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Sugar-Sweetened Beverages, Obesity, and Dental Caries among School Children in Indonesia: A Cross-Sectional Study

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ABSTRACT

Background: The prevalence of obesity among school-aged children has been increasing annually, and excessive sugar consumption is linked to a higher incidence of dental caries in this population. This study aims to analyze the relationship between Sugar-Sweetened Beverages (SSB) consumption and the obesity as well as dental caries among school children in Indonesia. **Methods:** This research is a quantitative observational study using a cross-sectional design. The study sample consisted of 121 elementary school children aged 9-12 years, selected through proportional random sampling. Data were collected included respondent characteristics, SSB consumption was assessed by a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), dental caries by the DMF-T/def-t index, and nutritional status based on BMI-for-age. Data were analyzed using the chi-square test. **Results:** The results showed a significant relationship between gender and nutritional status (P=0.003; OR=3.2), while SSB consumption was not associated with obesity. However, there was a relationship between the contribution of energy intake from SSB and the incidence of dental caries based on the def-t index (P=0.035; OR=2.2). Age was also found to be associated with dental caries in primary teeth (P=0.007, OR=0.4). A total of 41.3% of respondents indicated obese was another important finding. **Conclusion:** According the result of study, there is a need to reduce or limit SSB intake among school-aged children. Further studies and preventive strategies are needed to address the high prevalence of childhood obesity.

Introduction

Obesity, a multifactorial condition marked by excessive body fat due to energy imbalance, is influenced by genetic and lifestyle factors, leading to higher risks of diabetes and cardiovascular diseases (Panuganti *et al.*, 2024). As of 2022, over 390 million children and adolescents aged 5 to 19 were overweight, from 8% in 1990 to 20% in 2022, with boys at 21% and girls at 19% (World Health Organization (WHO), 2025). In Indonesia, 2018 data showed 9.2% of children aged 5-12 were obese, with East Java having an 11.1% prevalence. Moreover, a study in

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Surabaya reported a 23.9% obesity rate among schoolchildren (Farapti *et al.*, 2019).

Fat accumulation in children can cause serious health issues, including cardiovascular diseases and dental problems (Lin and Li, 2021). Studies on the link between obesity and dental caries in different countries have yielded mixed results, some showing no connection, while others indicating a correlation (Alshihri *et al.*, 2019). High sugar intake significantly raises the number of decayed, missing, and filled teeth (Naorungroj, 2020). The mixed dentition period, from ages 6 to 9, is critical for preventing dental caries (Supriatna *et al.*, 2017). In addition, the 2017 Global Burden of Disease study found over 530 million children worldwide had dental cavities in their primary teeth (World Health Organization, 2020). The prevalence of dental caries varied significantly across countries, with pooled rates of 65% for deciduous teeth in 5-year-olds, 61% for permanent teeth in 12-year-olds, 70% for 15-year-olds, and 66% for children aged 6 to 15 (Kale *et al.*, 2020).

Obese individuals are more prone to dental caries, often due to high consumption of sweetened beverages, which are energy-dense but nutritionally poor (Ashour *et al.*, 2018, Bassa *et al.*, 2023). In Indonesia, these beverages contain up to 54 grams of sugar per serving, far exceeding recommended limits (Akhriani *et al.*, 2016). Studies show that 62% of Indonesian children aged 4-9 consume excessive sweetened beverages, leading to higher sugar preferences (Farapti *et al.*, 2024, Laksmi *et al.*, 2018). However, previous studies examining the association between Sugar-Sweetened Beverages (SSB) consumption, obesity, and dental caries among children have yielded inconsistent findings, possibly due to the complex and multifactorial nature of these conditions. Therefore, this study aimed to examine the relationship between SSB consumption and obesity status as well as dental caries among school children in Indonesia.

Materials and Methods

Design of study and participants

This was a quantitative observational research with a cross-sectional study design conducted at Al-Azhar Elementary School, Kelapa Gading, Surabaya. Ethical approval for the study was obtained from the Health Research Ethics Committee of Universitas Airlangga Faculty of Dental Medicine, Surabaya, Indonesia (Date: April 16, 2019, Number: 154/HRECCFODM/IV/2019). The participants were fourth and fifth-grade students aged 9-12 years, with inclusion criteria including not being in a fasting state or on a diet during the study, being in good health, and willing to participate in the research. Students undergoing dental treatments such as braces or intensive training (athletes) were excluded from the study. Also, the sampling technique used was proportional random sampling, resulting in a sample size of 121 children. This study was conducted from January to July 2019.

The sample size for this study was determined using the formula for the hypothesis test of the difference between two proportions by Lemeshow 1997 with a 95% confidence level (Z=1.96) and an estimated proportion of 0.44 based on a study by Lakoro et al (Lakoro et al. 2016). The total number of fourth and fifth-grade students at Al-Azhar Kelapa Gading Elementary School in Surabaya is 140. Therefore, the minimum sample size for this study was calculated to be 102 respondents. The sample was selected using proportional random sampling by distributing screening forms to all eligible students and selecting participants proportionally from each class. Inclusion criteria included healthy students aged 9–12 years who were willing to participate, while students undergoing dental treatment, intensive athletic training, fasting, or dieting were excluded from the study.

Before collecting primary data, an ethical review was conducted to ensure respondent protection. Respondents were then provided with an explanation of the study and were required to sign an informed consent form to indicate their agreement to participate. Data collected included respondent characteristics (age, gender, amount of pocket money, physical activity, knowledge about sweetened beverages, and dental health

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behaviors), sweetened beverage consumption habits, obesity status, and dental caries.

Measurements

Data collection methods involved interviews. Respondent characteristics were identified using questionnaires; physical activity through Physical Activity Questionnaire for Children (PAQ-C), sweetened beverage consumption habits through Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ), and obesity status based on body mass index (BMI)-for-age using WHO AnthroPlus software, while dental caries were assessed using the DMF-T (Decay, Missing, Filled Teeth) and def-t (decayed, extracted, filled teeth) indices. The SQ-FFQ was adapted based on preliminary surveys and direct observations of sugar-sweetened beverages commonly consumed and sold within the school environment and surrounding food vendors to ensure its relevance to the study population. The DMF-T index was used to evaluate secondary caries in permanent teeth with permanent fillings, whereas the def-t index was used to assess primary teeth or teeth with temporary fillings. Dental examinations were conducted during the study period with the trained dentist using WHO standardized assessment procedures to determine the respondents' dental caries status.

Ethical considerations

Prior to data collection, an ethical review was conducted to ensure the protection of respondents. All participants were informed about the study, and informed consent was obtained from the parents and the class teachers who served as witnesses, as the study involved school-aged children aged 9-12 years. The study was conducted in accordance with relevant guidelines, including the Declaration of Helsinki, to protect these vulnerable participants.

Data analysis

Univariate analysis provides a general overview of the research problem by analysing the distribution and percentage of each variable. It is used to determine the frequency distribution, percentage, average, and median of variables such as age, gender, allowance, sweet drink consumption patterns, knowledge about sweet drinks, DMF-t index results, oral hygiene habits, and nutritional status. Data is presented in tables. Moreover, bivariate analysis utilizes the chi-square test to examine the relationship between sweet drink consumption patterns and both nutritional status and the DMF-T dental caries index. A significance level of alpha 5% or P-value>0.05 indicates no significant relationship, while P-value<0.05 indicates a significant relationship.

Results

The respondents in this study had an average age of 10.30±0.70 years, with other characteristics shown in **Table 1**. Male respondents (53.7%) were more than female ones (46.2%). The majority (57.9%) had pocket money of ≤Rp15,000, with an average of Rp15,876.00±8,511.34. The mean of energy intake from sweetened beverages and Sugar intake from sweetened beverages obtained 655.0±531.4 (kcal/day) and 64.6±58.1 (g/day), respectively. Through the identification of physical activity using the PAQ-C questionnaire, it was found that respondents with a high level of physical activity (43%) were fewer than those with a low level of physical activity (57%). A total of 41.3% of respondents were overweight or obese. This figure includes respondents who were overweight (18.2%) and obese (23.1%). The prevalence of dental caries based on the DMF-T index (55.4%) and the def-t index (59.5%) was also higher compared to those without caries. Based on these two indices, it was determined that the severity of caries in this population was categorized as moderate with a value of 3.4.

Dental hygiene behaviours included the time and frequency of tooth brushing, frequency of dentist visits, and the use of fluoride toothpaste. The results showed that the majority had good dental hygiene (53.7%). Knowledge about sweetened beverages was also dominated by respondents with good knowledge (68.5%). However, the majority of respondents had a high risk of excessive energy (60.3%) and sugar (51.2%) intake from sweetened beverages. Based on **Table 2**, it can be seen that the mean consumption of sweetened beverages that contributed the most to total energy was milk and tea.

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Table 1. Charactristics of study participants.

Variables	n	%
Age category (y)		
9-10	72	59.5
11-12	49	40.5
Sex		
Boys	65	53.7
Girls	56	46.2
Pocket money (Rp)		
>Rp15,000	51	42.1
≤Rp15,000	70	57.9
Physical activity level		
High	52	43
Low	69	57
Dental hygiene		
Good	65	53.7
Fair	56	46.2
Knowledge about sweetened beverages		
Good	83	68.5
Poor	38	31.4
Energy intake from sweetened beverages (kcal/day)		
High risk (>10%)	73	60.3
Low risk (≤10%)	48	39.7
Sugar intake from sweetened beverages (g/day)		
High risk (>50g)	62	51.2
Low risk (≤50g)	59	48.8
Nutritional status		
Obese	50	41.3
Not obese	71	58.7
Dental Caries (DMF-T)		
Caries	67	55.4
No caries	54	44.6
Dental Caries (def-t)		
Caries	72	59.5
No caries	49	40.5

Table 2. Mean of total energy from the consumption of various types of sweetened beverages (kcal/day).

Type of beverages	Mean ± SD
Soda	71.85±218.30
Tea	130.96±121.50
Flavored beverages	78.56±133.20
Health/sports drinks	49.38±82.79
Milk	212.22±178.30
Coffee	22.49±55.69
Fruit juice	66.53±107.60
Functional drinks	17.56±45.70

The relationships between variables can be seen in **Table 3**. Based on the characteristics of the respondents, only gender was related to obesity status (P<0.05). Boys were 3.2 times more likely to be overweight than girls. Age (P=0.007) and energy intake from sweetened beverages (P=0.035) were associated with dental caries based on the def-t index. Children aged 11–12 years had lower odds of experiencing dental caries compared with children aged 9–10 years (OR=0.36). Children with a high risk of excessive energy intake and sugar intake from sweetened beverages were 2.21 and 2.03 times respectively more likely to experience dental caries. Multivariable analysis was not performed because most independent variables showed p-values >0.25 in the bivariate analysis and therefore did not meet the criteria for inclusion in the multifactorial model.

Table 3. Analysis results of the relationships between study variables.

Variables	Nutritional Status		Dental caries (DMF-T)		Dental caries (def-t)	
	P-value[a]	OR	P-value	OR	P-value	OR
Age (y) 11-12 9-10	0.39	0.72	0.48	1.29	0.007	0.35
Sex Boys Girls	0.003	3.18	0.14	0.58	0.80	0.91
Pocket money >Rp15,000 ≤Rp15,000	0.91	0.96	0.59	1.21	0.91	0.96
Physical activity level High Low	0.57	0.81	0.65	1.17	0.69	1.16

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Dental hygiene Good Fair	0.95	0.98	0.46	0.76	0.17	1.66
Knowledge about sweetened beverages Good Poor	0.90	1.04	0.98	0.99	0.52	0.77
Energy intake from sweetened beverages High risk (>10%) Low risk (≤10%)	0.23	0.63	0.33	1.43	0.03	2.21
Sugar intake from sweetened beverages High risk (>50 g) Low risk (≤50 g)	0.55	0.80	0.54	1.25	0.04	2.03
Nutritional status Obese Not obese			0.53	0.79	0.51	0.78
Dental caries (DMF-T) Caries No caries	0.531	0.793				
Dental caries (def-t) Caries No caries	0.510	0.781				

[a]: *Chi-square test.*

Discussion

A total of 60.3% of the respondents in this study consumed sweetened beverages beyond the recommended limit of 10% of total energy intake. In fact, the average energy intake from sweetened beverages was three times the recommended amount for children aged 9-12 years (assuming a daily energy requirement of 2000 calories per day). These results are consistent with the findings of Sudono and Paramita, which showed that energy and sugar intake exceeded the recommended standards (Gómez-Miranda *et al.*, 2022). The highest total energy contribution from sweetened beverages came from milk and tea, due to their availability in the school canteen. A study at a junior high school in Bengkulu City also found that milk and tea were the beverages most frequently consumed by students. Packaged milk and unpackaged tea significantly contribute to total energy intake and require careful monitoring, especially for individuals with obesity (Qoirinasari et al. 2018).

The prevalence of childhood obesity in this study was 41.3%, significantly higher than the national prevalence in 2018, which was 9.2% for children aged 5-12 years, and higher than a study which reported a 23.9% obesity rate among the subjects (Farapti *et al.*, 2019, Ministry of Health of the Republic of Indonesia 2019). The prevalence of overweight and obesity in this study was relatively high, which may be related to the urban and high socioeconomic background of the participants. However, both data sources indicate that males are at a higher risk of developing obesity. This trend is observed globally, particularly in high and upper middle-income countries. For example, in 44 of 88 (50%) high and upper middle-income countries, the prevalence of obesity in boys was almost two-fold greater than girls within the same age group (Shah *et al.*, 2020). This could be because school-aged boys tend to have a higher food intake, contributing to the occurrence of obesity. In contrast, girls often restrict their food portions. Previous studies reported that boys tend to be more satisfied with their body image and less concerned about body weight compared with girls, which may contribute to higher food and energy intake among male adolescents (Bibiloni *et al.*, 2013). The intake of school-aged children is influenced in part by their pocket money. Generally, the larger the

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amount of pocket money a child has, the greater their ability to purchase food and beverages, leading to excessive intake regardless of nutritional content (Rosyidah and Andrias 2015). However, in this study, no relationship between the two variables was found. According to Muliawati the lack of association may be due to respondents not spending all of their pocket money (Muliawati, 2018). Limitation of this study was the absence of total daily energy intake assessment, which may better reflect the overall risk of obesity among children.

Physical activity among the children who participated as respondents was predominantly low. This is due to their daily routines being fairly uniform from morning until afternoon (homogeneous) and being scheduled. School-aged children are required to follow set lesson schedules, spending around 45 minutes per class period in a seated position. These activities take place from Monday to Friday. A study reported that many children did not regularly engage in physical activities such as exercise. Nevertheless, respondents in the present study generally demonstrated good knowledge regarding SSB consumption and oral hygiene practices. Most children reported brushing their teeth twice daily using fluoride toothpaste, which may contribute positively to oral health and overall nutritional status. These findings may also reflect the relatively high socioeconomic background and educational environment of the participants, as previous studies have shown that good oral hygiene behaviours, adequate health knowledge, and healthy lifestyle practices are associated with better health outcomes among children and adolescents (Dimaisip-Nabuab *et al.*, 2018, Gupta *et al.*, 2019, Maharani *et al.*, 2017, Virtanen *et al.*, 2019).

SSB are often strongly suspected to be the cause of obesity in children; however, this study did not find a significant association. This finding aligns with several studies which stated that there was no relationship between SSB and Body Mass Index (BMI) (Gómez-Miranda et al. 2022). This may be explained by the multifactorial nature of obesity, which is influenced by total energy intake, physical activity, sedentary behavior, and other environmental factors. Additionally, SSB contribute only a portion of sucrose intake. Many other foods, such as sweet snacks, chocolates, candies, and the like, are also not associated with obesity, as the total energy intake from all foods and drinks is higher when compared to sucrose alone (Nurwanti *et al.*, 2016). However, according to a study by Malik *et al.*, if someone consumes SSB daily, the risk of weight gain increases, potentially leading to chronic diseases such as type 2 diabetes, heart disease, and even early death (Malik and Hu, 2022) Children who frequently consume SSB are at risk of gaining weight in the future (Calcaterra *et al.*, 2023).

Dental caries is a widespread chronic infection caused by cariogenic bacteria, such as Streptococcus mutans, which adhere to teeth and metabolize sugars into acid, leading to the gradual demineralization of tooth structure (Rathee and Sapra, 2024). Similar to the occurrence of obesity, the prevalence of dental caries in the study population also exceeded the national average by 1.9% (Ministry of Health of the Republic of Indonesia 2019). Dental caries remains a major public health concern, with a pooled prevalence of 76% among Indonesian children, exceeding the reported global and lower-middle-income country averages of approximately 42–69% among 12-year-olds (Zhai *et al.*, 2025).

This study shows a significant relationship between age and dental caries based on the def-t index, which measures decay, extraction, and filling in primary teeth. Specifically, children aged 9-10 years are more likely to have primary teeth compared to older age groups, who have started transitioning to permanent teeth. This age group is more susceptible to caries in their remaining primary teeth due to the less resilient enamel and dentin structure. In contrast, the DMF-T index, which measures decay, missing, and filled permanent teeth, shows no significant relationship between age and the incidence of dental caries in this population. This is consistent with a study which reported that 6-year-old children had a

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dental caries prevalence of 1%, whereas 7-year-old children had a prevalence of 28.9% (Kiswaluyo, 2015). Therefore, as a person ages, the incidence of dental caries increases (Ali, 2023). Teeth that remain longer in the mouth will interact more frequently with various cariogenic factors. Good dental hygiene habits in this population provide evidence that the incidence of dental caries in children is not always associated with poor dental care practices. This contrasts with a study conducted in an elementary school in Malang, which showed that the high prevalence of dental caries was closely related to poor oral hygiene and a lack of knowledge about dental health (Gayatri and Ariwinanti, 2016).

Limiting sugar intake to less than 10% of total energy intake is associated with a lower incidence of dental caries in both children and adults (World Health Organization, 2025). Based on the analysis results of this study, there is a relationship between the contribution of energy intake from SSB and the occurrence of dental caries in primary teeth. This aligns with other studies showing that drinking SSB is linked to more cavities in young children and a higher risk of untreated cavities in both children and adults (Laniado *et al.*, 2020). The sweetness of drinks can come from natural or artificial sweeteners. Studies show that artificial sweeteners are not synthesized by oral cavity bacteria, whereas natural sweeteners provide a medium for bacterial growth, especially Streptococcus mutans (Gupta *et al.*, 2013). If these bacteria, or any other bacteria, are not cleaned by proper brushing, they can form colonies and cause dental caries. SSB contain sucrose, which can be found in granulated sugar or cane sugar. This natural sweetener is widely used because it contains nutrients and is relatively cheap, but it is also known as the most cariogenic carbohydrate (causing dental caries) (Du *et al.*, 2020). Therefore, good dental hygiene practices are crucial in influencing the cleanliness of teeth and mouth (Naseem *et al.*, 2017).

The findings of this study should be interpreted with caution due to several limitations. Data collection was conducted in a single private school, which may limit the generalizability of the results to children from different socioeconomic and educational settings. In addition, only fourth- and fifth-grade students were included, as children within this age range were considered more capable of providing reliable responses to dietary intake, knowledge, and physical activity assessments, thereby reducing the potential for recall bias and improving data quality. Nevertheless, efforts to minimize selection bias were undertaken through the application of proportional random sampling across all eligible classes.

Conclusion

There was no significant association between SSB consumption and the incidence of obesity; however, there was a relationship between gender and nutritional status. Boys are three times more likely to be obese compared to girls. Furthermore, a significant relationship was found between age and energy intake from SSB with the incidence of dental caries, based on the def-t index. School-aged children who consume SSB exceeding the recommended energy intake are twice as likely to experience dental caries in their primary teeth. SSB with the highest energy contribution were found to be milk and tea. Therefore, school-aged children should be encouraged to limit their intake of SSB. The high prevalence of obesity observed in this study highlights the need for further research to explore other potential risk factors and for preventive strategies to reduce childhood obesity among school-aged children. Parents and teachers are also expected to actively monitor the dietary intake and oral hygiene of school-aged children to prevent obesity and dental caries.

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Authors' contributions

Farapti F conceptualized, designed, and supervised the project. Wulanita Sari D collected and analyzed the data, interpreted the results, and wrote the original draft. Farapti F, Sheila Amara Putri

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P, Fadilla C, Ambrose Kalpana C critically revised the manuscript. Finally, Ambrose Kalpana C supervised the project.

Conflict of interests

There are no conflicts of interest

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