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Intake of simple sugars as a risk factor for decay in permanent first molars in children

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Abstract

Background: Dental caries remains one of the most prevalent oral health problems among school-aged children globally, including in Indonesia. Excessive intake of simple sugars is a major risk factor for dental caries, particularly in the first permanent molars, which erupt early and possess deep pits and fissures that facilitate plaque retention.

Purpose: to analyze the relationship between simple sugar intake and the incidence of first permanent molar caries among elementary school students in a stunting locus village in Negeri Sakti.

Method: A cross-sectional study was conducted from July to August 2025 involving 150 fourth- and fifth-grade students selected through total sampling. Simple sugar intake was assessed using a 24-hour food recall and analyzed with NutriSurvey. Dental caries examination of the first permanent molars was performed clinically by dental health professionals. Data were analyzed using the Chi-Square test with a significance level of $p < 0.05$ and Odds Ratio (OR) to determine risk magnitude.

Results: Children with high simple sugar intake had a significantly higher risk of developing first permanent molar caries compared to those with low intake (OR = 3.57; $p = 0.001$).

Conclusion: There is a significant relationship between simple sugar intake and the incidence of first permanent molar caries among elementary school children. Reducing simple sugar consumption may play a crucial role in preventing dental caries, particularly in high-risk populations living in stunting locus areas.

Keywords: Dental Caries; Permanent Molar; Simple Sugar Intake; School Children.

INTRODUCTION

Oral and dental health is an integral part of general health and plays a vital role in supporting the quality of life of school-age children. One of the most common oral health problems in this age group is dental caries, a chronic, multifactorial disease that remains a global public health problem, including in Indonesia. Data from the 2018 Basic Health Research shows that approximately 93% of children aged 5–12 years' experience oral health problems, and more than half

suffer from active dental caries (Ministry of Health of the Republic of Indonesia, 2018).

Permanent first molars are the teeth most susceptible to caries in elementary school children. These teeth erupt around the age of six and are often mistaken for baby teeth, thus receiving less attention in care. Furthermore, the morphology of first molars, with their deep pits and fissures, makes them ideal locations for plaque and food debris retention, increasing the risk of caries (Wong, Lam, Lai, Tam, & McGrath, 2019). This

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vulnerability is exacerbated by schoolchildren's eating habits, which tend to favor sweet foods and snacks. Elementary school age is a crucial period in the formation of long-term eating habits. During this phase, children begin to have greater autonomy in their food choices, particularly snacks sold in the school environment. Unfortunately, these snacks are often high in simple sugars, low in fiber, and cariogenic (Freeman, Doughty, Macdonald, & Muirhead, 2020). The habit of snacking on sweets between meals leads to a prolonged acidic environment in the oral cavity, which is ideal for enamel demineralization.

One of the main factors contributing to the development of dental caries is the consumption of simple sugars. Simple sugars such as sucrose, glucose, and fructose are readily fermented by cariogenic bacteria in dental plaque, particularly *Streptococcus mutans*, producing acids that lower plaque pH and lead to demineralization of tooth enamel (Fejerskov, Nyvad, & Kidd, 2015). Sucrose, in particular, is known as the "evilest sugar" because, in addition to being fermented into acid, it is also used by bacteria to synthesize extracellular polysaccharides (glucans), which allow bacteria to adhere more firmly to tooth surfaces and form a thick plaque matrix (Pitts, Zero, Marsh, Ekstrand, Weintraub, Ramos-Gomez, & Ismail, 2017). High frequency and quantity of simple sugar consumption, especially from sweet snacks and drinks, have been shown to significantly increase the risk of caries.

The relationship between sugar consumption and dental caries has long been studied and is dose-response, meaning the higher the frequency and amount of sugar consumed, the greater the risk and severity of caries (Sheiham & James, 2015). The World Health Organization (WHO) recommends limiting free sugar consumption (including added sugars in

processed foods and honey) to less than 10% of total daily energy intake, and ideally below 5% for additional health benefits, including caries prevention (World Health Organization, 2015).

Children living in areas where stunting is common are often characterized by unbalanced dietary patterns, including high consumption of sweets and cariogenic snacks. This condition is often influenced by socioeconomic factors and food access. Affordable sugary foods and drinks are preferred, while access to nutritious foods like fruits and vegetables may be limited. This creates a "double burden," where children are at risk of both malnutrition (stunting) and excess sugar intake, which can trigger other health problems such as obesity and dental caries (Peres, Macpherson, Weyant, Daly, Venturelli, Mathur, & Watt, 2019).

RESEARCH METHOD

This study used a cross-sectional design and was conducted from July to August 2025 in Lokus Stunting Negeri Sakti Village, Pesawaran Regency. The study population was all fourth and fifth grade elementary school students in the area. The sample size was 150 students selected using a total sampling method.

Simple sugar intake was measured using a 24-hour food recall method and analyzed using the NutriSurvey application. Simple sugar intake was categorized based on WHO recommendations (2015): high if $\geq 10\%$ of total daily energy and low if $< 10\%$.

Dental caries examinations were performed clinically on the permanent first molars by trained dental health professionals. Data were analyzed univariately to describe the distribution of respondent characteristics, and bivariately using the Chi-Square test with a significance level of $p < 0.05$, along with Odds Ratio (OR) calculations to determine the risk.

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RESEARCH RESULTS

Table 1. Characteristics of Respondent (N=150)

Variable	Results	OR	P-value
Gender (n/%)			
Male	81/54.0		
Female	69/46.0		
Simple Sugar Intake (n/%)		3.57	0.001
High	74/49.0		
Low	76/51.0		
Caries in the First Permanent Molar (n/%)			
Yes	78/52.0		
No	72/48.0		

Based on Table the majority of respondents were male (54.0%). The proportions of high and low simple sugar intakes were relatively balanced, at 49.3% and 50.7%, respectively. More than half of the respondents (52.0%) experienced caries in their first permanent molars, indicating a high caries burden among elementary school children in the study area. The chi-square test results showed a p-value of 0.001 ($p < 0.05$), indicating a statistically significant association between simple sugar intake and the incidence of caries in their lower first permanent molars. The odds ratio (OR) of 3.57 indicates that students with a high intake of simple sugars had a 3.57 times greater risk of developing caries in their lower first permanent molars compared to students with a low intake of simple sugars. This, the results of this study indicate that high intake of simple sugars is a significant risk factor for the occurrence of permanent lower first molar caries in elementary school students.

DISCUSSION

The results of this study indicate a significant association between simple sugar intake and the incidence of caries in permanent first molars in elementary school children. Children with a high simple sugar intake had a 3.57 times greater risk of developing caries than children with a low intake. This finding confirms that simple sugar consumption is a significant determinant of the development of dental caries in school-age children.

Biologically, simple sugars, especially sucrose, act as the primary substrate for cariogenic bacteria such as *Streptococcus mutans* and *Lactobacillus*. Fermentation of sugar by these bacteria produces organic acids that lower plaque pH below the critical threshold (± 5.5), triggering the demineralization of tooth enamel. If acid exposure is repeated and not accompanied by adequate remineralization, the initial lesion will progress

to caries. Permanent first molars are particularly susceptible due to their deep pit and fissure morphology and their early eruption, when children's ability to maintain dental hygiene is not yet optimal (Fejerskov et al., 2015).

The findings of this study (OR = 3.57) indicate a strong association. This is consistent with a study conducted on schoolchildren in Brazil, which found that high sugar consumption, particularly in the form of sweetened drinks, significantly increased the risk of caries in permanent first molars with an OR of 3.2 (Gonçalves, Cardoso, & de Oliveira, 2021). Similarly, a study in Thailand reported that children who habitually consumed sweet foods more than three times daily had a 2.8-fold higher risk of permanent tooth caries than those who rarely consumed them (Chankanka, Pitiphat, & Sringermyuang, 2021).

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Similar findings have also been reported in the Indonesian context. A study by Wulandari (2022) on 11-12-year-old children in Palembang found a significant association between cariogenic food consumption and the DMF-T index ($p = 0.000$). Another study in children in Bali reported that children who consumed sweet foods >4 times per day had a 3.5-fold higher risk of caries (Wahyuni, Handayani, & Purwati, 2022), which is very close to the OR of 3.57 found in this study. This indicates that the pattern of the relationship between the frequency of sugar consumption and the incidence of caries in elementary school children is consistent, both globally and nationally.

The results of this study align with what is stated that the frequency of simple sugar consumption has a stronger influence on caries incidence than the total amount of sugar consumed. Children who frequently consume sugary foods or drinks within short intervals will experience repeated decreases in plaque pH, thereby increasing the duration of acidic conditions in the oral cavity (Moynihan & Kelly, 2014). This concept is known as the "Stephan curve," which describes the decrease in plaque pH after sugar consumption and the time required for it to return to neutral pH. High frequency of sugar consumption means the Stephan curve occurs repeatedly, providing little opportunity for the salivary remineralization process to work optimally (Touger-Decker & van Loveren, 2020). A longitudinal study also showed that exposure to free sugars from an early age was significantly associated with increased caries in permanent teeth by school age (Bernabé, Ballantyne, Longbottom, & Pitts, 2020).

A study on schoolchildren in Saudi Arabia provides an interesting perspective on the interaction between frequency and quantity of sugar consumption. The study found that although the frequency of sweetened beverage (soft drink) consumption was more strongly associated with caries experience (OR = 1.33), the interaction between frequency and quantity of consumption together had a more significant relationship to caries prevalence and severity. This indicates that caries prevention efforts should consider not only how often children consume sugar, but also how much sugar they consume on each occasion (Al-Zahrani, Al-Qahtani, Al-Barti, & Bakhurji, 2022).

Furthermore, research confirmed that free sugar consumption above 10% of total daily energy is correlated with increased prevalence and severity of dental caries, even in populations with relatively good access to dental health services (Sheiham & James, 2015). This reinforces the WHO recommendation to limit free sugar consumption to less than 10% of daily energy, and ideally below 5%, as the primary preventive measure for dental caries in children (World Health Organization, 2015).

The analysis of sugar intake in this study, which showed a nearly equal proportion of high and low intakes (49.3% vs. 50.7%), indicates that half of the children in this stunting-prone village exceeded the recommended daily sugar intake. This is a serious concern, given its impact not only on dental caries but also on nutritional status. Excessive sugar intake, particularly from foods/drinks with high energy density but low micronutrients, can contribute to deficiencies in essential nutrients needed for linear growth, thus exacerbating stunting (Mallisetty, Mukherjee, & Patel, 2022).

The relationship between nutritional status and dental caries is also confirmed by research in Nepal, which found that the prevalence of dental caries reached 52.35% in underweight children, significantly higher than in children with normal nutritional status (38.89%) (Panjiyar, Singh, & Tiwari, 2024). A systematic review also concluded a significant relationship between nutritional status and the incidence of dental caries in elementary school children, where the lower the dental caries index, the better the nutritional status (Pardosi, Siahaan, Restuning, & Chaerudin, 2022). This finding strengthens the argument that the problem of dental caries in stunting focus areas cannot be separated from general nutritional problems.

When linked to national conditions, the results of this study are relevant to the findings of the 2018 Basic Health Research and the 2023 Indonesian Health Survey which showed that the prevalence of dental and oral problems in children aged 5-14 years remains relatively high, with a proportion of dental caries cases not being optimally managed. The data also indicates that consumption of sweet foods and high-sugar snacks

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still dominates the diets of schoolchildren, while the practice of brushing teeth at the correct time remains low. Furthermore, data from the Ministry of Health indicates that the proportion of the population consuming sweet foods/drinks more than once per day remains very high, reaching over 60% (Ministry of Health of the Republic of Indonesia, 2023). This condition creates an oral environment conducive to the development of caries, especially in newly erupted permanent teeth.

The context of the study area, which is a stunting hotspot, further strengthens the link between simple sugar intake and dental caries. Children's consumption patterns in this area tend to be dominated by inexpensive sweet snacks with high energy density but low nutritional quality. The generally low level of parental education also contributes to a lack of understanding of the negative impacts of excessive sugar consumption on children's dental health and nutritional status (Putri, Sukmasari, Herijulianti, Anggrawati, Nurjanah, & Setiawan, A2021). This situation not only increases the risk of dental caries but also contributes to chronic malnutrition. Other research shows that dental caries in children is related to nutritional status, diet quality, and socioeconomic factors. Therefore, caries cannot be viewed solely as a dental health problem, but rather as part of a broader public health problem that requires a holistic approach (Peres et al., 2019)

Thus, the findings of this study emphasize the need for an integrated promotive and preventive approach, including education on limiting simple sugar consumption, controlling school snacks, improving proper tooth-brushing behavior, and integrating dental health programs into child nutrition interventions. The common risk factor approach is particularly relevant here, as the same intervention such as promoting a healthy, low-sugar diet can have a positive impact on a variety of health conditions, including dental caries, obesity, and other non-communicable diseases (Watt & Sheiham, 2012). This strategy aligns with the lifecycle approach and common risk factor management efforts recommended in modern public health policy.

CONCLUSION

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This study concludes that simple sugar intake is significantly associated with the incidence of caries in first permanent molars in elementary school students in the Negeri Sakti Stunting Locus Village. Children with high simple sugar intake have a significantly greater risk of developing caries in first permanent molars compared to children with low simple sugar intake. These findings confirm that simple sugar consumption is an important risk factor for dental caries in school-age children, particularly in first permanent molars, which are susceptible to early decay. Therefore, controlling simple sugar intake needs to be an integral part of caries prevention efforts, particularly in children living in areas with chronic nutritional problems such as stunting loci, through an integrated promotive and preventive approach that integrates dental health and child nutrition programs.

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