The Bidirectional Relationship Between Weight, Height, and Dental Caries in Preschool Children: A Systematic Review

Fathiyyah Nurul Adzra[1], Ratna Indriyanti[2]*, Arlette Suzy Setiawan[2]

1. Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia.
2. Department of Pediatric Dentistry, Faculty of Dentistry, Universitas Padjadjaran, Bandung, Indonesia.

Abstract

Dental caries is considered one of the most common oral diseases in children. The problem of caries and child growth that coincide or are interconnected is a concern for global public health. This study aimed to analyze the bidirectional relationship between dental caries and changes in body weight and height in preschool children using a literature study.

This literature review used a systematic review method that refers to the Preferred Reporting Items for Systematic Review without Meta-Analyses (PRISMA) guidelines. The database used is PubMed, Science Direct, and Cochrane Library. Searched limited to articles published from 2012 to 2022. Assessment of the risk of bias was performed using the JBI Critical Appraisal tool. A total of seven articles are included after selection based on inclusion and exclusion criteria. Two articles show a negative and significant relationship between body weight and caries; one shows a positive relationship, and three found no significant correlation. Two articles state that the bidirectional relationship between nutritional status and caries is negative. Another article does not state the relationship between weight, height, and caries in the primary teeth.

The bidirectional relationship between body weight, body height, and caries that is visible is that caries causes the risk of lack of weight and height due to chronic inflammation, which can result in nonoptimal nutritional intake. On the other hand, weight and height deficiency can increase the risk of dental caries due to disruption of salivary secretion.

Introduction

One of the most common global dental health problems is dental caries.[1] Previous studies regarding the prevalence of early childhood caries (ECC) showed that ECC affects almost half of preschool children (48%).[1] Caries are the leading cause of mouth pain and tooth loss, considered a significant public health problem in children and one of the most common oral diseases.[2] According to the 2018 Basic Health Research in Indonesia, the percentage of children aged 3-4 years who experienced dental caries was 36.4%, while in the age group 5-9 years, they experienced similar tooth decay by 54.0%.[3]

Corresponding author:
Ratna Indriyanti,
Department of Pediatric Dentistry, Faculty of Dentistry,
Universitas Padjadjaran, Bandung, Indonesia.
E-mail: ratna.indriyanti@fkg.unpad.ac.id

The preschool-age period (3-6 years) is a period of growth and development of a child. The measurement of the growth and development of children is done by body weight, height and head circumference.[4] A child's growth can be affected by several factors, such as genetic, environmental and nutritional factors associated with dental caries.[5] Dental caries is a disease associated with multifactorial factors, especially diet.[6] High consumption of sugar found in sweet foods and drinks is the leading risk factor for caries.[6] Preschool children tend to like to eat sweet foods[7]; their fondness for sweet foods can explain the occurrence of dental caries and obesity in children.[8]

A study showed a relationship between consuming sweet foods and the incidence of dental caries in children.[7] The study argues that mouth pain associated with inflammation due to caries can interfere with a child's ability to eat, causing a decrease in food intake and can have a negative impact on children's growth.[9] Other studies suggested that underweight and stunting

lead to caries in primary teeth among preschool children.[10–13]

The problem of caries and child growth that occur together or are interconnected is a concern for public health globally.[5] Reports were systematically reviewed to assess the direction of the bidirectional relationship between body weight, height, and caries. The previous literature review has yet to explain this bidirectional relationship. Therefore, this systematic review aimed to analyze the bidirectional relationship between dental caries and changes in weight and height in preschool children. In particular, this research was conducted to provide information on measures to prevent dental caries and growth problems in children.

Materials and methods

This article is a systematic review following the Preferred Reporting Items for Systematic Review without Meta-Analyses (PRISMA) guidelines.[14] The research questions were designed based on the PICO framework, Population (P): preschool-aged children; Intervention (I): Caries, body weight, and height; Comparison (C): no comparison; Outcome (O): Two-way relationship. The literature search was conducted in September 2022 and was limited to published articles from 2012 to 2022. The databases used in the literature search were PubMed, Science Direct and the Cochrane Library. The search strategy is carried out using keywords combined with boolean operators: (dental caries) AND ((body weight OR adiposity) AND body height OR anthropometric) AND (preschool) for each database. Filter database free full text or open access and last ten years or ranging from 2012 to 2022 is used. Searching articles for additional studies were done manually by checking references from included studies.

The inclusion and exclusion criteria used are described in table 1. After identifying articles through the database, all titles/abstracts were imported into Mendeley. Next, a duplication check is carried out and screened through titles and abstracts. Then the full text of the articles selected after screening is reviewed to determine whether the article is included or excluded.

Articles included in the screening process using inclusion criteria were assessed for the risk of bias using The Joanna Briggs Institute (JBI) Critical Appraisal checklist, which had been adapted to the study design, namely the checklist for analytical cross-sectional. This JBI critical appraisal assessment contains questions to assess the quality of the study. Each question was answered 'yes', 'no', 'no clear' or 'not applicable'. Each criterion with the answer 'yes' is given a value of one, and the others are zero, then each score is calculated and summed up. The total score of the eight questions determines the quality of the article, with the following criteria: scores 1-3 have a high bias, score 4-6 has a moderate bias, and scores 7-8 have a low bias. Three researchers can carry out risk assessments, and if there are differences of opinion, discussions are held to reach a mutual agreement. The data extraction stage is carried out by summarizing the data in table format on an excel spreadsheet (Microsoft, Inc, Redmon, Washington State). Data were analyzed qualitatively by using thematic analysis following the research objectives.

Inclusion Criteria	Exclusion Criteria
1) Articles that discuss the relationship between caries, body weight, and body height	1) Literature review articles, case reports, editorials, conference abstracts
2) The relationship between caries with weight and height was examined in preschool children or children aged 3-6 years	2) Articles assessing body mass index
3) Articles in English	
4) Articles are available in full text and accessible	
5) Articles published within the last 10 years (2012-2022)	

Table 1. Inclusion and Exclusion Criteria.

Results

Based on the results of a literature search through three databases, 40 articles were identified through the Pubmed database, 56 articles through Science Direct and eight articles through the Cochrane Library, and the number of articles identified was 104 articles. Then a duplication check was carried out, three duplicate articles were obtained, and the remaining articles were 101. A total of 91 articles were excluded after screening based on title and abstract because they did not meet the inclusion criteria. Three articles were excluded from the remaining articles (n=10) after reading the full text. Seven articles that met the inclusion criteria were included in the systematic review. A flowchart of the search process is shown in figure 1. The JBI Critical Appraisal Tools were used to assess the risk of bias for each included study. A summary of the risk assessment of bias is shown in table 2.

Of the seven studies assessed, two articles had a low bias, and five articles had a moderate bias. Of the seven studies, 'no' ratings were primarily found in the domain of confounding factors. Only two studies were found to identify confounding factors and strategies to address them.

No	Question	Shen et al[15]	Ndekero et al[16]	Khanh et al[17]	Edalat et al[18]	Olatosi et al[19]	Zahid et al[20]	Seminario at al[21]
1.	Q_1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2.	Q_2	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3.	Q_3	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4.	Q_4	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5.	Q_5	No	No	No	No	Yes	No	Yes
6.	Q_6	No	No	No	No	Yes	No	Yes
7.	Q_7	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8.	Q_8	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Result		6/8	6/8	6/8	6/8	8/8	6/8	8/8
		Bias Moderate	Bias Moderate	Bias Moderate	Bias Moderate	Bias Low	Bias Moderate	Bias Low

Note:Q_1-Q_8 are questions 1 to 8 for articles with a cross-sectional design according to The Joanna Briggs Institute (JBI) Critical Appraisal checklist Category: Value 1-3 = High bias (high bias); value 4-6 = moderate bias; value 7-8 = low bias (low bias)

Table 2. Assessment of the risk of bias using the JBI Critical Appraisal Tools.

The characteristics of the seven studies included in the review are shown in table 3 and table 4. Six of these articles used a cross-sectional study design[16,17,18,19,20,21], and one used a longitudinal study[15]. Each study was conducted in a different country, China[15], Tanzania[16], Vietnam[17], Iran[18], Nigeria[19], Nepal[20] and Peru[21], with a study sample ranging from 67 to 871 children with an average age of three to six years. All studies used research methods by measuring body weight and height for anthropometric assessment. The anthropometric assessment method for children in each article is carried out by assessing weight and height and then converting them into z-scores according to WHO standards. Examination of dental caries in each study was based on a visual/tactile inspection by assessing the dmft index. In addition, all studies included demographic data and assessments of eating and oral health habits through questionnaires[15,16,19,21], survey questions[17], and interviews[20].

In the seven articles analyzed, each article showed the incidence of dental caries in the sample studied. For example, the study by Shen et al. showed that the average dmft index at the initial stage was 3.18 and increased to 4.21 at the follow-up stage[15], Ndekero et al. in their study stated that the prevalence of ECC in preschool children was 44.8%[16], Khanh et al. in their study showed an ECC prevalence of 74.4%[17], Edalat et al. found 55% of children in the study had severe ECC[18], Olatosi et al. said in their study active decay accounted for 96% of the dmft observed in the study[19], Zahid et al. found the frequency of caries in children under six years of age is 58%.[20] Seminario et al., in their study, stated that the prevalence of dental caries was 97.0%. The average dmft/DMFT was 7.2[21].

An overview of the relationship between body weight and caries in each article analyzed are in articles with moderate bias, and two articles stated that weight for age z-score had a negative and significant relationship with the index score dmft.[15,16] One article mentions that caries is associated with low body weight, as indicated by low weight for age z-score.[17] One article found that 14 of 25 underweight children had severe caries, but there was no significant association between increased caries and weight loss.[18] While in the low-bias articles, one article stated a positive but not significant relationship between the weight for age z-score (WFAZ) and caries.[19]

An overview of the relationship between height and caries in each article analyzed, that is, in articles with moderate bias, two articles found a correlation of height-for-age z-score that was not statistically significantly different from the index score dmft.[16,17] One article found that 6 out of 10 height-deficient children had severe caries, but there was no significant association between increased caries and decreased height.[18] In the low-bias articles, one article stated a positive but insignificant correlation between the height for age z-score and caries.[19]

Two articles stated that children with low nutritional status had high rates of dental caries; the two articles also stated a bidirectional relationship between nutritional status and DMFT which showed a negative relationship.[15,19]

One article did not find severe early childhood caries (S-ECC) in children under six years of age to be associated with a risk of malnutrition such as stunting, overweight and undernutrition[20]. One article made did not mention the relationship between caries in

primary teeth and anthropometry.[21]

Discussion

In this study, we reviewed seven studies that researched the relationship between caries, body weight and height. The studies reviewed researched preschool-age children or 3-6 years old. Preschool-aged children with dental caries included in each study were assumed to be in general medical health. The discussion of the seven studies is further explored below.

The majority of the age of the research sample is 3-6 years old, which is preschool-age children. While one study used a sample of children aged six months to 12 years, who were divided into 2 groups: the 6 months to less than 6 years group and the 6 years to less than 12 years group.[20] Another study used a sample of children aged 18 years and under which were divided into 3 age groups, namely the age group less than 5 years, the age group 6 years to 12 years, and the age group 13 years to 18 years.[21] Differences in results between included studies could be related to differences in the age of the research subjects. Study by Zahid et al found no association between S-ECC and the risk of malnutrition such as stunting, underweight and malnutrition in children under 6 years, however there was a significant relationship between significant index caries (SiC) and height for age z-score low levels are found in children aged 6 to 12 years.[20]

Dental caries is a disease that affects the hard tissues of the teeth, and cause tooth loss due to the demineralization process by acids produced by bacteria. Dental caries is multifactorial or influenced by several factors.[6] The seven articles studied used the WHO index of decayed, missing, filled primary teeth (dmft).[15–21] Other article also used the PUFA assessment to see the consequences of deep caries conditions that did not treated.[20] The majority of dental caries examinations were performed by dentists, one article mentioned dental caries examination by trained volunteers[20], and two articles provided no information[18,21]. Diagnosis of dental caries is done by visual oral examination without radiography. Differences in caries rates were found in each study in this study. This is due to various factors such as economic status, eating habits, and awareness to maintain oral health.

The respective studies were conducted on samples from developing countries. The study by Ndekero et al stated that the prevalence of caries reported in this study was higher than the prevalence in developed countries, this is because developed countries have integrated caries prevention policies and programs.[16] The samples used in several studies included children from rural and urban area[15,20], as well as rural and semi-urban areas.[16] A study by Ndekero et al found that children living in rural areas had a greater impact on ECC than children living in semi-urban areas. This is caused by inadequate information about oral health care and inefficiency in conducting oral hygiene training. Lack of parental assistance during tooth brushing and poor awareness of oral health practices caused most of the preschool children in the study to have poor oral hygiene.[16] Shen et al also found that 63.2% of children cleaned their teeth less than once a day, and 53.27% of children did not visit the dentist in the last 12 months.[15] This poor oral hygiene practice can encourage the development of dental caries.[22]

Generally, preschool-age children like to eat sweet foods such as biscuit.[7] Several studies in this study revealed an association between consumption of sweet foods and dental caries in children. The majority of children surveyed in Zahid et al's study showed children under 6 years of age who had caries, consumed sweet foods every day.[20] Not only children who like sweet foods, some the study also found that children who were exclusively breastfed, as well as children who drank milk with a bottle or both (breastfeeding and bottle-feeding) showed an increase in dental caries.[15,19]

Increasing the severity of caries affect the growth of children. Assessing a child's growth can be done by measuring the body weight and height. The method of measuring body weight and height in each study is the same. The seven articles convert the assessment of the child's weight, height and age into z-scores according to WHO standards, which were weight for age (WAZ) and height for age (HAZ). The nutritional status index categories found in this study for WAZ were underweight and severe underweight and for HAZ were stunting and severe stunting. Four of the seven articles also assessed body mass index[17,19–21], and two of the seven articles assessed weight for height[16,19]. Detailed descriptions of anthropometric measurement

standards are reported in five articles (such as children wearing light clothing and removing shoes).[15–17,19,20] The studies examined demonstrated that dental caries is associated with lower body weight and height for age. While in Olatosi et al's study, the results of the assessment of height for age z-score, weight for age z-score and dmft showed a positive relationship describing low dmft levels in stunting and underweight children, a negative relationship was found between body mass index for age z-score, weight for height z-score with dmft.[19]

The majority of studies found high dental caries in children with a deficiency in weight and height. Some of these studies stated that untreated severe caries causes chronic inflammation that can affect the ability to eat, decreased appetite and sleep disturbances in children.[15,17,20] Children with dental caries difficult to chew food due to pain when chewing. Thus, the presence of masticatory disorders causes nutritional intake that is less than optimal because children cannot consume food properly.[23] This finding is equal to other studies showing dental caries as a risk factor for stunting due to a decline food proteins.[24–26]

Two studies said that children with malnutrition or lack of weight and height affect the composition of saliva so that it predisposes to dental caries.[15,19] Protein Energy Malnutrition (PEM) occurs when there is a lack of protein, energy from food or both, so that it does not suit the needs of the body. Manifestations of PEM are measured in underweight (low weight for age), stunting (lower height for age) and malnutrition (lower weight for height).[25,27] There is research that stated malnutrition conditions such as vitamin, zinc and iron deficiencies can increase the risk of dental caries. due to disturbances in salivary secretion.[28] Saliva has an important role in maintaining the health of the oral cavity by protecting the teeth and mucosa from the effects of acid. PEM conditions and vitamin A deficiency have a relationship with the occurrence of salivary gland hypofunction which results in decreased salivary flow rate and buffer capacity, which reduces the ability to retain acid from plaque.[28,29]

The bidirectional relationship between body weight, height and dental caries can be explained by various factors related to caries risk factors such as consumption of a high-sugar diet, oral health practices, visits to the dentist and factors that affect children's growth such as environmental factors, genetics, nutrition and eating habit. Besides being a risk factor for caries, high consumption of sugar appears to be a risk factor for obesity.[15] Controlling risk factors can prevent oral health problems and growth in children. Health promotion program for preschool children to reduce daily consumption of a high-sugar diet and carry out caries screening in early childhood.

The three studies did not examine intra- or interexaminer reliability[17,18,21] as this may affect the accuracy of caries diagnosis, so future studies are necessary to provide a standard for measuring dental caries. The two articles do not describe the standard procedure for anthropometric measurements[18,21] that it is possible to influence the accuracy of the information. The results of research on the relationship between body weight, height and dental caries were only found in samples from developing countries, so future studies can provide a comparison of the results of the relationship between weight, height and caries in samples of developing countries. Information from a literature review regarding the bidirectional relationship between body weight, height and caries is very limited. Correlational research that directly examines this bidirectional relationship needs to be carried out to strengthen the assumptions that have been put forward in this study.

Conclusions

Based on the results of a systematic review of seven research journals regarding the relationship between caries, weight, and height in preschool children, it can be concluded that the majority of studies show a relationship between caries and malnutrition in this case lack of weight and height. A bidirectional relationship is seen, that is caries causes a risk of underweight and stunting due to chronic inflammation which causes mastication disorders, resulting in suboptimal nutritional intake. Saliva to protect the oral cavity from acids decreases.

Declaration of Interest

The authors report no conflict of interest.

Author (year)	Article title	Country	Research design	Sample	Research Method	Result
Shen A, et al (2019)[15]	The bidirectional relationship between weight, height, and dental caries among preschoolchildren in China	China	Longitudinal Study	1,111 at baseline 722 at follow-up	1. Anthropometric measurements 2. Assessing the dmft index 3. Questionnaire	1. The mean dmft index increased at follow-up stage; Significant negative associations between early dental caries and children's growth were shown by height-for-age, and weight-for-age
NdekeroTS, et al (2021)[16]	Prevalence of early childhood caries, risk factors and nutritional status among 3-5-year- old preschool children in Kisarawe, Tanzania.	Tanzania	cross-sectional study	831	1.Anthropometric measurements 2. Assessing the dmft index 3. Questionnaire	The prevalence of ECC is 44.8% ; The dmft score index is negative and significant with the height for age z-score ; The dmft score index is not statistically significant with the height for age z-score
Khanh LN,et al (2015)[17]	Early Childhood Caries , Mouth Pain , and Nutritional Threats in Vietnam	Vietnam	cross-sectional study	593 parent-child pairs	1.Anthropometric measurements 2. Assessing the dmft index 3. Survey questions	Prevalence of ECC (74.4%); A significant relationship between z-score weight and BMI-for-age) and experience of dental caries; The mean height-for-age z-scores did not differ significantly according to the severity of dental caries
Edalat A,et al (2014)[18]	The Relationshipof Severe Early Childhood Caries and Body Mass Index in a Groupof 3- to 6-year- old Children in Shiraz.	Iran	Descriptive analytical cross- sectionl study	202	1.Anthropometric measurements 2. Assessing the dmft index 3. Record socio demographic data, Medical history	14 of 25 children with weight deficiency have dmft above 3; 6 of 10 children with height deficiency have dmft above 3; 55% of the children studied had SECC; There is no significant relationship between increased caries and decreased body weight and height.
Zahid N, etal (2020)[20]	Associations between Child Snack and Beverage Consumption, Severe Dental Caries, and Malnutrition in Nepal.	Nepal	cross-sectional study	273 children under 12 years	1.Anthropometric measurements 2. Assessing the dmft+DMFT, PUFA+PUFA 3. Interview	Children under 6 years of age have a higher weight-for-age z-score (BAZ) than children over 6 years of age; The frequency of caries in children under 6 years of age is 58%.

Table 3. Results of analysis of reviewed articles (moderate bias).

Author (year)	Article title	Country	Research design	Sample	Research Method	Result
Olatosi OO, et al(2022)[19]	Dental Caries Severity and Nutritional Status of Nigerian Preschool Children.	Nigeria	Cross-sectional study	273 ecc cases	1.Anthropometric measurements (body weight, height and body mass index according to age z-score, weight fir height according to z-score) 2.Assessing the dmft index 3.Questionnaire	1. 96% active decay of the dmft observed in the study 2. The correlation between HFAZ, WFAZ and dmft is positive but not significant 3. High dmft scores in the group of children with severe or severe malnutrition assessed by body mass index for age z-score 4. The bidirectional relationship between nutritional status and dmft showed a negative relationship
Seminario, AL et al (2022)[21]	Dental caries and anthropometrics ofchildren living in an informal floating Amazonian community: a cross-sectional pilot study.	Peru	Cross-sectional study	67	1.Anthropometric measurements (body weight, height and body mass index according to age z-score) 2.Oral examination (dmft/DMFT ,SiC index) 3.Questionnaire (demographic, & nutrition data)	1. The prevalence of dental caries is 97.0%. Average dmft/DMFT is 7.2 2. Half of the study population had normal weight (37, 55.2%), 13 were stunting (19.4%) and 1 wasting (1.5%) 3. Not stated regarding the relationship between caries in primary teeth and anthropometry

Table 4. Analysis results of reviewed articles (low bias).

References

1. Uribe SE, Innes N, Maldupa I. The global prevalence of early childhood caries: A systematic review with meta-analysis using the WHO diagnostic criteria. International Journal of Paediatric Dentistry. 2021;31(6):817–30.
2. Alswat K, Mohamed WS, Wahab MA, Aboelil AA. The Association Between Body Mass Index and Dental Caries: Cross-Sectional study. Journal of Clinical Medicine Research. 2016;8(2):147–52.
3. Kementerian Kesehatan Republik Indonesia. Laporan Nasional Riskesdas 2018. Jakarta: Badan Penerbit Penelitian dan Pengembangan Kesehatan; 2019. 1–627 p.
4. Prastiwi MH. Overview of Growth and Development in Children Age 3-6 Years. Jurnal Ilmiah Kesehatan Sandi Husada. 2019;10(2):242–9.
5. Li LW, Wong HM, Peng SM, McGrath CP. Anthropometric measurements and dental caries in children: a systematic review of longitudinal studies. Advances in nutrition (Bethesda, Md). 2015;6(1):52–63.
6. Mathur VP, Dhillon JK. Dental Caries: A Disease Which Needs Attention. Indian Journal of Pediatrics. 2018;85(3):202–6.
7. Elamin A, Garemo M, Gardner A. Dental caries and their association with socioeconomic characteristics, oral hygiene practices and eating habits among preschool children in Abu Dhabi, United Arab Emirates - the NOPLAS project. BMC Oral Health. 2018;18(1):1–9.
8. Uerlich MF, Baker SR, Day PF, Brown L, Vettore M V. Common determinants of dental caries and obesity in children: A multi-ethnic nested birth cohort study in the United Kingdom. International Journal of Environmental Research and Public Health. 2021;18(23).
9. Zulkifli N, Rahardjo A, Darwita RR, Adiatman M. Self-Reported Oral Health Problems and Risk Factors Associated with 3–6-year-old Children Nutritional Status in Indonesia. Journal of International Dental and Medical Research. 2022;15(1):190–8.
10. Madhusudhan KS, Khargekar N. Nutritional status and its relationship with dental caries among 3–6-year-old Anganwadi children. Int J Clin Pediatr Dent. 2020;13(1):6–10.
11. Abdat M, Usman S, Chairunas C, Suhaila H. Relationship between stunting with dental and oral status in toddlers. Journal of Dentomaxillofacial Science. 2020;5(2):114.
12. Sadida ZJ, Indriyanti R, Setiawan AS. Does Growth Stunting Correlate with Oral Health in Children ?: A Systematic Review. Eur J Dent. 2022;16(1):32–40.
13. Setiawan AS, Abhista N, Andisetyanto P, Indriyanti R, Suryanti N. Growth Stunting Implication in Children: A Review on Primary Tooth Eruption. Eur J Gen Dent. 2022;11(1):7–16.
14. Page MJ, Moher D, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. The BMJ. 2021;372:n160.
15. Shen A, Bernabé E, Sabbah W. The bidirectional relationship between weight, height and dental caries among preschool children in China. Denis F, editor. PLOS ONE.

2019;14(4):e0216227.

16. Ndekero TS, Carneiro LC, Masumo RM. Prevalence of early childhood caries, risk factors and nutritional status among 3-5-year-old preschool children in Kisarawe, Tanzania. PloS one. 2021;16(2):e0247240.

17. Khanh LN, Ivey SL, Sokal-Gutierrez K, Barkan H, Ngo KM, Hoang HT, et al. Early Childhood Caries, Mouth Pain, and Nutritional Threats in Vietnam. American journal of public health. 2015;105(12):2510–7.

18. Edalat A, Abbaszadeh M, Eesvandi M, Heidari A. The Relationship of Severe Early Childhood Caries and Body Mass Index in a Group of 3- to 6-year-old Children in Shiraz. Journal of dentistry (Shiraz, Iran). 2014;15(2):68–73.

19. Olatosi OO, Alade AA, Naicker T, Busch T, Oyapero A, Li M, et al. Dental Caries Severity and Nutritional Status of Nigerian Preschool Children. JDR clinical and translational research. 2022;7(2):154–62.

20. Zahid N, Khadka N, Ganguly M, Varimezova T, Turton B, Spero L, et al. Associations between Child Snack and Beverage Consumption, Severe Dental Caries, and Malnutrition in Nepal. International journal of environmental research and public health. 2020;17(21).

21. Seminario AL, Alpert E, Bernabé E, Liu J, Andrews L, Alarcón JA, et al. Dental caries and anthropometrics of children living in an informal floating Amazonian community: a cross-sectional pilot study. Brazilian dental journal. 2022;33(1):87–95.

22. Anil S, Anand PS. Early Childhood Caries: Prevalence, Risk Factors, and Prevention. Frontiers in pediatrics. 2017;5:157.

23. Alshihri AA, Rogers HJ, Alqahtani MA, Aldossary MS, El Tantawi M. Association between Dental Caries and Obesity in Children and Young People: A Narrative Review. International Journal of Dentistry. 2019;2019:8.

24. Yani RWE, Ma'rufi I, Rahayu T. Dental Caries Status and Dietary Characteristics During the Covid-19 Pandemic Towards Increased Risk of Stunting among Preschool Children. Journal of International Dental and Medical Research. 2022;15(1):151–7.

25. Yohana S, Indriyanti R, Suryanti N, Rahayuwati L, Juniarti N, Setiawan AS. Caries Experience among Children with History of Neonatal Stunting. Eur J Dent. 2022 Sep 8;

26. Mahriani Y, Indriyanti R, Musnamirwan IA, Setiawan AS. A cross-sectional study on dietary assessment, oral hygiene behavior, and oral health status of adolescent girls. Front Nutr [Internet].2022 Oct 5;9:973241. Available from: https://www.frontiersin.org/articles/10.3389/fnut.2022.973241/ful

27. Bhutia D. Protein energy malnutrition in India: The plight of our under five children. J Family Med Prim Care. 2014;3(1):63–7.

28. Sheetal A, Hiremath VK, Patil AG, Sajjansetty S, Sheetal Kumar R. Malnutrition and its oral outcome - A review. Journal of Clinical and Diagnostic Research. 2013;7(1):178–80.

29. Sianturi E, Primarti RS, Setiawan AS. A self-reported cross-sectional study on the oral function and the quality of life in children with stunted growth. Front Pediatr. 2023 Jan 5;10.