonesia (27). The high frequency of sugar intake is a risk factor for the onset of caries in early childhood. This situation may be complicated since the children's dietary patterns are strongly influenced by mothers and other primary caregivers,

whose consumed, and preferred foods are based on cultural and societal influence.

Discussion

The food and nutrition policies implemented in Indonesia are expected to impact ECC prevention positively. One important nutrient responsible for the increasing prevalence of ECC is excessive consumption (quantity or frequency) of sugar (sucrose) (28). Thus, it is interesting that Ministerial Regulation on Health No. 30/ 2013 concerning the Inclusion of Information on Sugar, Salt, and Fat for Processed and Fast Foods states: 'The recommended sugar consumption per person per day is 10% of total energy (200 kcal) or the equivalent of 4 tablespoons/person/day or 50 grams/person/day). This recommendation is in line with the result of a systematic review, which showed that the group that consumed sugar <10% of the total energy needed had a lower prevalence of caries than the group that consumed sugar >10% of the total energy needed (29). It shows that Ministerial Regulation on Health No. 30 of 2013 provides a warning for the community that is in line with controlling the incidence of ECC.

Ministerial Regulation on Health No. 41 of 2014 concerning Guidelines for Balanced Nutrition provides recommendations for the number of servings according to adequate caloric intake levels for various age groups. Unfortunately, there is not enough information about the right amount (units in grams) of food (especially sugar) that children should consume on a daily basis. The explanation of the measured weight is very important, especially for a child's mother/caregiver, because the recommended amount of sugar consumed by children every day (in grams) will impact the incidence of ECC (30). Thus, there needs to be a more concrete rule regarding the exact size and frequency of consuming sugar instead of only focusing on portions.

Moreover, the policies implemented in Indonesia are currently limited to only providing information on the sugar content in foods and beverages sold commercially, not directly regulating restrictions on consumption. Many people find it challenging to decrease their sugar intake on a voluntary basis. Restricting the sugar added to food and beverages sold commercially should become the efforts enacted to prevent caries in children (31). Research conducted in Indonesia shows that some beverages, such as energy drinks and carbonated drinks sold in the country, are high in sugar (27). It is such a concern that the rush of attractive advertisements and aggressive sales models for junk food targeting children causes them to be attracted to that type of food and want to consume it.

Ministerial Regulation on Health No. 28 of 2019 concerning the recommended nutritional adequacy rate for Indonesians must be presented in a simple and easy-to-understand way to meet the children's daily nutritional adequacy rate. It will be very useful for mothers or caregivers and help them identify the right foods and beverages that are good for their children. It is not wise to just let parents focus on how to meet the nutritional needs of children by only informing them about the standards of nutritional adequacy while ignoring the skills they need to choose enjoyable and healthy foods. Combining carbohydrate intake with the consumption of vegetables and fruits is crucial since studies showed that increasing the intake of fibrous foods can produce saliva, which has protective properties against ECC (32).

The Presidential Regulation of the Republic of Indonesia Number 83 of 2017 concerning Strategic Food and Nutrition Policy and Ministerial Regulation on Health No. 29 of 2019 concerning the management of nutrition problems for children due to disease may become the ultimate Regulation on strengthening community empowerment in the field of food and nutrition for having a significant role in preventing ECC. Since health promotion programs and early childhood education have become important strategies, health workers must actively provide consultation on nutrition and good feeding practices for children in the community to prevent ECC. This kind of intervention has significantly reduced the incidence and severity of caries in 4-year-olds in low-income communities (23). Another effort could be to implement a policy of providing healthy food every day in preschools, which can be a model for introducing good food to children and successfully lowering the caries status of children, like in a study in Auckland (33).

It is concluded that since national health programs vary widely in mission, policies related to ECC are not specifically mentioned or discussed in those documents. However, some potential contents of the existing regulations may encourage efforts to prevent ECC.

Actionable recommendations

1. A more detailed explanation regarding sugar intake restrictions for children in Indonesia is needed. For instance, in the Regulation concerning Guidelines for Balanced Nutrition, there is no detailed explanation on how much the right amount of sugar for a group of children (units in grams) in 1 day. The content contained in the Regulation only describes the size of the number of servings. It is important to set rules for limiting sugar intake based on age to become a guide for parents when choosing safe and healthy foods for children and, further, may control the incidence of Early Childhood Caries (ECC).

2. Guidelines for child feeding practice need to be emphasized more on information related to nutritional adequacy rates in each age group. A guideline is needed for parents to implement good eating patterns for their children, which can avoid the risk of Early Childhood Caries (ECC).

3. Includes Healthy Diet education to prevent ECC, particularly for pre-schoolers' parents/caregivers. Thus, it

is hoped that parents or caregivers have more skills in implementing healthy eating parenting patterns for children. Parents also can teach their children to choose healthy snacks and have an impact on reducing the prevalence of ECC.

4. Since high sugar consumption and obesity is the crucial risk factor for ECC, there must be strict supervision and sanctions for the company that sells food and beverage exceeding the maximum standard amounts of sugar, salt, and fat. In addition, there should be coordination in the trade sector, food system, and agricultural policy to protect children's health.

5. Professionals Training for dental health workers to improve skills in providing nutrition education in a dental clinic setting or the community is needed. Dental health workers should provide accurate information about nutrition's influence on ECC occurrence and information related to current nutritional regulations. However, multisectoral approaches that includes health, nutrition and education are needed to address ECC.

It is hoped that the above recommendation efforts to implement policies related to food and nutrition in Indonesia will complement efforts to improve children's dental health, namely to reduce the prevalence of ECC.

Author contributions

RA came up with the initial concept for the manuscript, produced the preliminary draft, and revised it. According to their areas of competence, FS, MA, and LA added materials. All authors gave the manuscript a close reading to assess its intellectual quality. All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors thank Prof. Al. Supartinah from the Pediatric Dentistry Department, Universitas Gadjah Mada and Dr. Iwan Dewanto, former Vice Secretary General of Indonesia Dental Association, for their insightful comments and suggestions.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Public Health

TYPE Policy and Practice Reviews
PUBLISHED 18 October 2022
DOI 10.3389/fpubh.2022.931243

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Public Health Policy, a section of the journal Frontiers in Public Health

RECEIVED 28 April 2022
ACCEPTED 20 September 2022
PUBLISHED 18 October 2022

CITATION
Saikia A, Aarthi J, Muthu MS, Patil SS, Anthonappa RP, Walia T, Shahwan M, Mossey P and Dominguez M (2022) Sustainable development goals and ending ECC as a public health crisis. *Front. Public Health* 10:931243. doi: 10.3389/fpubh.2022.931243

Sustainable development goals and ending ECC as a public health crisis

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Early Childhood Caries (ECC) remains a global issue despite numerous advancements in research and interventional approaches. Nearly, 530 million children suffer from untreated dental caries of primary teeth. The consequences of such untreated dental caries not only limit the child's chewing and eating abilities but also, significantly impact the child's overall growth. Research has demonstrated that ECC is associated with nearly 123 risk factors. ECC has also been associated with local pain, infections, abscesses, and sleep pattern. Furthermore, it can affect the child's emotional status and decrease their ability to learn or perform their usual activities. In high-income countries, dental care continues to endorse a "current treatment-based approach" that involves high-technology, interventionist, and specialized approaches. While such approaches provide immediate benefit at an individual level, it fails to intercept the underlying causes of the disease at large. In low-income and middle-income countries (LMICs), the "current treatment approach" often remains limited, unaffordable, and unsuitable for the majority of the population. Rather, dentistry needs to focus on "sustainable goals" and integrate dental care with the mainstream healthcare system and primary care services. Dental care systems should promote "early first dental visits," when the child is 1 year of age or when the first tooth arrives. The serious shortages of appropriately trained oral healthcare personnel in certain regions of the world, lack of appropriate technologies and isolation of oral health services from the health system, and limited adoption of prevention and oral health promotion can pose as critical barriers. The oral health care systems must focus on three major keystones to combat the burden of ECC—1. Essential oral health services are integrated into healthcare in every country ensuring the availability of appropriate healthcare accessible and available globally, 2. Integrating oral and general healthcare to effectively prevent and manage oral disease and improve oral health, 3. Collaborating with a wide range of health workers to deliver sustainable oral health care tailored to cater to the oral health care needs of local communities.

KEYWORDS

SDG, early childhood caries, oral health, sustained anticipatory guidance, child health, healthcare workers, infant oral care, first dental visit

Introduction

The Sustainable Development Goals (SDGs) framework, first launched in 2015 during the UN General Assembly, includes 17 universal goals and 169 targets, while the sustainable development agendas are envisioned to be accomplished by 2030 (1). Of these SDGs, the health goal (SDG3) is to focus on good health and well-being (1, 2). World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." Good oral health is complementary to good general health. Approximately 3.5 billion people worldwide are affected by oral disease, of whom 530 million are children (3). However, despite its high prevalence, oral health remains primarily neglected and is neither included under Universal Health Coverage (UHC) of global health (4), nor mentioned in SDG3. Similarly, chronic diseases are the leading cause of hospitalization, accounting for nearly 46% of the global disease burden (5, 6). Moreover, the evolving landscape of chronic diseases and their co-existing risk factors levitate each other, thus sparking global concern (6–8). It is to be noted that dental caries remains the most common chronic disease of humans (9).

Early Childhood Caries (ECC) is a common chronic disease of childhood (10), and its prevalence is five times higher than asthma and seven times more than hay fever (11, 12). ECC disproportionally affects the economically deprived families and vulnerable population groups (13). Limited infrastructure, inadequate workforce, and significant barriers to dental care are social determinants related to poor oral health (14, 15), resulting in millions of children with untreated caries (16). Subsequently, the negative consequences, namely, pain, infections, abscesses, disturbed sleep and eating patterns, loss of school days, reduced activity, visits to the emergency departments, and hospitalisations, significantly impair the child's and their family's overall health-related quality of life (9, 17). Moreover, poor dental health in childhood frequently results in poor dental health in adulthood (10, 17, 18).

Despite ECC being largely preventable, its increasing prevalence continues to raise concern. The coinciding inequalities in oral health, both within and between countries, high cost of dental treatment and competing health priorities with available resources to address are policy makers' concerns (19). Moreover, in many world regions, the uneven distribution of oral healthcare personnel and a lack of coherent stakeholders and policymakers are barriers to implementing preventive approaches (10, 11, 15). Therefore, population-wide strategies with sustainable maneuvers are critical to evaluating practical, sustainable approaches to reduce the ECC burden globally. Nevertheless, no policy/recommendations emphasize on SDGs of ECC and their targets. Hence, this paper highlights three significant strategies to combat the burden of ECC, namely. (i) Integration of oral health services into primary health care centers (ii) amalgamating oral and general healthcare for better patient care and (iii) Multidisciplinary approach collaborating with wide range of health care workers.

Methods

A PubMed and google scholar search was conducted using the following keywords: ECC, Sustainable Developmental Goals, SDG, Oral Health and Policy, fields: all; without limits on the year of publication. Additionally, websites of the World Health Organization (WHO), FDI and National Immunization Schedules (NIS) were reviewed.

Integration of oral health services into primary health care centers

Primary Health Care (PHC) is an all-inclusive society approach toward health and well-being. It focuses on people's needs along with continued health promotion, disease prevention, treatment, rehabilitation and palliative care in concordance with people's day-to-day environment (20, 21). The vision of PHC is to achieve Universal Health Coverage (UHC) and SDGs. The various determinants of health and interlinked aspects of physical, mental and social health, well-being are addressed by PHC. This indicates the necessity of a comprehensive PHC workforce which works in multitudinal directions (22) including oral health.

Integrating immunization schedule with early dental visits

In order to achieve the SDG target of early diagnosis, it is imperative to work in concordance with medical personnel and integrate oral health monitoring at each stage of primary tooth eruption with immunization schedule. Most governing bodies of children such as AAPD, the American Academy of Pediatrics (AAP), American Dental Association (ADA) recommend the children to have their first dental visit within 1 year of their life (23). Unfortunately, oral health is not part of pediatric primary healthcare (22, 23), and efforts for unification are often a low priority (24, 25), causing oral health disparities in children. Therefore, inter professional collaborative efforts among health professionals are critical for ECC prevention. Furthermore, such initiatives will address this public health crisis by ensuring all infants and toddlers to have access to dental screenings that are synchronized with vaccination schedules, and allow age appropriate counseling, and preventive procedures (24). Establishing an integrated periodic dental screening in line with immunization schedule could be instrumental in implementing the first dental visit by year one or as soon as the first tooth erupts into the oral cavity (Table 1).

TABLE 1 Integrating vaccination schedule with eruption of various primary teeth.

WHO immunization schedule	Vaccination schedule (NIS, India)	Teeth to be screened	Implementation of SDG Target
9 or 12 months	9–12 Months	Lower central incisor	First dental visit
Measles, rubeola/	Measles, rubeola, PCV Booster	Upper central and lateral incisor	SAG
9–18 months			Oral health education to parents
Td/DT containing vaccine			Early diagnosis of enamel defects for
Pneumococcal conjugate booster			White Spot Lesions (WSL).
12–23 months	16–24 months Measles and Rubeola—2,	Lower lateral incisor, upper and lower	Fluoride varnish
DTP booster	DPT, OPV	first molar, upper and lower canine	Oral health education to parents
			Early diagnosis of enamel defects
			for WSL.
		Second molar screening	Seal deep fissures
			Early diagnosis of enamel defects

Early diagnosis is the key

One of the primary ways to achieve the SDG3 on health indirectly relies on early diagnosis of the disease entities. Hence efforts to diagnose ECC early becomes a priority. Enamel hypoplasia or Enamel defects (EH/ED) emerging as the primary risk factor for ECC, permits a window of opportunity to diagnose them as soon as the tooth erupts into the oral cavity. Early diagnosis or identification of these changes on the enamel surface and timely interventions plays a significant role in successful management of ECC (15). With early diagnosis and minimally invasive treatment approaches, it is now possible to remineralize (with fluoride varnishes) or stabilize the carious lesions [with silver diamine fluoride (SDF)] (20–22). Therefore, awareness of oral health and hygiene practices, including early dental visits, are critical for preventing negative consequences of ECC.

Dissemination of the recent evidence on EH/ED being the primary risk factor for ECC needs to be disseminated widely to the dental, medical and primary health care workers. Simple screening and drying the tooth surface soon after its eruption will help the health care workers to identify the earliest changes of ECC. This also raises a need to create self-reporting tools useful for the parents/caretakers to identify these early changes on the enamel.

MAAAC charts

The MAAAC charts are a series of charts developed at the "Center for Early Childhood Caries Research (CECCRe)" to educate primary health care providers, parents, and caretakers. These charts illustrate the various early patterns of enamel defects (demarcated and diffuse opacities on various maxillary teeth) as a collage of pictures organized as incisors and canines. Thus, these charts can be practical, accessible tools for primary healthcare workers to match and report the early signs of ECC [MAAAC charts for self-diagnosis of early signs of ECC, unpublished data]. The preliminary results have been very encouraging as the parents could identify, the earliest changes on the enamel and report to the dental team soon after the tooth erupts into the oral cavity. Following either self-reports or early diagnosis by the health care team, there is a need for further guidance on handling these early changes.

Sustained anticipatory guidance (SAG)

Delivering cost-effective sustained interventions at an early age can also be effective in preventing ECC, the principle being termed as sustained anticipatory guidance (SAG) (26). SAG can be defined as periodic or continuous guidance/support provided by the health care workers or health care professionals, to the caretakers by education, and technology thereby facilitating early diagnosis, improved oral hygiene practices, and initiate early intervention protocols if needed. SAG was first tested in a small cohort of cleft children and reported promising results (27). SAG involved the following steps: early recruitment of the participants, motivational interviewing (MI) of primary caregivers, oral health education by audio visual aids and demonstration, providing oral hygiene aids in the form of sterile gauze pieces packed in color coded envelopes for wiping the gums of children, reinforcing the same with pictorial representation on the envelopes, providing finger toothbrush and non-fluoridated toothpaste after the eruption of the first tooth and confirming the same *via* telephone calls, SMS or follow-up visits, continuous monitoring and evaluation with application of fluoride varnish wherever necessary (effect of sustained interventions). This type of sustained interventions with periodic follow up and reinforcement could therefore be highly effective in early diagnosis and prevention of ECC (27).

Preventive strategies

Management of ECC involves prevention, remineralization and arrest of carious lesions (14). These can be achieved by use of various minimally invasive techniques. Less technique sensitive procedures are now possible due to the emergence of newer materials (10, 26, 28–33). These techniques are less invasive, surpassing the use of local anesthetic agents and are hence child-friendly. Thus, application of fluoride varnish, silver diamine fluoride (SDF) and glass ionomer sealants can be carried out by primary care teams (15, 30).

Awareness among parents and caregivers

Early intervention protocols for ECC can allow precise, easy instructions for parents and caretakers. These protocols could be followed in early infancy with few erupted teeth showing signs of non cavitated lesions (in the forms of a line or a patch on one or more tooth surfaces) and minimal or early-stage cavitation of one or more surfaces. During the first consultation, the clinical appearance of the white spot lesions and the role of plaque in the demineralization of tooth surfaces are explained to the parents. If appropriate preventive measures are not taken, the possibility of developing a full-blown ECC is also put forward to them. The consequences of severe ECC are described to them with the possibility of an intervention in the hospital under general anesthesia. Counseling regarding diet, oral hygiene measures, fluoride adequacy and the need for frequent recall to monitor the progress of the ECC is also elucidated.

Regarding diet, the importance of frequency of refined carbohydrates intake is enumerated, and the need to clean the infant's teeth after every meal or intake is stressed. The need for assistance in performing oral hygiene measures (mother or father brushing the child's teeth) is emphasized. In the presence of EH/ED, fluoride varnish applications (fluorprotector) are recommended 2–4 times in 2 months interval. If the parents take appropriate care and the professional advice is followed meticulously, ECC can be arrested at an early stage. Periodic application of fluoride varnish has been proven to aid in preventing the development of new lesions and in remineralization of white spot lesions (26, 29, 31) (Table 2).

TABLE 2 SDG targets of ECC and their implementation.

SDG Target	Implementation of SDG Targets
Prevention of ECC	First dental visit
	Sustained anticipatory guidance (SAG)
	Early interventions
	Prenatal oral health care
	Parental education
	sealants
Remineralization of White Spot	Fluoride varnish
Lesions	Early interventions protocol
Arrest of caries lesions	Silver diamine fluoride
	ART

Health education and community engagement for the prevention of early childhood caries

It is crucial to analyze the reasons for unfavorable behaviors, such as poor oral hygiene and intake of free sugars, which are deemed primary risk factors of ECC (14). Socially disadvantaged people, such as those with low socioeconomic status and belonging to ethnic minorities, have higher rates of ECC (34). AAPD thus addresses and emphasizes the role of social determinants in poor oral health in children (35). Social Determinants of Health (SDH) are defined by the World Health Organization as "the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life" (34). Thus, SDH works on improving social conditions to envision enhanced health outcomes in vulnerable populations (35). The multi-level conceptual model by Fisher-Owens demonstrates the various biological, social and environmental factors that influence the child's oral health (36). These factors highlight the need for health education and community engagement in preventing early childhood caries and thus improving children's oral health. Since a child's chief source of learning about health lies with the family (37, 38), it is prudent to create oral health awareness and increase the mindfulness about prevention of ECC among parents. Dental health education of mothers through home visits was reported to positively impact their children, resulting in better oral health for the Latter (39). Oral health education delivered to pregnant women also had a beneficial outcome on ECC prevention (40). Apart from the family-level influences, it is also necessary to address the community-level influences, such as caregivers and nursery staff at kindergarten school, health personnel who have a significant role in impact on the health of young children (14). They may be instrumental in carrying out preventive strategies for ECC, such as imparting healthy diet habits, encouraging proper tooth brushing and promoting fluoride administration (41, 42). The use of fluorides for children and oral health education for teachers and children was associated with reducing dental caries (39). Thus, preschool teachers must understand health and risk factors (43). The policies and interventions thus drafted should be inclusive of the SDH. Another importance of reaching the public is through the way of mass communication. This could be achieved by using media (television and radio), books, pamphlets, flyers, posters, emails, and SMSs to improve parental and caregiver knowledge of child oral health (44). A schematic framework has been outlined in Figure 1.

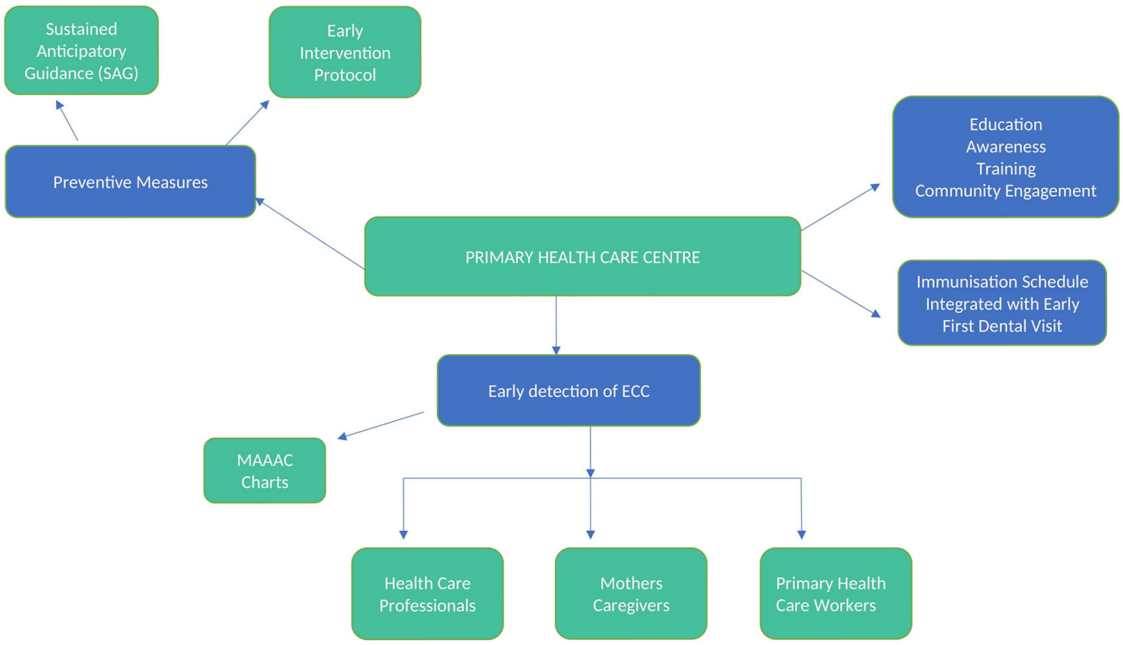

FIGURE 1
Illustrates possible integration of oral health services into primary health care centers.

Amalgamating oral and general health for better patient care

Bridging the gap between oral and general health

In 2011, the UN Political Declaration on Prevention and Control of NCDs first recognized oral diseases as a significant health burden (45, 46). This declaration was the turning point and a step forward for NCD and the oral health community in recognizing oral health and general health as one (45, 46). The WHO then advocated, Health in all Policies (HiAP) as an essential strategy that supports health in all policies. As evidence affirms common risk factors between oral diseases and NCDs, including oral health to HiAP approaches become inevitable. The FDI Vision 2020: Shaping the future of oral health at the FDI World Dental Congress (WDC) in Hong Kong, China is a marked shift in FDI's focus from a treatment-based approach to a rights-based approach to what oral health is. This publication highlights oral health as an integral component of good health. In 2020, the Member State and recommendations of the board's office and its Director-General recommended the inclusion of oral health into the 2030 Agendas (47).

The next question to consider is, "How do we bridge this gap between oral and general health?" There may be an implicit number of theories and visions from various experts on how oral and general health can be integrated, but the translation of theories to practice is critical. Furthermore, this translation requires a deeper understanding of healthcare professionals of how oral health is a part of general health. This is also essential for advocacy purposes. Therefore, the next logical question is whether it is possible to deliver a clear, precise explanation of oral health that will foster communication and support broader advocacy efforts between general health and oral health key personnel. A group of 22 experts, including the FDI-International Consortium for Health Outcomes Measurement (ICHOM) team, focused on producing a tool for measuring oral health. The team identified the key domains that fit under the physiological and psychosocial dimensions of oral health based on a series of Delphi-type consultations (Table 3). This tool can thus be an excellent example of how oral health related outcomes could be used to measure oral health related well-being, which can be linked to general well-being of an individual.

In 2016, FDI World Dental Congress in Poznan, Poland, proposed a definition of oral health as "multi-faceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow and convey a range of emotions through facial expressions with confidence and without pain, discomfort and disease of the craniofacial complex"(48, 49). Later, this definition was adopted by an overwhelming majority at FDI's General Assembly due to the three critical elements highlighted: disease and condition status, physiological

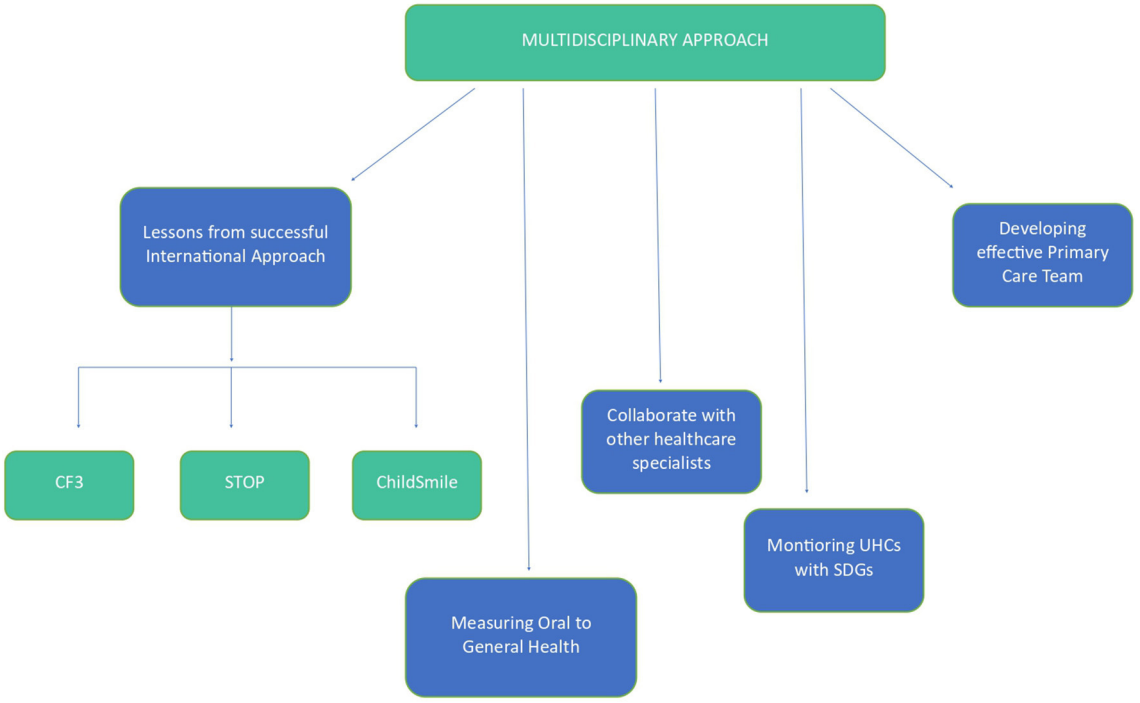

FIGURE 2
Possible Oral Health related linkage to 17 SDGs.

TABLE 3 The key domains for measuring the physiological and psychosocial dimensions of oral health.

Physiological	Psychosocial
Ability to eat	Overall patient satisfaction (consequential upon some physiological elements)
Chewing	Participation in life activities/social interactions
Food alteration	Emotional well-being (embarrassment/shame, anxiety/fear)
Pain-discomfort	Aesthetic satisfaction
Ability to sleep	Lost productivity
Speaking/phonetic impairment	Self-esteem, confidence

function, and psychosocial function. Therefore, the pre-eminent focus of the definition of oral health is the disease and condition status. A schematic framework of possible ways to integrate general health with oral health and the 17 sustainable development goals has been depicted in Figure 2. This framework comprises of various broad ideas and strategies. These need to be developed and customized for each country keeping in mind their demographics and cultural background.

Multidisciplinary approach collaborating with wide range of healthcare workers

Developing effective primary health care teams

Children aged under five or six years are more often seen by primary care teams and less often by oral health professionals in most countries for the purpose of for vaccinations or consultation for systemic health problems. Such primary care teams who are already trained to deliver a wide range of services (e.g., child immunization, family planning, health promotion) and to treat minor conditions and injuries, have the educational background and clinical skills needed to learn about oral health promotion and control of ECC. WHO's guidelines on health policy and system support optimize community health worker programmes (14). The WHO developed robust training programmes for community health workers to acquire core competencies like i., service promotion, ii. to identify family health, risk and social health iii. to integrate work activities and the role of community health workers, including referral for health care, iv. collaborative work within primary care teams, tracking patients, surveillance, monitoring of community diseases, data collection and analysis; v. providing psychosocial support; skills related to maintaining patient confidentiality, community engagement, mobilization and personal safety (14, 50).

FIGURE 3
Illustrates multidisciplinary approaches and possible collaboration with wide range of healthcare workers.

Xiao et al. in (51) reported that children whose mothers received prenatal oral health education had a reduced incidence of ECC. Educating pregnant mothers through their obstetricians can help women maintain good oral health and instill good oral hygiene practices and dietary behaviors (51, 52), which can be passed on to their children. Also, knowledge and awareness of ECC and its effect on general health should be emphasized to pediatricians who have routine access to infants and children (See Figures 3, 4).

Lessons from successful international approaches

Cavity Free at Three (CF3)

Cavity Free at Three (CF3) is a state-wide Oral Health Promotion (OHP) training program of Colorado (53) that was developed to teach medical and dental health care providers regarding oral examination, caries risk assessment, oral health instructions, dental referrals and Fluoride Varnish Application (FVA). This program proved to reduce the incidence of caries in children who received four or more FVAs by the age of 3 years

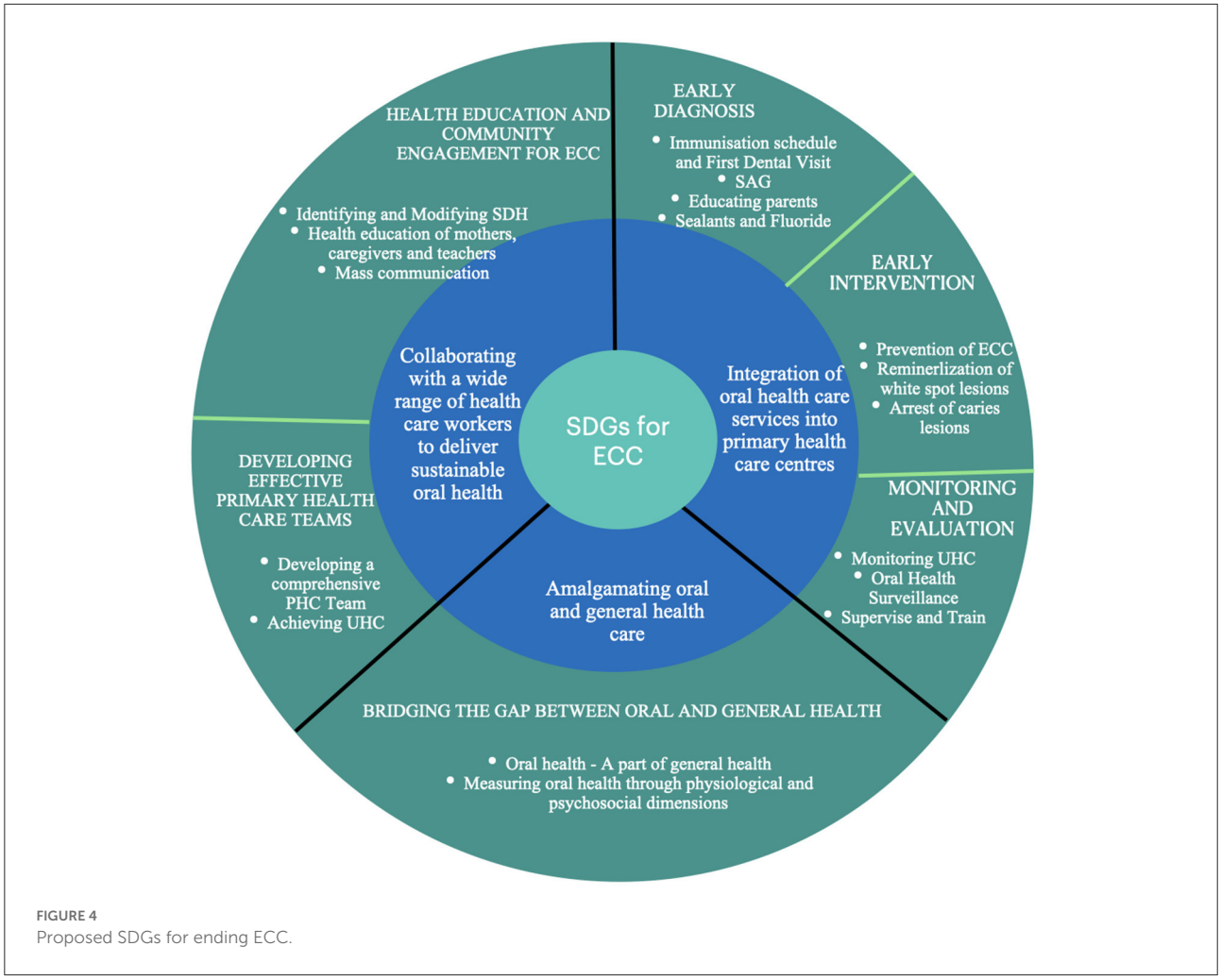

FIGURE 4
Proposed SDGs for ending ECC.

TABLE 4 Primary health care team.

PHC team member	SDG targets assigned
Gynecologists and Obstetricians	Prenatal oral health education
Pediatricians, Physicians and Cleft care teams	Early Diagnosis, Early Intervention, Oral Health Education
Nurses, mid-wives	Oral Health Promotion services like FVAs, Early Interventions
Kindergarden and preschool teachers, anganwadi workers and social workers	Oral Health Education, Regular dental visits

(53, 54). Similar results were reported by Pahel et al. using Into the Mouth of Babe (IMB) program in children who received at least four FVAs from medical providers (55).

Smile train oral health program (STOP)

In addition, Smile Train Oral Health Project or STOP was developed using the SAG principles. This was piloted and tested at the Center for Early Childhood Caries Research (CECCRe). Through this program, infants with cleft lip and/palate are recruited during their early visits for lip repair to the Smile Train unit. These babies with a cleft are then provided SAG to help them grow cavity-free [Smile Train Oral Heath Project (Ongoing project)]. The phase 1 of the project achieved 69.7% caries reduction (27). The phase 2 of the project is ongoing at this point of time with 70 plus children recruited into the program.ca.

Collaboration with other healthcare specialties

Adopting such programs to educate obstetricians, pediatricians, physicians, physician assistants, nurses, and medical assistants can be an effective method of preventing and early intervention of ECC. Thus, the PHC team should comprise medical and dental health care providers comprising obstetricians, pediatricians and physicians, cleft care teams, nurses, midwives, kindergarten and preschool teachers, and anganwadi (in India) and social workers (Table 4).

Monitoring universal oral health coverage across nations within SDGs

Oral health coverage is the goal that all people receive essential oral health services effectively and is central to the oral health-related targets of SDGs (37). The broader scope of SDGs is to ensure the availability of a wide range of services for oral health promotion, prevention, treatment, and care, including rehabilitation and palliation (2, 37, 56). The establishment of tracer indicators to represent overall oral health coverage of essential services is recommended (56). Integrated surveillance and monitoring of clinical evidence, community programs and impact evaluation are essential to advocate conceptions, fine-tuning and practical strategies (11). Despite numerous efforts from the World Health Organization, periodic monitoring and evaluation of regional oral health policies have not been adopted in many LMICs. Supporting approaches such as "supervise and train," which fosters flexibility in who does what, including remote supervision systems, must be integrated to achieve significant results (11, 56).

The WHO proposed, STEPwise approaches such as "WHO Oral Health Surveys Basic Methods" for oral health surveillance that could be adapted to local and national settings.

Step 1—involves assessment of oral conditions and risk factors by one's self, which in turn facilitates effective surveillance of ECC programs. The WHO Oral Health Surveys tool also facilitates the collection of information by self-reporting of dental caries, painful teeth, modifiable risk factors such as consumption of sugars and dietary patterns, oral hygiene, quality of life, and socioeconomic and environmental conditions. This tool reflects suitable core components of a questionnaire and allows self-interview. Similarly, the clarity of questionnaires has been designed for primary school teachers engaged in oral health education of young children (14).

Step 2—Clinical oral health data is collected in step 2. ECC Lesions are recorded using a WHO oral health assessment form. involves the collection of clinical oral health data. Step 2 also allows using photographs for caries assessment in countries with a shortage of oral health professionals. However, WHO insists on well-trained examiners to make reliable clinical judgements (11, 14).

Thus, it is peremptory that existing oral health promotional programs exclusive to ECC prevention are evaluated periodically. Furthermore, the involvement of preschool children in oral health surveillance programs globally and the use of mHealth applications such as "Smart Systems of Disease Management (SSDM)" can allow easy and systematic monitoring of SDGs (57).

Existing national approaches toward SDG and oral health

National-level health missions, infant immunization programs, and pregnant women's health programs carried out on a large scale in most countries, if integrated with Oral health/ECC and SDGs targets, can help achieve a more holistic coverage.

Scotland

Childsmile is a national program for the children of Scotland, developed to improve their oral health. This also targets to reduce the disparities in dental health and increase the access to dental services. As a result of this program, it has been reported that 60% children upto the age of 7 years have no noticeable decay. It has three main elements:

Childsmile practice

A tailored oral health advice and preventive services is provided to infants and children through Health Visitors / Public Health Nurses and Oral Health Support Workers after the child is registered.

Childsmile core

All children under this scheme receives 6 dental packs which includes toothbrush, toothpaste and fluoride toothpaste until 5 years.

Childsmile nursery and school

Children from poor communities are being offered additional fluoride varnish applications. This is provided by trained staff under NHS Highland's Salaried General Dental Service (58).

India

"Mission Indradhanush (MI) 4.0," a flagship scheme, intensified in 2022 and aims to achieve 95% of immunization coverage in children. This program conducts head count survey in all districts across the country for identifying children and pregnant mothers who may have been missed out in earlier surveys. This program also allows "Flexible session timings" and "On demand vaccination timings" to ensure better turn-out of community (59). Another scheme called "Universal Immunization Programme (UIP)" is one of the most extensive public health programmes targeting close to 2.67 crore newborns and 2.9 crore pregnant women annually (NHM) (51). Integration of early dental visits with such national schemes can escalate coverage to rural pockets across nations. We propose the integration of oral health and general health aligned with the SDGs. This approach will facilitate dialogue between oral and general health practitioners focusing on tailored SDGs integration.

An important initiative called Rashtriya Bal Swasthya Karyakram (RBSK) was introduced under Nation Rural Health Mission (NHM) which aims at early identification and intervention for children from birth through 18 years of age, who will be managed at the District Early Intervention Centers (DIEC). Although, dental conditions are included under the

RBSK scheme, the availability of pediatric dentists at DIECs remain sparse. Specific guidelines on early diagnosis and prevention of caries need to addressed in this scheme in future. The principle of Sustained Anticipatory Guidance developed by the Center for Early Childhood Caries Research (CECCRe) has shown promising results in prevention of caries in cleft children (SAG) (27, 60, 61).

Taiwan

The concept of a government run insurer with a single-payer insurance system was first established in Taiwan in 1995, to ensure health coverage to all citizens. This health insurance system provides topical fluoride application for all children under 6. In addition, pit and fissure sealant are used to seal first permeant molars along with oral prophylaxis and oral mucosal screening for children above 12 years. Thus, universal national health insurance facilitates nation-wide oral care (62).

Australia

The National Oral Health Plan 2014–2024 is a blueprint that ensures healthy teeth and mouths among Australian children and adults across different sectors and jurisdictions (63).

Brazil

The Smiling Brazil National Oral Health Program (NOHP) was launched in Brazil with the vision to prevent ECC. The model developed to achieve this involved collective and individual educational-preventive actions among pregnant women. This created an opportunity for the establishment of early dental homes for infants. This program also utilized vaccination campaigns to introduce good oral health habits for pregnant mother and newborn infants. Group activities and home visits for early identification and referral of high risk children was also another crucial element of this program (64, 65).

China

The National Program for Chronic Disease Control and Prevention (2017–2025) launched agendas and action plan for the Healthy China 2030. This program included the following strategies for oral health promotion (1) promoting oral health education in kindergarten, primary and middle schools. (2) developing oral health-related techniques and instruments. (3) promoting early intervention in community health service centers and township hospitals. (4) integrating oral examination into the regular physical examination. (5) developing a personalized interventions for children and the elderly, which focus on dental caries and periodontal disease management; and (6) providing topical fluoride, pit and fissure sealing and other oral health-care measures to reduce the caries prevalence rate to below 30% by 2025 (66, 67).

Hong Kong

In 2019, the Faculty of Dentistry at the University of Hong Kong started a "Jockey Club Children Oral Health Project" (JCCOHP), supported by The Hong Kong Jockey Club Charities Trust. This large-scale school-based oral health project aims to screen all preschool children for ECC (68). Furthermore, the program also provides early interventions for ECC, using SDF along with conducting awareness programs for parents and teachers (27).

Thailand

In Thailand, the Bureau of Dental Health focuses on the primary prevention of dental caries, and promotes reduction of sugar consumption through the "Sweet Enough Network." This program, started in 2002 which was later adapted as a national policy to stop added sugar in infant formulas in 2006. This policy played a pivotal role in the reduction of ECC prevalence. Another program was launched by the Ministry of Public Health called "Tooth-brushing on the first tooth eruption with appropriate fluoride toothpaste." This campaign aims to enhance community participation along with providing hands-on training for the mothers or caregivers on how to brush the baby's first tooth (69, 70).

United Kingdom

The National Health Service (NHS) provides free oral care in England and other devolved nations such as Scotland, Wales, and Northern Ireland (71).

The way forward

Although the work on integrating oral health into general health is underway, the introduction of robust SDGs and their targets for ending ECC will pave the way for using oral health outcome measurements as the basis for remuneration schemes. The monitoring and evaluation (M&E) frameworks for measuring the progress of national health policies, strategies, SDGs and core health indicators have been established across nations. How well "oral health" M&E fits into this framework solely depends on four critical steps:

1. Inclusion of oral health under SDG3 or health goal,
2. Establishment of childhood caries under non-communicable disease (NCD),
3. Amalgamation of oral health with UHC,
4. Embedding oral health into all health policies.

Furthermore, linking potential SDGs to the health linkage with 17 SDGs could accelerate the process across the globe (Figure 4). National-level health missions, infant immunization programs, and pregnant women's health programs carried out on a large scale in most countries, if integrated with ECC SDGs targets, can also help achieve more excellent coverage.

Technology-driven teledentistry/mhealth in ending ECC

The term digital health is rooted in e-health and allows the employment of consistent and effective forms of healthcare

delivery for underserved populations. In 2018, the World Health Assembly Resolution on Digital Health recognized the value of digital technologies in contributing to the advancement of Universal Health Coverage (72). The American Academy of Pediatric Dentistry (AAPD) endorses teledentistry (a part of teleHealth) as an excellent way of improving access to care for children (73). Broader sets of recommendations for digital health include transmission of patient records, a real-time live video involving patient-doctor interaction, remote monitoring of patients, and mobile phone technologies, which is termed mHealth (74). Mobile Health (mHealth), a subset of e-health, allows mobile technologies for health. The extensive use of mobile phone technologies in health has led to significant translation across the globe. In Low- and Middle-income countries (LMICs), the growth of mobile phone networks with more incredible data transmission speeds has allowed for the transformation of the accessibility, delivery and management of health care services (74). Amid the heightened interest, digital health must be developed in tune with the SDG targets and only when oral healthcare demands can be met. The set core recommendations of digital health can include video consultation, SAG, ECC timeline, AI-assisted picture-based applications for early diagnosis of ECC, diet monitoring, and a repository of dental records. Furthermore, integrations of oral digital health with general digital health can leveraged to enhance the success of UHC. Appointment reminders using Short Messaging Services (SMS) can be effectively used in the periodic follow-up of pediatric patients, which can aid in the early diagnosis of white spot lesions. Information on preventive strategies such as fluoride application, Sealants and SDF can be sent *via* mobile services to parents of young children in rural regions. Oral Health promotion and awareness of ECC among parents, caregivers and preschool teachers could be provided through mHealth. Reminders on reducing sugar intake can act as a reinforcement measure. Automated daily SMS in regional languages has proven to be an effective strategy to sustain health education among parents. Such approaches have revealed significant results in ECC prevention among children with a cleft.

Challenges underway

Lack of financing

The importance of consolidating oral health within primary health care systems and universal health coverage programmes has been described in the Lancet Issue on Oral Health (2019) (75). Coverage on dental benefits by health system has been restricted in most countries (76, 77). Limited coverage on dental care could cause inequalities in access to dental health services, leading to disparities in oral health (75). Research on variations in coverage and access to dental care remains limited (77–79).

Instability of resources

The year 2022 has faced the sharpest economic slowdown in past eight decades with rising inflation, food insecurity, war and the continued negative impact of Covid−2019 (22). The war in Ukraine has caused global financial conditions to be tightened, mostly affecting Eastern Europe and Middle East countries with close ties to Russia. Also the International Monetary Fund (IMF) chief has reported Srilanka's economic crisis to be a warning to several other countries with high debt. Also the sharp rise in prices of commodities is anticipated to increase the inflation pressure (80). Such instances could cause instability of resources in low and lower-middle income countries. This poses a challenge in mobilizing financial resources toward dental health services.

Lack of human resources

An increase in the number of dental schools has led to an increase in the number of dentists. But sadly, the availability of dentists in rural areas is still sparse. Also, in LICs, very few dental schools exist and hence the availability of dental personnel is extremely low (11).

Lack of proper insurance

Dental Insurance schemes could play a major role in treating patients with low socio-economic status, who would otherwise ignore dental services. In the United States of America, Medicaid provides health insurance to most population including the low-income groups. It also provides dental insurance for children to relieve pain and infection, restoration of teeth and maintenance of dental health [Medicaid.Gov]. In United Kingdom (UK), insurance is provided by the National Health Service (NHS). However, these are High—Income countries. In India, Arogya Finance provides medical and dental loans. However, presence of dental insurance in low and middle income countries still remain a far-fetched reality.

Despite vital initiatives and the development of strategic frameworks for ending ECC (WHO, FDI), the success of these frameworks is possible only if they are in practice. Once launched, monitoring and sustaining these goals are the biggest challenge. Factors such as politics, governance, national health schemes, education, regional oral health leaders, trained personnel, socio-demographic index etc., can constrain the implementation of these solution-based frameworks. Nonetheless, oral health leaders must demonstrate and prove the impact of oral health on general health in a child. Overcoming these fundamental challenges can be elusive if not proven.

Conclusion

With the current knowledge of ECC and its effects on the child's general health, it is imperative to set up long-term

sustainable goals, which could be beneficial for the pediatric population. Shifting the focus from treatment minimally invasive, preventive and to patient-driven is critical to achieve an exponential outcome from such strategies. The culmination of oral health with NCD, UHC and SDG3 are the key steps. Raising awareness at the global, national and regional levels through benchmark research will mitigate the ECC burden in societies. Early Interventional Protocol and principles of SAG need to be widely disseminated. Political mandate, proper governance, using the common risk factor approaches and the alignment of ECC SDG targets with emerging political opportunities can further aid to remove regional disparity. Surveillance and monitoring of demographics and health-related indicators in the SDGs era will aid in attaining sustainability. Tailored cutting-edge mHealth services need to be curated to achieve these sustainable targets across nations.

Author contributions

AS, AJ, and MS contributed to design, acquisition, analysis, interpretation, drafted manuscript, critically revised the manuscript, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. RA contributed to design, drafted manuscript, contributed to interpretation, critically revised the manuscript, gave final approval, and agrees to be accountable for all aspect of work ensuring integrity and accuracy. AS and AJ drafted manuscript, critically revised manuscript, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. SP, TW, and MS critically revised manuscript for important intellectual content, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. MS contributed to conception and design, contributed to acquisition, contributed to analysis, contributed to interpretation, drafted the manuscript, critically revised the manuscript, gave final approval, and agrees to be accountable for all aspect of work ensuring integrity and accuracy. PM and MD contributed to acquisition, critically critically revised the manuscript, gave final approval, and agrees to be accountable for all aspects of work ensuring integrity and accuracy. All authors contributed to the article and approved the submitted version.

Acknowledgments

The authors would like to thank the Center for Early Childhood Caries Research for providing critical data of their ongoing projects and Smile Train for providing financial aid to publish this paper in open access journal.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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frontiers | Frontiers in Pediatrics

TYPE Systematic Review
PUBLISHED 10 November 2022
DOI 10.3389/fped.2022.975340

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Children and Health, a section of the journal Frontiers in Pediatrics

RECEIVED 22 June 2022
ACCEPTED 12 October 2022
PUBLISHED 10 November 2022

CITATION
Xu S, Zhao C, Jia L, Ma Z, Zhang X and Shi H (2022) Relationship between preterm, low birth weight, and development defects of enamel in the primary dentition: A meta-analysis. Front. Pediatr. 10:975340. doi: 10.3389/fped.2022.975340

Relationship between preterm, low birth weight, and development defects of enamel in the primary dentition: A meta-analysis

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Background: This study aimed to systematically analyze the relationship between preterm (PT), low birth weight (LBW), and developmental defects of enamel (DDE) in the primary dentition.

Methods: Following the retrieval of the databases, case–control studies, cross-sectional studies, and cohort studies on the relationship between PT, LBW and DDE, which had been published in English or Chinese up to January 2022 were included. The data about odds ratio (OR) and 95% confidence interval (95% CI) were extracted and calculated using STATA 12.0 Software. Case–control studies were evaluated using the Newcastle–Ottawa Scale (NOS), while cross-sectional studies and cohort studies were evaluated using the JBI scale. The heterogeneity of each study was evaluated using the Q test.

Results: A total of 15 studies were included, of which 8 studied the relationship between PT and DDE, and 13 explored the relationship between LBW and DDE including three about the relationship between very low birth weight (VLBW) and DDE. Seven studies explored the relationship between PT, LBW, and DDE. The results of this meta-analysis showed that both PT and LBW especially VLBW (OR = 7.19, 95% CI: 4.98–10.38) were risk factors for DDE in the primary dentition (OR = 2.33, 95% CI: 1.55–3.51) (OR = 1.67, 95% CI: 1.08–2.59). The subgroup results showed that PT and LBW were both associated with the occurrence of enamel hypoplasia (EHP) (OR = 6.89, 95% CI: 3.33–14.34; OR = 2.78, 95% CI: 2.10–3.68) rather than enamel opacity (OR = 0.94, 95% CI: 0.55–1.61; OR = 1.03, 95% CI: 0.66–1.61). There was no publication bias about the included studies ($P = 0.75 > 0.05$; $P = 0.47 > 0.05$).

Conclusion: This meta-analysis demonstrated that both PT and LBW especially VLBW are associated with a higher risk of DDE in the primary dentition. PT and LBW are both related to the occurrence of EHP. However, the relationship between PT, LBW, and enamel opacity has not been verified.

Systematic Review Registration: https://www.crd.york.ac.uk/prospero/display_record.php?, identifier: CRD42021262761.

KEYWORDS

preterm, low birth weight, developmental defect of enamel, primary dentition, meta-analysis

Introduction

During odontogenesis, many factors can affect the ameloblastic function and interfere with the enamel organ formation process, triggering anomalies called developmental defects of enamel (DDE) in the primary dentition (1, 2). According to epidemiological studies, DDE occurs in 15%–49% of primary dentitions worldwide in the last two decades (3–7). Previous studies showed that plaques can easily adhere to the pits and spots on the tooth surface caused by DDE, which increases the incidence and enhance the progression of early childhood caries (ECC) (7, 8). The influence of ECC on DDE children is great and quick. As a result, DDE in primary dentition poses a significant risk of ECC, and lowering its prevalence can lessen the impact of ECC on children's physical and mental health (9).

The etiology of DDE is diverse. The formation of primary dentition starts during pregnancy and ends after the birth of the child, during which there are various maternal and infant risk factors affecting ameloblasts and odontoblasts (10). The global or local effects lead to qualitative or quantitative defects in the enamel during the formation, mineralization, and maturation of the enamel matrix (1). DDE is frequently thought to be influenced by a variety of factors, including genetic disorders, the mother's physical health throughout pregnancy, fetal intrauterine infection, the maternal state at birth, and the infant's condition after birth (11). Most studies focus on the physical condition of mothers during pregnancy, low birth weight (LBW) or preterm (PT) during birth and the infant's condition after birth (10). Many studies showed that an infant's condition after birth such as PT, and LBW may be related to DDE (10, 11–13). Meanwhile, other studies pointed out that PT and LBW are not related to DDE (14). The relationship between PT, LBW, and DDE remains inconclusive.

The World Health Organization (WHO) defines PT as living babies born less than 37 weeks of gestational age (15). Cortines et al. (16) found that 46.3% of PT has DDE in the primary dentition, which is 4.8 times higher than that of normal-born infants, and enamel hypoplasia (EHP) is the most common type, suggesting that the higher incidence rate of DDE in the primary dentition is severely related to PT. In 2012, a case–control study involving 80 children in Brazil showed that compared with normal-born infants, PT has a higher incidence rate of DDE, suggesting that PT is an important factor, which causes enamel opacity and EHP (17). Pinho et al. pointed out that the incidence rate of DDE is 15.3% in normal birth and 16.2% in PT, but there is no statistically significant difference in the incidence rate of DDE (12).

LBW is defined as a newborn less than 2,500 g at birth. Very low birth weight (VLBW) is defined as a newborn less than 1,500 g at birth (18). Previous studies reported that birth conditions are the common factor affecting DDE (10). Some researchers found that DDE is more common among LBW than that among normal birth weight (NBW) (19). On the contrary, Ruschel et al. (14) believed that the incidence rate of DDE is 11.3% in NBW and 12.5% in LBW, and the difference is not statistically significant.

Above all, the relationship between PT, LBW, and DDE remains controversial. This meta-analysis systematically analyzed the relationship between PT, LBW, and DDE in primary dentition, and provided a scientific and comprehensive basis for the prevention of DDE in primary dentition.

Methods

Focused question

This meta-analysis was conducted according to the guidance of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Appendix 1) (20). Registered with PROSPERO, the registration number was CRD42021262761. Whether PT and LBW are more susceptible to DDE in the primary dentition than normal-born infants was explored, following the Participants, Intervention, Control, Outcome, Study (PICOS) design principle.

P: Children aged 0–6 years.

I: PT, LBW (including VLBW) or PT and LBW.

C: Full-term delivery or NBW.

O: DDE in the primary dentition.

S: Case–control study, cross-sectional study, and cohort study.

Search strategy

Seven recognized electronic databases, PubMed, Wiley, Cochrane Library, Science Direct, China National Knowledge Infrastructure (CNKI), Database for Chinese Technical Periodicals (VIP), and WanFang, were retrieved for relevant publications in English or Chinese from inception up to June 2022, supplemented by manual retrieval. The relevant references of all retrieved articles were included. The data retrieval was through the combination of means of computer retrieval and manual retrieval of cross-sectional study, cohort study, and case–control study on the correlation between PT, LBW, and DDE. The relevant references of all retrieved articles were included. Medical subheadings (MeSH) combined with free word were applied to search through a computer: ("low birth weight" [MeSH] OR "very low birth weight" [MeSH]) AND ("preterm" [MeSH] OR "premature" [MeSH] OR "prematurity" [MeSH]) AND ["enamel development defect" OR "enamel hypoplasia" OR "Enamel opacity" (MeSH)] AND ("primary dentition" [MeSH] OR "deciduous dentition" [MeSH]).

Inclusion criteria

Two reviewers independently identified and selected relevant studies by reading titles, abstracts, and full texts. The studies were selected based on the following inclusion criteria:

(1) Literature research types: Epidemiological research (case–control study, cohort study, cross-sectional study).
(2) Samples in the literature: Children less than or equal to 6 years old.
(3) Exposure factors in the literature: PT and LBW.
(4) Outcome index: DDE in the primary dentition in the literature and the modified DDE index published by FDI for the diagnostic criteria (1).
(5) Effective quantity: Odds ratio (OR) of DDE and 95% confidence interval (95% CI). All data which could be converted to OR were also included.

Exclusion criteria

To reduce the selective bias, the study that met one of the following situations was excluded:

(1) Failure to check the credibility and the consistency.
(2) Not in English or Chinese.
(3) Repeatedly published literature.
(4) OR and 95% CI could not be extracted or transformed.

Data extraction

Two reviewers (SX and LJ) selected the studies and extracted the data independently according to the inclusion and exclusion criteria. Disagreements were resolved through consensus or by seeking help from an arbitrator (HS). OR and 95% CI of DDE in PT, LBW, and VLBW compared with normal-born infants were calculated or extracted. The following information was extracted from each study: first author, year of publication, study method, number of patients, and age range of patients.

Quality evaluation

In this study, the JBI scale was used to evaluate the quality of cross-sectional and cohort studies, and a score of 70% of full marks indicated a low risk of bias. The Newcastle–Ottawa Scale (NOS) was used to evaluate the quality of case–control studies, and 0–3, 4–6, and 7–9 points indicated low, moderate, and high quality, respectively.

Statistical analysis

The meta-analysis was conducted by using the software STATA version 12.0 (STATA Corporation, College Station, TX, United States). The OR was used as the common measure of associated across studies. Heterogeneity across studies was assessed using the Cochrane Q Statistic (significance level at $P < 0.10$) and the I^2 statistic (21). Heterogeneity was considered statistically insignificant if $P > 0.10$ and $I^2 \leq 50\%$, and then the Mantel–Haenszel fixed-effect model (FEM) was used for calculating pooled OR among studies. Otherwise, the DerSimonian and Laird random-effect model (REM) was used for combining the results (22). Sensitivity analysis refers to the comparison between the combined effect after removing any one document and the result without removing it. The same overall result indicated that the results of this meta-analysis were stable and reliable. Publication bias was assessed by Begg's test for quantitative analysis with a $P > 0.05$ indicating statistical significance (23).

Results

Literature search and study characteristics

The flow diagram of the study selection process is shown in **Figure 1**. A total of 1,125 articles were identified according to the search strategy, of which 162 were excluded because of duplication. By screening the titles and abstracts, 905 articles were further excluded because they were review reports, which did not study the relationship between PT, LBW, and DDE. After screening the full text of the remaining articles, 43 articles were excluded because no efficient data could be extracted. At last, 15 articles containing 6,066 individuals were enrolled (3, 5, 14, 19, 24–34). Eight out of the 15 articles studied the relationship between PT and DDE. Seven articles studied the relationship between LBW and DDE, of which three studied the relationship between VLBW and DDE. The main characteristics of the selected studies for analysis are summarized in **Table 1**. Among the 15 articles, six studies were case–control studies, six studies were cross-sectional studies, and three studies were cohort studies. In addition, seven studies were listed according to the classification of DDE. Thirteen studies were of high quality and two studies were of moderate quality.

Meta-analysis results

A total of eight studies on the relationship between PT and DDE are shown in **Figure 2**. The meta-analysis was conducted through the REM based on the result of heterogeneity ($I^2 = 53.3\%$, $P_{\text{heterogeneity}} = 0.036$). The meta-analysis results of the included studies showed that PT was a risk factor

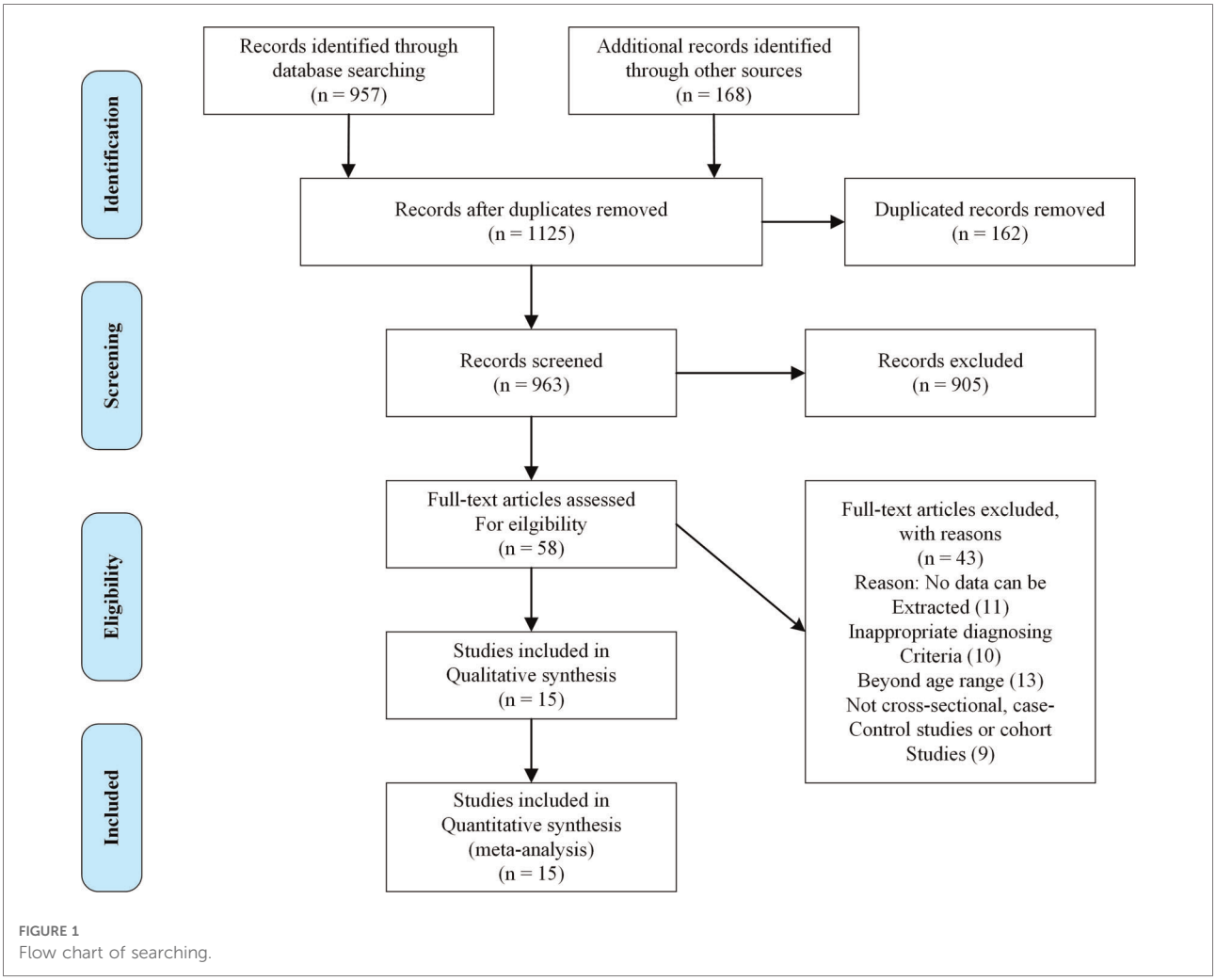

FIGURE 1
Flow chart of searching.

for DDE compared with full-term infants (OR = 2.33, 95% CI: 1.55–3.51).

A total of 10 studies on the relationship between LBW and DDE are shown in **Figure 3**. The meta-analysis was conducted through the REM based on the result of heterogeneity ($I^2 = 75.2\%$, $P_{\text{heterogeneity}} < 0.001$). The results suggested that LBW was associated with DDE compared with NBW (OR = 1.67, 95% CI: 1.08–2.59).

A total of three studies on the relationship between VLBW and DDE are shown in **Figure 4**. The meta-analysis was conducted through the FEM based on the result of heterogeneity ($I^2 = 43.8\%$, $P_{\text{heterogeneity}} = 0.149$). The results suggested that VLBW was associated with DDE compared with NBW (OR = 7.19, 95% CI: 4.98–10.38).

Sensitivity analysis

Sensitivity analysis was conducted by omitting one study at each time and recalculating the pooled results. Following the sensitivity analysis, the results of this study were stable and reliable. The results of this study were similar to the main results.

Publication bias

There was no publication bias in the enrolled studies (PT and DDE: $P = 0.75 > 0.05$; LBW and DDE: $P = 0.47 > 0.05$; VLBW and DDE: $P = 0.06 > 0.05$).

Subgroup analysis according to the classification of DDE in the study

(1) Relationship between PT and EHP

DDE was divided into EHP and enamel opacity. Two studies recorded the relationship between PT and the classification of DDE. The meta-analysis was conducted through FEM ($I^2 = 0\%$, $P_{\text{heterogeneity}} = 0.83$, OR = 6.89, 95% CI: 3.33–14.34). As shown in **Figure 5**, the OR

TABLE 1 The characteristics of the included studies.

Study ID	Age range	*n*	Case group (DDE/Health)			Control group (DDE/Health)			Study method	Subgroup of DDE	Quality score
			Preterm group	LBW group	VLBW group	Preterm group	LBW group	VLBW group			
Nelson, 2013	8 months	368			77/72			33/116	Cohort study	H:65 O:12	16
Nelson, 2013	18–20 months	378			98/86			89/95	Cohort study	H:60 O:38	16
Massoni, 2009	2–3 years	102		40/20			18/39		Cohort study		17
Takaoka, 2011	NA	91		39/6			20/26		Cohort study		16
Masumo, 2013	6–36 months	1221		18/32			76/154		Cross-section	H:11 O:7	17
Ruschel 2017	2–5 years	827		42/28			395/325		Cross-section	H:14 O:39	17
Wagner, 2017	3 years	377		3/13			17/344		Cross-section		18
Gabriela, 2017	2–3 years	467	12/60	6/38		49/327			Cross-section		17
Patricia, 2012	3–5 years	381	11/22	12/25		97/241	198/240		Cross-section		15
Masumo, 2014	6–36 months	816		10/76			96/934		Cross-section		17
Merglova, 2020	1 year	190		46/86	19/63		4/54	4/54	Case–control	H:36 O:14	7
Schüler, 2018	3–4 years	128	42/32			11/53			Case–control		5
Gravina, 2013	30–40 months	192	54/42	3/35	49/91	35/61	2/12	2/12	Case–control	H:36 O:18	7
Patricia, 2013	3–5 years	202	9/11	9/14		58/93	82/91		Case–control		7
Peres, 2015	3–5 years	204	21/10	8/5		74/99	87/104		Case–control		8
Franco, 2007	18–34 months	122	35/26			15/46			Case–control	H:48 O:32	5

DDE, developmental defects of enamel; LBW, low birth weight; VLBW, very low birth weight.

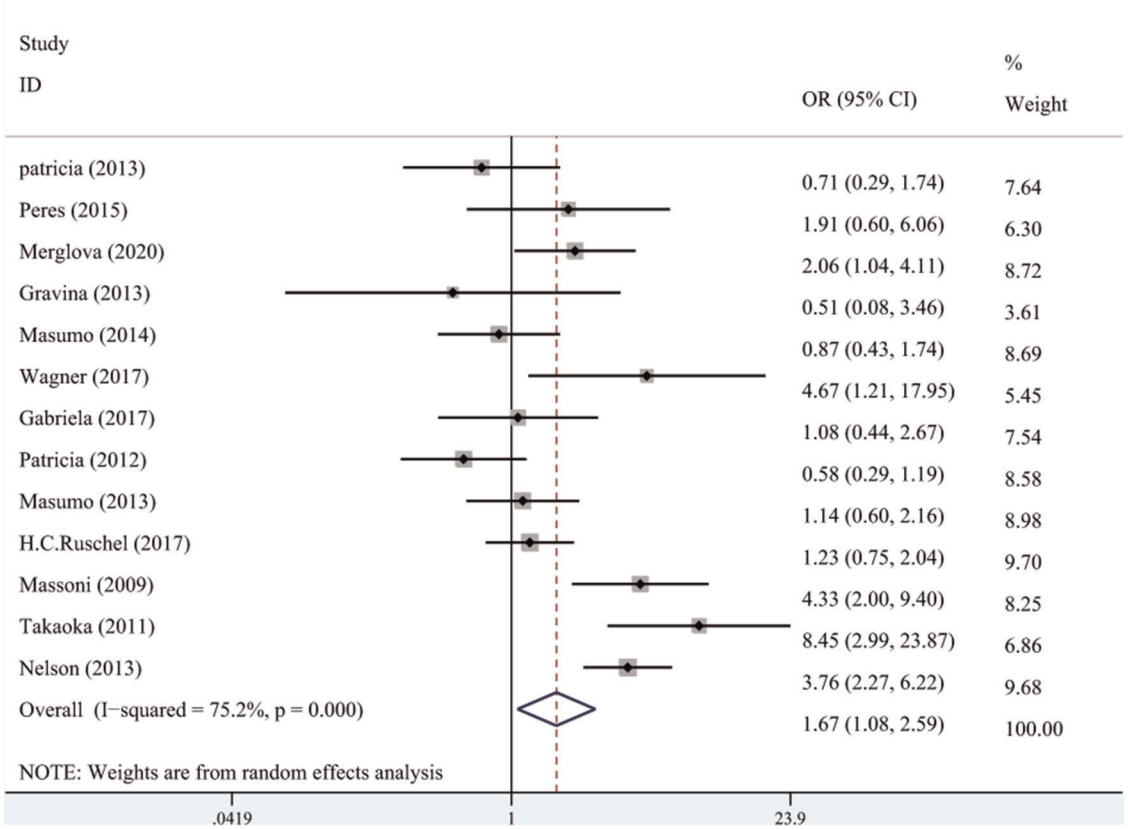

FIGURE 2
The forest plot shows the relationship between PT and DDE in primary teeth (REM). PT, preterm; DDE, developmental defects of enamel.

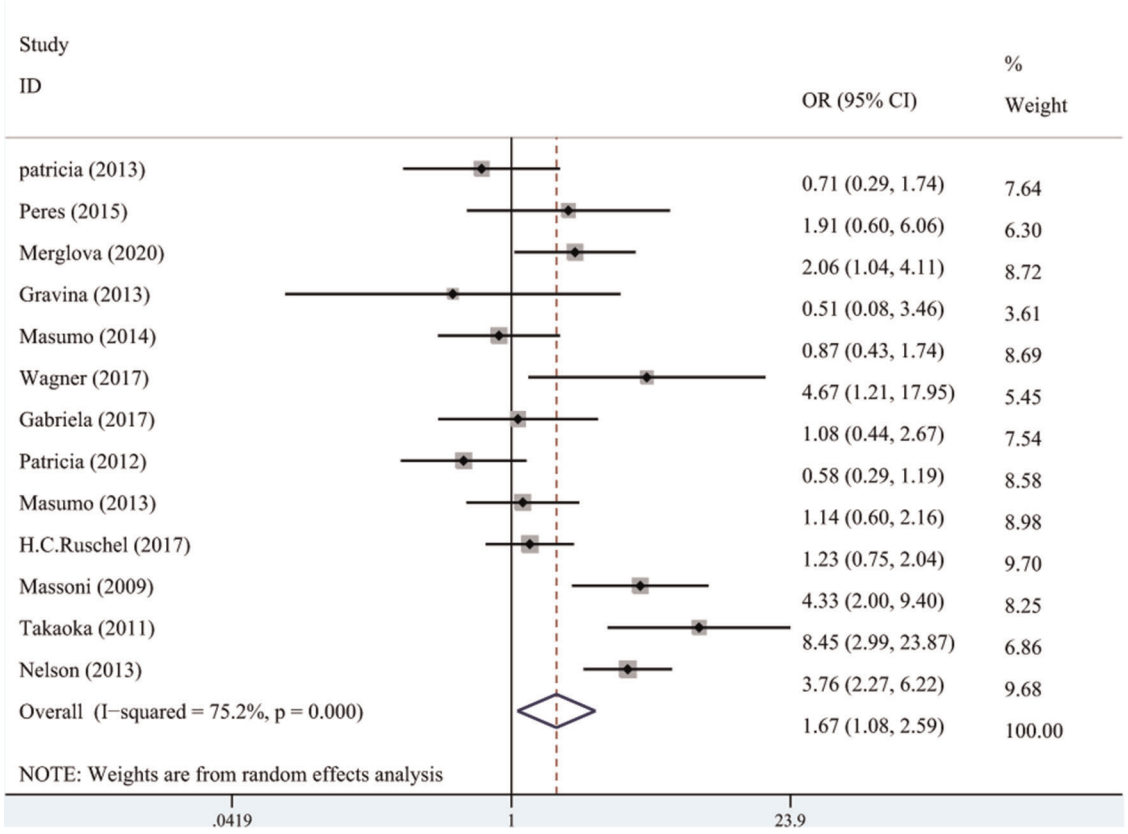

FIGURE 3
The forest plot shows the relationship between LBW and DDE (REM). LBW, low birth weight; DDE, developmental defects of enamel.

combined with 95% CI horizontal line was on the right side of the dotted line, indicating that PT was associated with EHP.

In terms of the relationship between PT and enamel opacity, the meta-analysis was conducted through REM ($I^2 = 55.9\%$, $P_{heterogeneity} = 0.13$, OR = 0.94, 95% CI: 0.55–1.61). As shown in **Figure 6**, the OR combined 95% CI crossed the dotted line, indicating that PT was not associated with enamel opacity.

(2) Relationship between LBW and EHP

Five studies recorded the relationship between LBW and the classification of DDE. The meta-analysis was conducted through FEM ($I^2 = 47.9\%$, $P_{heterogeneity} = 0.09$, OR = 2.78, 95% CI: 2.10–3.68). As shown in **Figure 7**, LBW was associated with EHP.

In terms of the relationship between LBW and enamel opacity, the meta-analysis was conducted through REM ($I^2 = 53.6\%$, $P_{heterogeneity} = 0.06$, OR = 1.03, 95% CI: 0.66–1.61). As shown in **Figure 8**, LBW was not associated with enamel opacity.

Discussion

In this meta-analysis, a total of 15 articles about the relationship between PT, LBW, and DDE published before June 2022 were retrieved, involving 6,066 children aged 0–6 years old. Among the 15 studies, there were 6 cross-sectional studies, 6 case–control studies, and 3 cohort studies. The results showed that compared with full-term and NBW infants, PT and LBW were associated with a higher risk of DDE, and the incidence rate of EHP was higher both in PT and LBW. In previous studies, Jacobsen PE concluded a meta-analysis of 23 original studies on the relationship between PT and DDE from January 1966 to February 2013 (35). The results showed that the risk of DDE in PT is about 2.3 times that of full-term infants and that there is a strong correlation between PT and the risk of EHP in primary dentition. However, although 23 articles were included in this paper, a meta-analysis on high-quality studies and uniform diagnostic criteria was needed to increase credibility due to the lack of distinction between primary and permanent teeth, the huge difference in diagnostic criteria, the lack of research on the relationship between LBW and DDE, and the lack of research on the classification of DDE. This meta-analysis overcame the differences in diagnostic criteria in previous studies, focused on DDE in the primary dentition, and explored the relationship between PT, LBW, and DDE in the primary

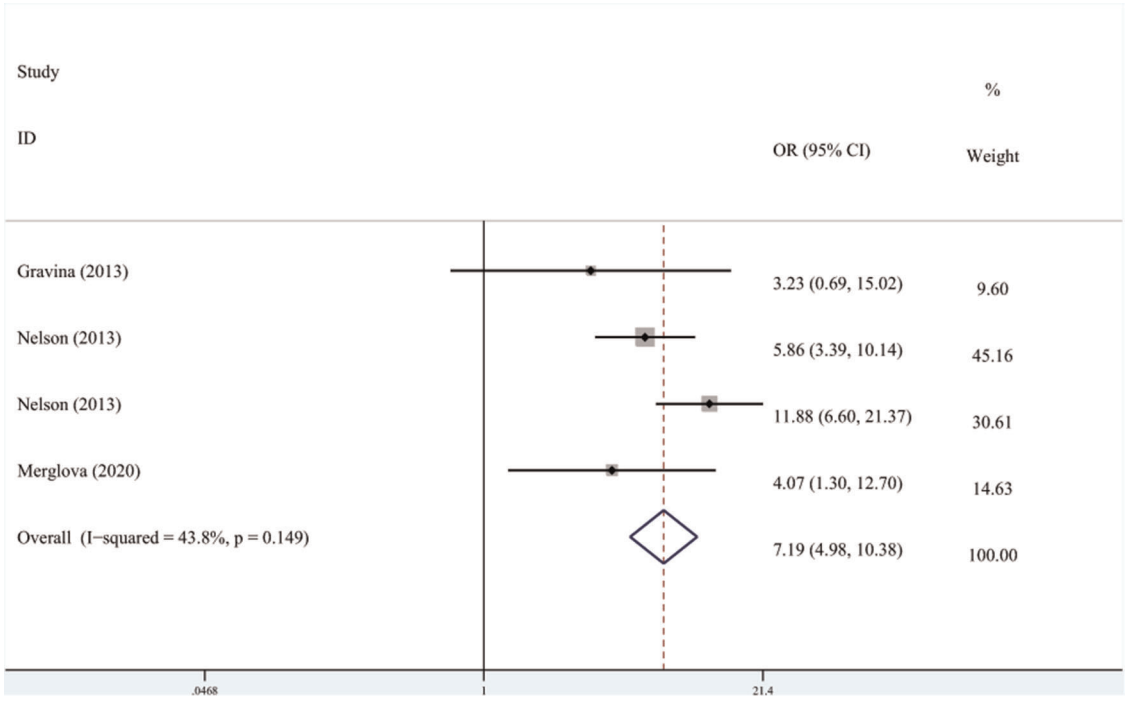

FIGURE 4
The forest plot shows the relationship between VLBW and DDE (FEM). VLBW, very low birth weight; DDE, developmental defects of enamel.

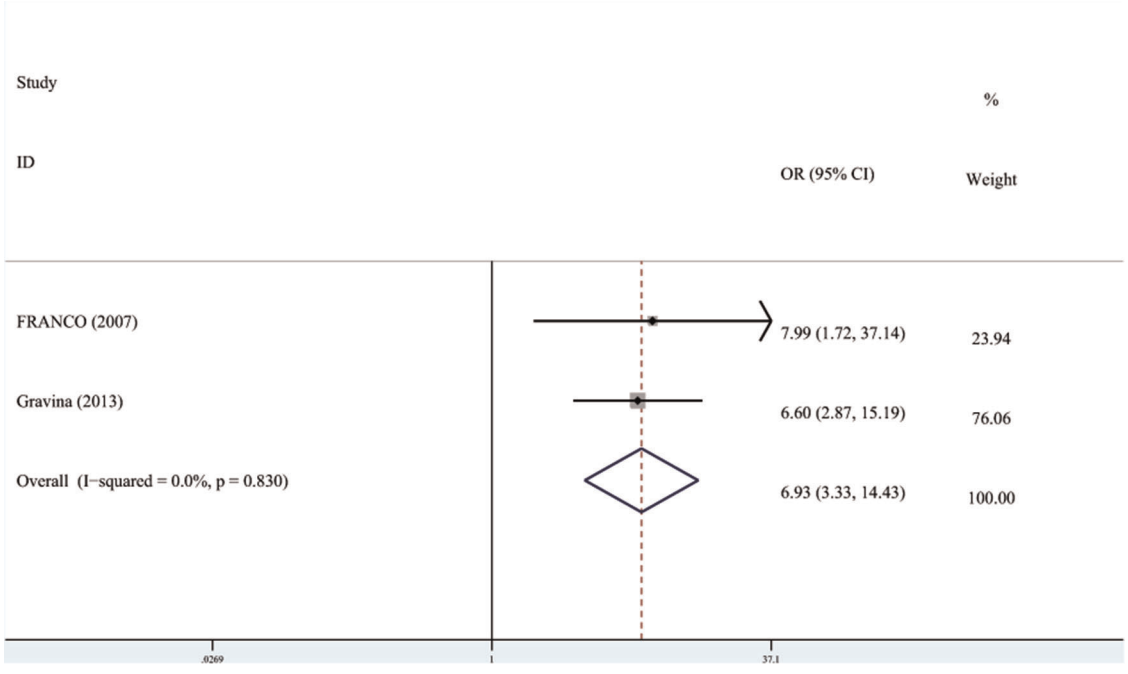

FIGURE 5
The forest plot shows the relationship between PT and EHP (FEM). PT, preterm; EHP, enamel hypoplasia.

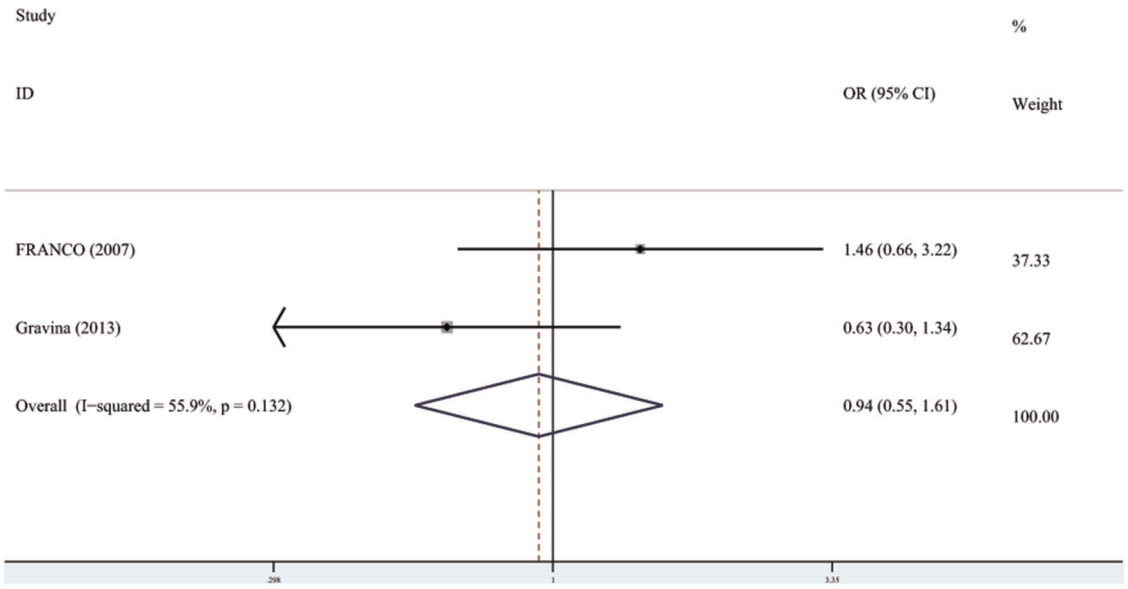

FIGURE 6
The forest plot shows the relationship between PT and enamel opacity (FEM). PT, preterm.

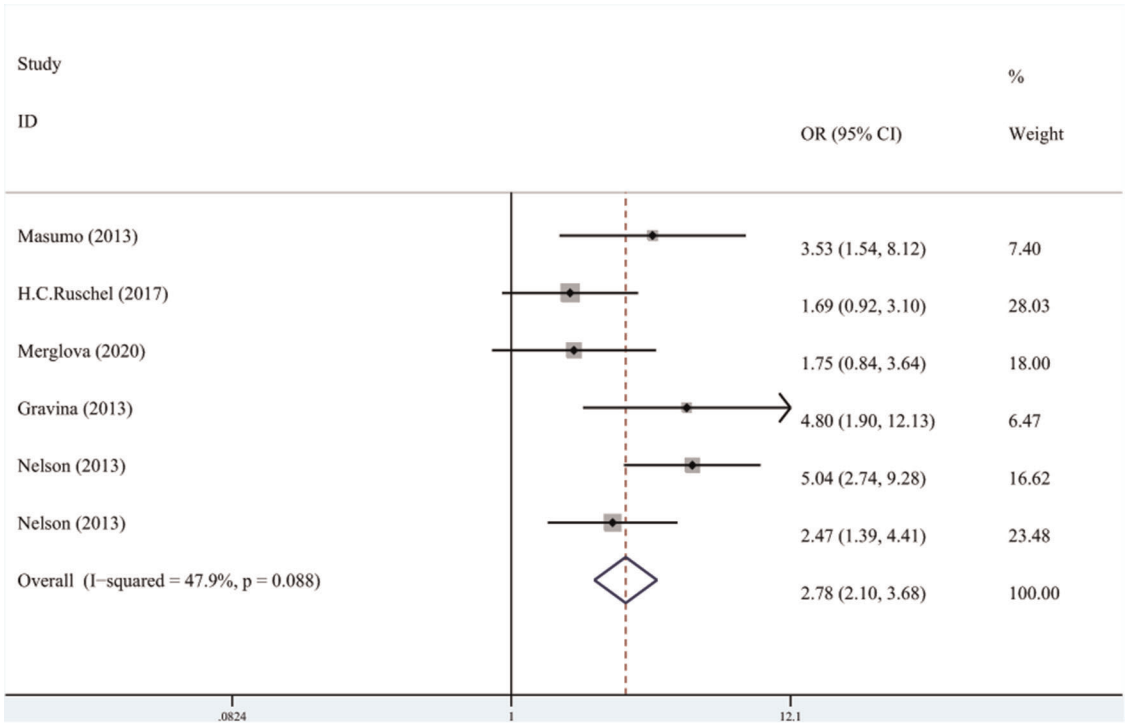

FIGURE 7
The forest plot shows the relationship between LBW and EHP (FEM). LBW, low birth weight; EHP, enamel hypoplasia.

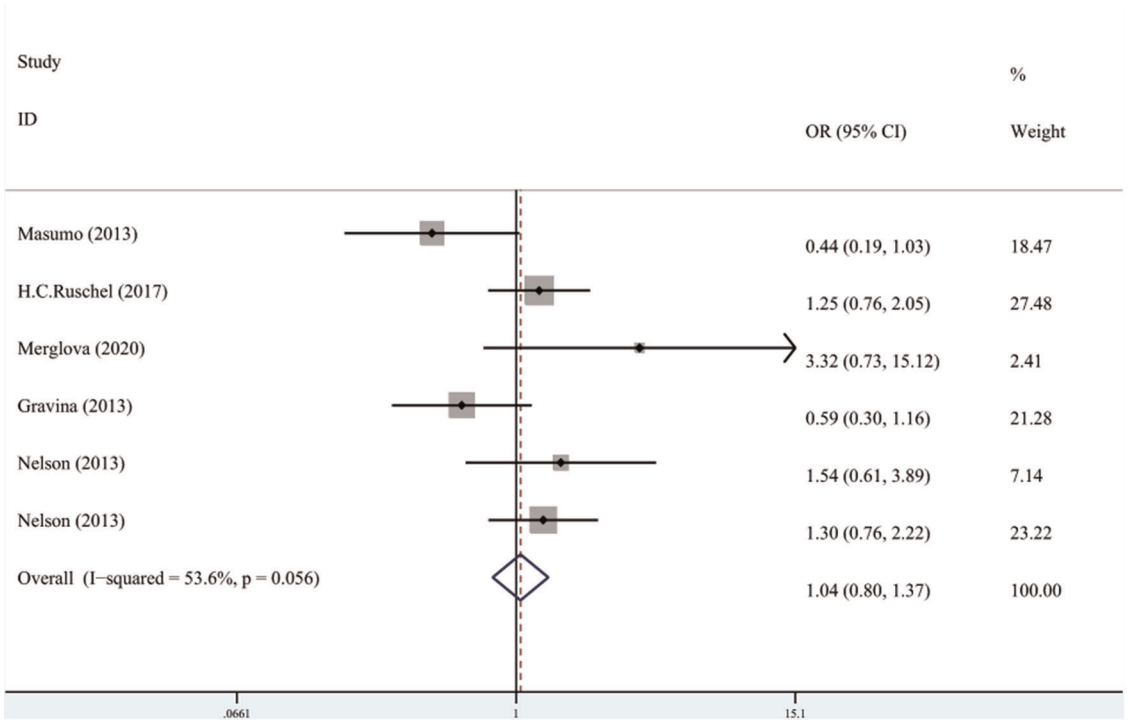

FIGURE 8
The forest plot shows the relationship between LBW and enamel opacity (REM). LBW, low birth weight.

dentition. At the same time, the subgroup analysis was performed according to different types of studies and the classification of DDE to ensure the accuracy of this meta-analysis. Up to now, this was the most comprehensive systematic paper, which explored the association between PT, LBW, and DDE in the primary dentition.

DDE index introduced by the Federation Dentaire Internationale (FDI) divided DDE into demarcated opacity, diffused opacity, and EHP, which was used to quantify and grade DDE since 1982 (36). In 1992, FDI revised the DDE index into modified DDE (FDI 1992), which classified DDE into enamel opacity and EHP. Enamel opacity is characterized by the absence of defects on the enamel surface, but the presence of diffuse or well-defined areas of varying enamel translucency, which is classified as diffuse or localized opacity (37). Enamel opacity occurs during the calcification and maturation stages of enamel development, which is usually characterized by changes in translucency or enamel opacity, such as white, cream, yellow, or brown changes (38). Demarcated or diffused opacity is defined as enamel opacity (1). EHP involves the reduction of enamel thickness, which is a quantitative defect (38). EHP occurs during the enamel matrix formation stage, resulting in enamel changes and calcification disturbances due to damage to ameloblasts (37).

This meta-analysis showed that the prevalence of DDE in primary dentition was significantly associated with the physical condition of prenatal mothers and postpartum infants (38). Enamel was mainly composed of inorganic substances containing calcium and phosphorus. The accumulation of fetal calcium and phosphorus was mainly concentrated after 27 weeks of pregnancy, PT would cause insufficient fetal calcium and phosphorus storage and cause DDE (39). In addition, pregnant women were undernourished or metabolically deranged, the fetus cannot obtain adequate nutrition from the placenta, especially the deciduous teeth begin to mineralize at the 14th week of gestation and complete mineralization 1 year after the child was born, malnutrition in pregnant women during this period can lead to DDE in primary teeth (40). Previous studies have shown that smoking during pregnancy can cause PT and DDE (39). At the same time, nicotine affects the function of ameloblasts caused to DDE (39). The study showed that gestational diabetes mellitus during pregnancy could also cause PT and DDE in the primary dentition because the physiological disturbance, which was caused by excess glucose could contribute to the dysfunction of ameloblasts (41). A great deal of evidence showed that PT infants with impaired immune systems would increase the risk of DDE. In addition, PT infants were prone to respiratory diseases, cardiovascular diseases and other serious diseases, which would affect the development and mineralization of enamel (42). We should pay close attention to the situation of PT infants after birth to

reduce the risk of DDE. Thus, paying attention to the physical condition of premature babies and mothers, and carrying out targeted prevention can help avoid DDE (39, 43).

The results of this meta-analysis showed that LBW infants were susceptible to DDE, which suggested that various unfavorable factors for the growth and development of LBW infants may be closely related to the occurrence of DDE. Cruvinel et al. believed that LBW infants are prone to hypoxia after birth, which can lead to various diseases. Hypoxia makes ameloblasts more sensitive and even causes damage to ameloblasts to affect the formation and mineralization of enamel, thus leading to DDE (17). In the case of hypoxia, various drugs are often used for treatment, and tracheal intubation or laryngoscope intubation is often conducted to overcome breathing difficulties (38). The excessive pressure exerted by the laryngoscope and tracheal intubation on the alveolar ridge can bring a negative influence, so trauma will permanently affect enamel development during this development period, resulting in DDE (44). Previous studies found the same result and pointed out that local trauma caused by left-sided tracheal intubation results in EHP mainly on the left side of the maxilla (12, 45). To sum up, the use of a laryngoscope and tracheal intubation in the treatment of hypoxia may be one of the causes of DDE.

The reasons for the heterogeneity in this meta-analysis included the selection bias of included samples and different clinical examination methods. There was a case–control study containing 128 children aged 3–4 years in this meta-analysis, of which the participants must get the consent of their mothers with a high level of education (24). In this study, infants were randomly selected from the expected date of confinement and invited to a dental clinic visit, which might contribute to heterogeneity. Additionally, the methods used to clinically detect DDE might also increase heterogeneity. There were three different examination methods in the literature: inspection, inspection + probing, and inspection + probing after cleaning. Visual examination alone was not as accurate as exploratory diagnosis of DDE, and examination of untreated tooth surfaces was not so accurate as visual examination alone after cleaning. Thus, inspection + probing could lead to an inaccurate result. In this meta-analysis, two studies were examined only by inspection, while the remaining 13 studies were examined by inspection + probing. Three studies did not treat the tooth surface before the examination, and the tooth surface was wiped using dry cotton balls in the remaining 10 studies. This study contained three research methods, i.e., six cross-sectional studies, three cohort studies, and six case–control studies. The heterogeneity was high in the relationship between PT, LBW, and DDE of all included studies. According to subgroup analysis, heterogeneity was low in each group, indicating that different research methods may be the main reason for the heterogeneity in the relationship between PT, LBW, and DDE.

There were several potential limitations of this study that deserved further consideration. (1) It was found that VLBW was highly correlated with DDE; unfortunately, there were only three related studies that met the inclusion criteria, which suggested that we should pay attention to the relationship between VLBW and DDE in the future. (2) In the included studies, the inspectors were all trained, but there were differences in the examination methods (inspection, inspection + probing, and inspection + probing after cleaning), which could influence the result. Therefore, studies with a high-consistency examination method are needed in the future. (3) In some of the included studies, some data were recorded and provided by hospital professionals with high accuracy, but in some studies, the data were provided by parents and guardians through memory, but there were deviations in the memory of different people, which could create information bias and affect accuracy. (4) All of the 15 studies in this meta-analysis were only in English and Chinese, and some studies in other languages that met the inclusion criteria might be lost, which would increase the limitations of this meta-analysis.

Conclusion

This meta-analysis demonstrated that both PT and LBW especially VLBW increase the risk of DDE. In addition, both PT and LBW are associated with EHP, but their relationship with enamel opacity has not been verified.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

SX, HS, XZ, and CZ have been involved in study design, data acquisition, data analysis, and manuscript writing. SX, LJ, and ZM have been involved in data interpretation, data analysis, and manuscript revision. HS has been involved in study concepts, study directions, manuscript review, and final approval of the version to be published. All authors contributed to the article and approved the submitted version.

Funding

This research was supported by the Project funded by the Hebei Provincial Department of Finance: Government-

funded specialty competence Building and Professional leader Training (Professional leader) (grant no. 0300000062), the Project funded by the Hebei Provincial Department of Finance: Study on the Correlation of Caries Activity and Dietary Nutrition among Younger Children (grant no. 361029). The funders did not influence any stage of this study.

Acknowledgments

We extend our gratitude to all the participants, coordinators, and administrators for their support and assistance during the study. In addition, we acknowledge the contribution of Ms. Xiaolin Zhang in collecting and analyzing data for this research.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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TYPE Original Research
PUBLISHED 06 January 2023
DOI 10.3389/fped.2022.956365

OPEN ACCESS

EDITED BY
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SPECIALTY SECTION
This article was submitted to Children and Health, a section of the journal Frontiers in Pediatrics

RECEIVED 30 May 2022
ACCEPTED 07 December 2022
PUBLISHED 06 January 2023

CITATION
Shmueli A, Assad-Halloun A, Fux-Noy A, Halperson E, Shmueli E, Ram D and Moskovitz M (2023) Promoting oral and dental health in early childhood - knowledge, views and current practices among paediatricians in Israel.
Front. Pediatr. 10:956365.
doi: 10.3389/fped.2022.956365

Promoting oral and dental health in early childhood - knowledge, views and current practices among paediatricians in Israel

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Early childhood dental caries is the most prevalent disease in childhood. Paediatricians are considered by parents as the main authority on prevention and treatment of all the health requirements of their infants.

Aim: The aim of this study was to evaluate the knowledge and practice of paediatricians in promoting oral and dental health among young patients (under age 36 months) and their parents.

Materials and methods: 145 anonymous questionnaires were distributed among paediatricians, 130 of them were 90% or above answered and were suitable for analysis for this study.75% of the questionnaires were distributed during the national convention of the Israeli Association of Clinical Paediatrics, 10% in paediatric ambulatory clinics and 15% in paediatric departments in hospitals. Questionnaires were distributed between 2018 and 2020. The inclusion criteria were physicians specialists in paediatrics or residents in paediatrics, all have Israeli licences to practice in Israel. exclusion criteria were partially filled questionnaires. The questionnaire was validated in a pilot study during the years 2010–2012. In addition to demographic variables that included medical training, post-graduate education and clinical practice the questionnaire included 42 questions. Eleven questions on demographics and amount of dental training during academic and clinical training 31 questions belonged to several sections that referred to the participants' awareness of the AAP guidelines regarding oral and dental health and knowledge of oral health. In each section paediatricians were asked to answer or give an opinion on a specific issue, their answers were coded to scores on a scale of 0–5 and summed per section. Correlations between different variables were analysed. The *t*-test and Mann-Whitney *U* test were performed for comparing two variables. For comparing more than two variables, we used the Kruskal-Wallis one-way analysis of variance test or ANOVA.

Results: The response rate was 89% (130 questionnaires out of 145). The survey showed that most paediatricians (80%) recognized their role in maintaining the oral and dental health of their young patients. Nevertheless, most admitted that they do not perform simple procedures on a regular basis, like dental examinations (64.6%), or asking parents about feeding habits (59.2%) or teeth brushing (75.4%). Only 21% of the participants expressed adequate knowledge of dental care for children younger than age 3 years. Fifty-eight percent of the participants never had any dental training during their entire paediatric medicine training, including medical school. Paediatricians in private or baby clinics received higher scores in practicing caries prevention, 24.15 ± 5.17 (SD), than paediatricians in hospitals, 2.79 ± 0.54 (SD) ($p = 0.006$). Caries prevention practice was not found to correlate with paediatricians' knowledge or attitudes regarding oral and dental caries prevention.

Conclusion: Oral and dental knowledge should be incorporated into the paediatric medicine curriculum. With their heavy workload, paediatricians generally do not implement dental caries risk assessment and counselling.

KEYWORDS

early childhood caries, paediatricians, caries risk assessment, dental education, dental health

Introduction

Early childhood dental caries (ECC) is an infectious multifactorial disease, and is the most common chronic disease in childhood, according to the U.S. Centre for Disease Control and Prevention (CDC) (1–3). Though the prevalence of dental caries in the general population has declined, this trend is not seen in early childhood caries (4, 5). In developed countries, the prevalence of early childhood caries has been reported as 1%–12%, but can reach 70% in high-risk populations, such as low socioeconomic groups or ethnic minorities (6).

Data regarding early childhood caries in Israel are limited. A survey conducted in nursery clinics in Jerusalem reported a prevalence of ECC of 15.3% (7). In a study of the Bedouin population in the periphery of Jerusalem, the prevalence of ECC was 17.6% (8). Of 1,210 6-year-old-children residing in 23 local authorities, 61.7% had dental tooth decay and only 38.3% were caries free (9). Although ECC is defined as dental caries before age 6 years, trends can be learned from data regarding the dental caries experience of children in their early years of life.

ECC is a virulent form of dental caries, which is biofilm (plaque)-induced acid demineralization of enamel or dentin, mediated by saliva. The disease is characterized by rapid and wide damage to the primary dentition soon after teeth eruption. ECC presents initially on the maxillary incisors and then spreads to the molars. Etiologic factors include inadequate feeding habits like nursing *ad libitum* and failure to maintain oral hygiene. In the past, ECC was termed baby bottle tooth decay. Today, ECC is defined as the presence of tooth decay (with or without cavitation) before age 6 years. Evidence of caries in smooth surfaces before age 3 years or a decay-missing-filled teeth score greater than child age in years is considered severe ECC.

The current treatment approach for ECC focuses on primary prevention (5). The American Academy of Paediatric Dentistry (AAPD) recommends assessing caries risk from age 6 months and providing instructions for caries prevention to infants' parents. According to AAPD recommendations, children by their first birthday should be examined by a dentist, to establish dental home (1).

During early childhood, infants and their parents meet paediatricians routinely to follow growth and development. Parents consider the paediatrician as proficient in topics of prevention, early detection of medical problems and consultation for adequate infant care. While the paediatric dentist usually meets the infant after caries damage is already detectable, the paediatrician is in a key position for early examination, detection, and prevention (2, 5, 10).

In May 2003, the American Academy of Paediatrics (AAP) published a policy statement regarding oral and dental health of children (5). According to AAP recommendations, paediatricians and medical staff should incorporate caries risk assessment and caries preventive instructions routinely, even before infants reach age 6 months (5, 10). Several publications have supported implementation of the AAP recommendations for caries risk assessment. Dela Cruz (2004) (11) and Lewis CW et al.' (12) found that most American paediatricians agree that early detection and prevention of dental problems is part of routine paediatric examination. Only 15% considered it necessary to refer infants to paediatric dentists by age 1 year (13).

In Israel, the degree to which paediatricians perform caries risk assessment and caries preventive consultation was not previously studied. The aim of this study was to evaluate the knowledge and practice of Israeli paediatricians regarding oral and dental health promotion among young patients (under age 36 months), and to evaluate barriers to such practice.

10.3389/fped.2022.956365

Materials and methods

145 questionnaires were distributed between March 2018 and March 2020 among paediatricians at the national conventions of the Israeli Association of Clinical Paediatrics, in paediatric ambulatory clinics and in paediatric departments in hospitals. 75% of the questionnaires (98) were collected in the national convention of the Israeli Association of clinical Paediatrics 2018, 15% (19) were collected in Paediatric departments in hospitals and 10% (13) were collected in Paediatric ambulatory clinics. The questionnaires collected in Paediatric ambulatory clinics were given only to paediatricians who had attended the convention of the Israeli Association of Clinical Paediatrics but did not fill the questionnaire during the convention. The same researcher that distributed questionaries at the conventions collected the questionnaires at the other locations and answered technical questions the responders that came up. The questionnaire was anonymous, no name or Identification number was mentioned, every questionnaire was numbered with serial number for the analysis.

Ethical considerations

The study protocol was approved by the Institutional Human Subjects Ethics Committee of Hadassah Medical Organization, Jerusalem, Israel (0429-16-HMO). The ethics committee exempt from signing consent form, since answering the questionnaire was voluntary the consent was received by the will of the pediatrician to fill the questionnaire.

Validation

The questionnaire was based on similar studies (13, 14) that were conducted in the U.S. and on the AAP position paper regarding pediatrician's role in caries risk assessment in children under 3 years (5). The questionnaires were distributed in a congress of the Israeli Association of Clinical Pediatrics among 87 pediatricians between 2010 and 2012 and the results were in accordance with previous studies (13, 14) (data not published). Based on that pilot study, we conducted the current study with the same questionnaire.

An introduction was added to the questionnaire explaining the identity of the researchers and the aims of the study. In addition, the researcher was present in the convention and was able to answer participants' questions.

The questionnaire was composed of multiple-choice questions with four response options, and open questions, and was administered anonymously. It included 42 questions and statements: Eleven questions on demographics: age, gender, institute of residency and seniority in paediatrics, amount of dental training during academic and clinical training.

Variables regarding clinical practice: geographic region of working, type of clinic (private, national health service, nursery clinic, paediatric department in a hospital), the number of patients per day and the proportion of them under age 3 years.

The second part included 31 questions that referred to the participants' awareness of the AAP guidelines regarding oral and dental health and Knowledge of oral health. It consisted of 5 statements, and the participants were asked to decide if they agree or disagree. To differentiate between the overall score between the variables, the answers of the participants were summarized into scores between 0 and 5, this score was referred as final score in knowledge of oral health. For example, if all the answers were right the final score in knowledge of oral health was 5. If all answers were wrong the score was 0.

The third part referred to attitudes regarding the role of paediatricians in promoting oral and dental health. It consisted of 5 statements and the participants were asked to grade their consent as "I do not agree", "I partially agree" or "I agree." "To correlate between variables, the answers of the participants were transformed into score between 1 and 3, this score 5–15) and were summarized as measured attitudes regarding the role of paediatricians in promoting oral and dental health".

The practice and promotion of oral health among children, and the obstacles encountered

Participants were asked about their confidence in providing oral health consultation and diagnosis, and about their knowledge regarding the Israeli Ministry of Health recommendations regarding oral health promotion among paediatric patients. Finally, the participants were asked if they would like to take part in a course about preventive dentistry for infants and toddlers.

There were 10 questions, for every question there were four options to answer: "Never", "Hardly", "Usually", "Always" and "No opinion". "Always" gave score of 4 and "never" gave score of 1. "No opinion" was scored zero. Statement scores were summed to give a possible score range of 10–40.

This score was referred as final score in practice and promotion of oral health among children.

Statistics

Statistical analysis was performed only on questionnaires that were at least 90% filled out. From the 145 questionnaires that were distributed 130 (89.7%) were found suitable for statistical analysis. The other fifteen were excluded.

Data were analysed using SPSS 22.0 software (IBM Inc., Chicago, Ill., USA). The *t*-test and Mann-Whitney *U* test were performed for comparing two variables. For comparing more than two variables, we used the Kruskal-Wallis one-way analysis of variance test or ANOVA. In cases of statistical significance in the ANOVA test, correction to the degree of significance was performed by Scheffe or T3 Dunnett tests, to identify the contribution of each of the two variables to the correlation.

Correlations between two categorical variables were performed by χ^2 and Fisher's exact test.

The level of statistical significance was set at $p < 0.05$.

Results

The study population comprised paediatricians who were members of the Israeli Society of Clinical Paediatrics, and paediatricians who worked in one of several hospitals in Israel.

Demographics

Of the 130 paediatricians included in the study, 53 (40.8%) were males and 77 (59.2%) females. The median age was 42 years (27–73 years). The range of professional experience was 0.5–50 years, the mean was 18.13 years, SD = 14.21. Only 82 paediatricians stated the country where they performed their residency: 48 (59%) graduated in Israel and 34 (41%) in other countries.

Clinical practice

Paediatricians from the entire country participated in the study: 35% from the north, 23% from the centre, 15% from Jerusalem, and 10% from the south; 17% did not provide this information. Sixty-four reported working in hospitals, 43 in baby clinics, 27 in the national health service, 24 in independent clinics, and 6 in private clinics. Some of the paediatricians worked in more than one position.

Patient populations

Paediatricians reported seeing 0–75 children in a day, 24 children on average; of whom 65% (SD = 25.25) on average were below the age 3 years (the value 0 is because some of the responders were retired from clinical work).

TABLE 1 Reported oral health medical education during each professional training stage: the number of courses in medical school, residency and continuing education.

	No answer	More than one course	One course	No training
Medical school	2.3 (3)%	3.1 (4)%	20.8 (27)%	73.8 (96)%
Residency	6.2 (8)%	5.4 (7)%	10.0 (13)%	78.5 (102)%
Continuing education	4.6 (6)%	7.7 (10)%	13.1 (17)%	74.6 (97)%
Any training	2 (3)%	40 (52)%		58 (75)%

Oral and dental health training during academic and clinical training

Data regarding dental training during the stages of clinical training are shown in Table 1.

Most paediatricians (58%) did not receive any oral and dental health training during their clinical paediatric training. No correlation was found between dental training and professional seniority, stratified by 5 years and above, and below 5 years. The rationale for this analysis was the assumption that paediatricians with 5 years of experience or more are further from their basic paediatric training and may have been more exposed to continuing education.

Oral and dental health knowledge

This was evaluated by participants stating whether they thought that each of five statements regarding oral and dental health was correct or incorrect. Only 27.7% ($n = 36$) reported familiarity with the AAP guidelines regarding oral and dental health; 66.9% ($n = 87$) were not familiar with the guidelines.

A significant positive correlation was found between dental education during the paediatrician's clinical training and familiarity with AAP guidelines (OR 3.67; 95% CI: 1.59–8.33; $p = 0.003$).

No correlation was found between seniority in paediatrics, and oral and dental knowledge.

The results are shown in Table 2.

Attitudes of paediatricians toward their role in promoting oral and dental health

This was evaluated by participants' responses, in agreement or disagreement, with five declarations of the role of paediatricians in promoting oral and dental health among children younger than age 3 years (Table 3). A significant correlation ($p = 0.027$) was found between working in an independent office and agreement with the statement that paediatricians have a central role in promoting their patients' oral and dental health.

TABLE 2 Responders' answers distribution to statements on oral and dental health knowledge.

Statement	Correct/ Incorrect	Right answer	Wrong answer	No answer
Only bottle-fed infants develop early childhood caries	Incorrect	113 (86.9%)	17 (13.1%)	-
Fluoride supplementation is acceptable in geographic areas with partial fluoridation	Incorrect	54 (41.5%)	74 (56.9%)	2 (1.6%)
Cariogenic bacteria may transfer from mother to child	Correct	93 (71.5%)	32 (24.7%)	5 (3.8%)
The AAP recommends a paediatric dental examination at age 1 year	Correct	93 (71.5%)	32 (24.7%)	5 (3.8%)
Preterm babies are at higher risk for dental caries	Correct	83 (63.9%)	42 (32.3%)	5 (3.8%)

For each statement, the correct answer is given and the percentage of paediatricians that gave a right answer a wrong answer or no answer is given.

TABLE 3 Responders' answers distribution to the role of paediatricians in promoting oral and dental health.

Statement	Does not agree	Partially agrees	Agrees	No answer
Inspection of teeth is an integral part of a physical examination	9 (6.9%)	6 (4.6%)	113 (86.9%)	2 (1.5%)
Children from age 6 months should be routinely assessed for risks of early childhood caries	15 (11.5%)	36 (27.7%)	76 (58.5%)	3 (2.3%)
Guidance for caries prevention should be given during routine follow-up	3 (2.3%)	10 (7.7%)	115 (88.5%)	2 (1.5%)
Paediatricians have a central role in promoting their patients' dental health	5 (3.8%)	20 (15.4%)	104 (80.0%)	1 (0.8%)
Every child should be referred to a paediatric dentist for examination at age 1 year	23 (17.7%)	40 (30.8%)	66 (50.8%)	1 (0.8%)

For each statement, the correct answer is given and the percentage of paediatricians that agreed, partially agreed, disagreed, or gave no answer is given.

Clinical practice

Eighty-five percent ($n = 111$) of the participants in the survey reported that they provided the parents of their patients verbal consulting regarding oral and dental health and caries prevention. One participant reported providing parents with a demonstration and three reported giving a leaflet with information regarding caries prevention. Table 4 summarize responders' answers distribution regarding clinical practice in dental caries prevention and treatment. We found a correlation between the number of patients younger than 36 months treated by paediatricians and favourable clinical practice regarding caries prevention ($p = 0.005$). Accordingly, paediatricians who examined more young children performed more caries prevention in their daily practice. We also found a positive correlation between paediatrician seniority and the tendency to practice caries prevention as part of routine practice (95% CI: 0.285–0.585; $p \leq 0.001$). Paediatricians who work in private or baby clinics received higher scores in practicing caries prevention 24.15 ± 5.17 (SD), than

TABLE 4 Responders' answers distribution regarding clinical practice in dental caries prevention and treatment.

Question	Never	Hardly	Usually	Always	No opinion
Do you inquire if an infant goes to sleep with a sweetened beverage?	15.4%	36.9%	31.5%	16.2%	
Do you instruct parents to avoid giving their children sweetened foods and beverages?	4.6%	29.2%	32.3%	35.6%	
Do you inspect children's teeth?	3.1%	29.2%	32.3%	35.6%	
Do you refer children that you diagnose with dental caries, to paediatric dentists?	6.9%	16.9%	28.5%	45.4%	2.3%
Do you instruct parents about the importance of tooth brushing, from eruption of the first tooth?	7.7%	26.2%	26.2%	40%	
Do you recommend parents to brush their children's teeth with fluoridated toothpaste?	23.1%	25.4%	24.6%	24.6%	2.3%
Do you explain to parents that their children's untreated caries are at high risk to develop infections?	37.7%	30.8%	14.6%	13.1%	3.8%
Do you refer 12-month-old infants to paediatric dentists?	39.2%	40%	10%	7%	3.1%
If a child needs a syrup medication, do you recommend giving a sugar-free medication?	56.2%	25.4%	9.3%	5.4%	3.8%

For each question, the percentage of paediatricians that gave an answer on the frequency of the specified behaviour or had no opinion is given.

paediatricians in hospitals, 2.79 ± 0.54 (SD) ($p = 0.006$). Correlations were not found of caries prevention practice with knowledge was ($p = 0.148$, rs = 0.128 by Pearson correlation coefficient) or with attitudes of the paediatrician about oral and dental caries prevention ($p = 0.836$ rs = 0.018 by Pearson correlation coefficient). A significant correlation was not found between consent with the statement that visual examination of teeth is part of the physical examination, and the actual performance of such examination ($p = 0.46$ by Fisher's test). A significant correlation was found between consent with AAP recommendations and the referral of every child at age 12 months to a dental check-up (OR 10.8; 95% CI: 1.49–10; $p = 0.001$).

Barriers to implementation of AAP guidelines for ECC prevention

Forty-five percent of the respondents indicated that limited time interfered with their implementation of the guidelines, 58.5% stated the absence of oral and dental training, 45.7% stated the lack of confidence in caries risk assessment and 53.2% stated lacking confidence in recognizing early signs of caries. Sixty percent of the participants reported not being familiar with the Israeli Ministry of Health recommendations for caries risk assessment by paediatricians.

Reasons associated with the practice of caries risk assessment

A positive correlation was found between the paediatrician's confidence in performing caries risk assessment and its actual practice ($p = 0.001$). No correlation was found between dental training during the paediatrician's clinical training and confidence in performing caries risk assessment. Eighty-six percent of the participants in the survey expressed their interest in having a continuing education program in paediatric dentistry.

Discussion

The present study was a survey among paediatricians regarding their knowledge about diagnosis and treatment of early childhood caries. The survey also estimated the implementation of knowledge. We found that despite most of paediatricians found oral and dental health prevention important, they actually did not succeed to perform these measures to all of their young patients. Barriers for that were few: lack of knowledge, lack of confidence and high work load and time shortage this findings are in accordance to findings that were lately published in a systematic rview by Rangel A et al. (15). Paediatricians show interest in participating in continuing education programs regarding early diagnosis and prevention of early childhood caries.

From 145 paediatricians who were offered participation between 2018 and 2020, the questionnaires of 130 were included in this survey, corresponding to 89.6% response rate. The response rates in comparable surveys conducted in the U.S. were 46% (13) and 62% (10). In those surveys, questionnaires were sent by mail, whereas in the current survey they were distributed during a professional convention.

Dental and oral training during paediatricians' clinical training

In our study, slightly more than half reported a lack of oral health training. This is consistent with previous reports.

The participants of the current survey reported not having received training during their paediatrics program, in the oral and dental health of infants. In our study, slightly more than half reported a lack of oral health training. Eighty-five percent reported not having received any oral and dental training during their residency; only 15% had received some training in this field This is consistent with previous reports regarding unsatisfactory oral and dental training of paediatricians during their clinical training (10, 11, 13, 14, 16). These findings contrast with the recommendations of the AAP (5). In a U.S. national survey from 2009, 21% of post-residency fellows in paediatrics reported not having received any oral or dental training (12). Sixty-one percent of the participants of the present study thought that the oral and dental training they received was insufficient.

Dental and oral knowledge among paediatricians

In the current survey, 62% of the paediatricians responded correctly to three or fewer questions of five, which tested their dental and oral knowledge. Only 27% replied correctly to all five questions. These findings suggest a moderate level of knowledge, and lower than expected from a professional who advises parents of infants. Similarly, insufficient knowledge was found in a few surveys from the U.S. The conclusion of those surveys was that oral and dental training should be added to the paediatrics curriculum (10, 13, 16).

Less than half the participants answered correctly regarding fluoride supplements. This was somewhat surprising as according to the Israeli Ministry of Health, fluoride supplements should be recommended for high-risk patients, by a paediatric dentist or paediatrician. However, as guidelines for fluoride supplements have changed over time, a gap in knowledge may be expected, in the absence of routine training on this matter or of self-learning.

Dental knowledge and the correlation to dental training

Surprisingly, no correlation was found between receipt of dental training during professional training and knowledge scores. The mean score on the five knowledge questions was higher among respondents who received dental training as part of continuing education than among those who did not: 4.10 ± 0.56 vs. 3.36 ± 1.9. From this finding we conclude that during residency programs, paediatricians are busy learning the core of their profession and dental training is only one of the many fields included.

Dental training regarding caries risk assessment and prevention during continuing education, seems much more effective than dental training during basic medical education. It seems that at this later stage the paediatrician is more confident in the main skills of paediatrics and may be more open to acquiring skills and knowledge that are not part of the core of the profession. The higher scores in dental knowledge among respondents who received dental training in continuing education compared to those who did not receive such training suggests that medical schools and paediatric education programs do not provide the dental skills and knowledge that are anticipated from paediatricians. From this finding we understand that dental education must be strengthened during medical school, in post-graduate programs and in continuing education programs.

Paediatricians' attitudes regarding promoting dental health among their young patients

Eighty percent of the participants in this survey believed that the paediatrician has a major role in promoting oral and dental health among their young patients. Eighty-seven percent thought that dental inspection should be part of the paediatric physical examination. Eighty-nine percent thought that paediatricians should provide dental caries preventive instruction, as part of routine growth and development follow up. This is in accordance with other surveys (10, 13, 17).

Only 50.8% of the participants in this survey agreed with the AAP guidelines that children should be referred to paediatric dentists by their first birthday. In a survey in the U.S., paediatricians explained that they referred at an older age, as infants might not be able to cooperate in a dental examination (13). Socioeconomic status of the patients affected the time of referral. As dental service for children is free of charge in Israel since 2010, socioeconomic status presumably does not pose an obstacle for early dental referral.

In the current survey, 58.5% of the participants thought that caries risk assessment should be performed by the paediatrician from age 6 months. This finding contrasts with the AAP guidelines that promote prevention. We examined a correlation of this finding with the level of confidence paediatricians have in performing caries risk assessment. As the level of confidence increased, paediatricians' attitude to performing caries risk assessment was more favourable ($p = 0.015$). Surprisingly, the level of confidence was not correlated to the scope of their dental training ($p = 0.131$). Strengthening the confidence of paediatricians in performing caries risk assessment should be emphasized throughout dental training, in all the professional levels of training (undergraduate, residency and continuing education).

A positive correlation was found between the opinion that caries risk assessment is necessary for every 6-month-old child, and the opinion that all children should be referred to an evaluation by a paediatric dentist by their first birthday ($p = 0.015$). Enhancement of dental awareness and dental knowledge could raise the confidence of paediatricians to perform caries risk assessment and to increased referral of infants to paediatric dentists.

In contrast to our expectation, no significant correlation was found between the paediatricians' work environment (hospital, private clinic, public clinic, baby clinic) and their attitude toward promoting dental health. The main parameter that seems to influence the attitudes of paediatricians is the degree to which they are updated with the professional literature. In every work environment, some paediatricians are updated. Paediatricians who treat life-threatening situations in hospitals were not less updated than other paediatricians. Efforts should be made to improve knowledge and awareness in every realm of paediatrics.

Actual clinical performance

Forty-eight percent of the survey's participants stated that they do not instruct their patients' parents in preventing dental caries. Among those who do instruct parents, 85% gave oral instructions (and not a written leaflet for example). Among paediatricians in the U.S., 80% reported instructing their patients in dental caries prevention (10, 16). We assume that this difference might be explained by the high workload of paediatricians in Israel, and relates to knowledge and awareness, areas that can be influenced.

Seventy-five percent of those who instructed their patients gave dietary instructions, mainly avoidance of sugar consumption, but only 47% sought information regarding what children drink through bottle feeding. This finding is disturbing, as consumption of beverages that are not water through a bottle is a known risk factor for early childhood caries (3, 4).

Thirty-four percent of those who instructed their patients' parents, gave oral hygiene instructions. This low proportion is also disturbing, as teeth brushing to infants is not a trivial concept for parents and has a major influence on dental caries risk.

Dental examinations as part of physical examinations

Only 36% of the participants in the survey reported that they examine their infants' teeth routinely. This is in contrary to the 87% who agreed that dental examinations are part of paediatric physical examinations. Performing dental examinations as part of physical examinations is highly important, for the promotion of caries risk assessment tailored to every patient.

Referral to paediatric dentists

Sixty-six (51%) of the respondents reported that they refer patients to paediatric dentists if they diagnose caries. Only 23 (18%) of the responders reported that they refer patients on a routine basis at age 12 months. This finding is coherent with the literature. In a national survey in the U.S., only 14.6% found it necessary to refer patients at age 12 months to paediatric dentists for first examinations (10).

Explanations to parents on bacterial transmission

Thirty-eight percent of the respondents reported that they do not explain to parents that dental caries pathogens can be transmitted from a major caregiver to an infant's mouth, while 31% sometimes explain this. This finding contrasts with the finding that 71.5% of the participants in the survey responded correctly regarding the relation between high caries activity in a parent's mouth and transmission of the disease to a child. Understanding the concept of pathogen transmission from parent to child is crucial for young parents. As most paediatricians understand the aetiology of caries, it is surprising that only a small proportion find it necessary to communicate this important knowledge to parents. The reason may be shortage of time and a high load of patients.

Clinical performance and the work environment

Though paediatricians from all work environments (hospital, private clinic, public clinic, baby clinic) showed positive attitudes toward promoting oral and dental health, higher proportions of paediatricians who worked in private clinics and baby clinics, compared to those who worked in a hospital environment, reported promoting oral and dental health. This finding was significant ($p = 0.005$ regarding private clinics and $p = 0.002$ for baby clinics); several explanations are possible. Firstly, paediatricians who work in hospital environments deal with life-threatening situations and have a very high workload, while paediatricians who work in private clinics and baby clinics deal with more elective situations and may have more time to perform caries risk assessment and to provide instructions for prevention. Another reason is that paediatricians in baby clinics are especially well trained in treating very young patients and their health needs. This may explain the tendency of these paediatricians to dedicate more time and efforts to dental caries prevention and promoting oral and dental health.

Barriers to complying with the AAP recommendations

The main difficulties cited in implementing AAP guidelines regarding promoting oral and dental health were lack of awareness to the AAP guidelines regarding oral and dental health (60%), time shortage (46%), and lack of confidence in diagnosing early signs of dental caries (53%) and in risk assessment of dental caries (45%) (13).

Fifteen percent of the respondents reported not referring patients to paediatric dentists due to socioeconomic reasons. This finding is low compared to findings from the U.S. (77.4% and 55.1%) (10, 14). While in the U.S., dentistry is private or covered by insurance; in Israel, since 2010, paediatric dentistry is free of charge for children under age 18 years.

We found that paediatricians with more confidence in risk assessment of dental caries are more likely to perform activities that promote oral and dental health among infants. Pierce et al. found that following 2 h of training, paediatricians were able to diagnose early signs of dental caries with sufficient accuracy to refer to a paediatric dentist (17). Competence in dental caries diagnosis and caries risk assessment can be acquired and improved. Including these topics in continuing education programs for paediatricians is highly important.

Study limitations

The sample in our study is a convenience sample and is not a representative sample of all the 3,000 licensed paediatricians in Israel.

As in every questionnaire, responder bias should be considered. Paediatricians who cooperated with filling the questionnaire may have been more updated with the guidelines.

Another limitation of the study is that the long length of the questionnaire, which included 42 questions, may have discouraged some paediatricians from participating. Nonetheless, the response rate of 90% was high.

All potentials work places for paediatricians were represented in the current survey: hospitals, private practice, the national health services and baby clinics. Most (64.7%) of the respondents' patients were younger than 36 months. More than half the respondents worked in hospitals. We assume that in hospitals, most patients have severe diseases or life-threatening conditions, and that caries risk assessment is not an urgent matter.

Conclusion

1. In the present study more than half reported a lack of oral health training.
2. Dental and oral knowledge among paediatricians is moderate and lower than expected from a professional who advises parents of infants.
3. Most paediatricians agreed that dental inspection and providing dental caries preventive instruction should be part of the paediatric physical examination.
4. Oral health and dental knowledge should be incorporated into the paediatric medicine curriculum, and especially in continuing education programs for paediatricians.
5. Many paediatricians do not perform dental caries risk assessment and counselling, due in part to their high workload and lack of knowledge.

Data availability statement

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

Author contributions

SA was responsible for writing, statistical analysis and ethical approval. A-HA contributed in distributing and collecting the questionnaires and writing. F-NA and HE contributed by reviewing the manuscript. SE contributed in pediatric medicine consulting. MM and RD contributed in writing and reviewing. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fped.2022.956365/full#supplementary-material.

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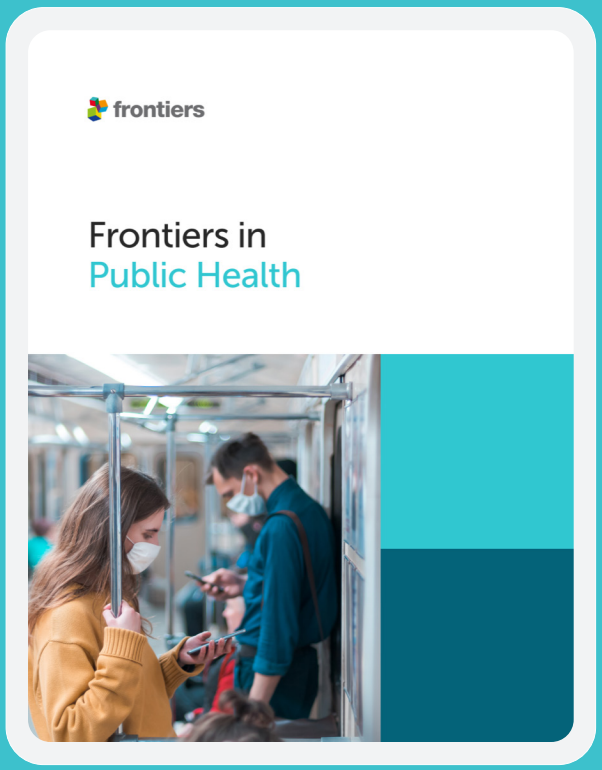

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