



**Association Between Cariogenic Dietary Patterns and Dental Caries
Among Elementary School Students in Denpasar, Bali:
A Cross-Sectional Study**

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ABSTRACT

Dental caries continues to be a prevalent oral health problem among school-age children and may negatively affect eating, concentration, learning activities, and overall daily well-being. Among its modifiable determinants, frequent consumption of cariogenic foods and beverages plays an important role in caries development. This study aimed to examine the association between cariogenic dietary patterns and dental caries among elementary school students in Denpasar, Bali. An analytical observational study with a cross-sectional design was conducted among 50 fifth-grade students at SDN 3 Panjer, Denpasar. The association between dietary patterns and caries severity was assessed using the Fisher–Freeman–Halton exact test. A statistically significant association was identified between cariogenic dietary patterns and dental caries severity (two-sided exact $p = 0.020$). Students with less favorable dietary habits tended to show greater caries severity, whereas those with healthier dietary patterns were more commonly classified in the very-low caries category. These findings support the integration of healthy dietary practices into school-based oral health promotion as an important strategy for preventing dental caries in children.

Keywords: cariogenic dietary pattern, dental caries, elementary school students



INTRODUCTION

Dental caries is more than a localized defect of the tooth structure. In elementary school students, it can interfere with daily activities and overall well-being, causing discomfort during meals, sleep disturbances, difficulty concentrating in the classroom, and reduced confidence when speaking or interacting with others. Although largely preventable, dental caries continues to be the most prevalent noncommunicable disease globally, affecting an estimated 2.5 billion people. The World Health Organization (WHO) further estimates that approximately 510 million children are affected by caries in their primary dentition. When left untreated, dental caries may lead to pain, eating and sleeping difficulties, tooth loss, school absenteeism, and deterioration in quality of life (WHO, 2025).

Dental caries develops through the interaction of multiple determinants rather than from a single cause. Behavioral, genetic, environmental, social, and policy-related factors may all contribute to its occurrence [Cavallari]. Nutritional status also plays an important role in dental health because adequate nutrient intake is required for normal tooth development and maintenance. Previous studies have indicated that nutritional deficiencies may increase susceptibility to dental caries [Gondivkar]. At the same time, dietary quality and nutritional adequacy are shaped by wider social and ecological influences, including education, socioeconomic status, place of residence, and sociocultural conditions (Rippin *et al.*, 2020). This broader perspective highlights that children's oral health cannot be separated from the environments in which they live, eat, learn, and grow.

Elementary school students, especially vulnerable to cariogenic dietary exposure because eating habits established during childhood are strongly influenced by family routines and the school environment. Sugar-sweetened beverages, candies, chocolate, biscuits, cakes, and other sweet snacks are often readily available and may be consumed repeatedly between meals. In a systematic review, (Large *et al.*, 2024) found that 34 of 37 included studies reported a positive association between the consumption of sugar-sweetened beverages or foods high in free sugars and dental caries in children. The review also suggested that frequent consumption and nighttime intake of sugary foods and drinks may further increase caries risk. However, the considerable heterogeneity and risk of bias across studies indicate the need for additional well-designed research in specific populations. Consistent with this evidence, research among Indonesian elementary school children has also demonstrated a significant relationship between cariogenic food consumption and dental caries, reinforcing the importance of dietary behavior as a potential target for preventive strategies (Widyastuti *et al.*, 2024).

The burden of dental caries among Indonesian children remains substantial. The 2023 Indonesian Health Survey provides national and provincial data showing that oral health problems continue to represent an important public health issue in Indonesia (Kemenkes RI, 2023). Recent reports indicate that approximately 49.9% of children aged 5–9 years experience dental caries, meaning that nearly half of children in this age group are affected by tooth decay. In Bali, recent evidence from Denpasar has reported a caries prevalence of 31.6%, suggesting that dental caries remains a relevant health concern even

in urban areas where access to oral health information and dental services may be relatively more available (Cahyani *et al.*, 2025).

Local evidence from Denpasar further supports the need to pay closer attention to the relationship between children's dietary habits and oral health. In a descriptive study among third-grade students at SDN 14 Dauh Puri, Denpasar, (Cahyani *et al.*, 2025) reported that 62.5% of students experienced dental caries and 50.0% were categorized as frequently consuming cariogenic foods. Among children with frequent cariogenic food consumption, 81.3% had dental caries. However, because the study mainly used descriptive analysis, it did not determine the statistical association between cariogenic dietary patterns and dental caries. Another study published in IJASSD involving students at SDN 21 Dangin Puri, Denpasar, found a significant association between nutritional status and dental caries and also highlighted the importance of sugar intake, oral hygiene practices, and integrated school-based nutrition and oral health promotion (Agung *et al.*, 2026). Together, these findings suggest that dental caries among children in Denpasar should be considered within the wider context of nutrition and everyday dietary behavior rather than viewed only as an isolated dental problem.

Despite these findings, evidence specifically examining the association between cariogenic dietary patterns and dental caries among elementary school students in Panjer, Denpasar, remains limited. Children's dietary behaviors may differ between schools and communities depending on food availability, family practices, personal preferences, the school food environment, and access to sugary snacks and beverages. Understanding these patterns at the school level is therefore important for developing preventive strategies that reflect children's actual daily experiences. Such evidence may support stronger school dental health programs, improved nutrition education, greater parental involvement, and the development of healthier food environments within schools. Therefore, this study aimed to analyze the association between cariogenic dietary patterns and dental caries among students at SDN 3 Panjer, Denpasar. The findings are expected to contribute to sustainable school-based dental health promotion by placing healthier dietary behavior at the center of dental caries prevention.

RESEARCH METHOD

This analytical observational study used a cross-sectional design to investigate the association between cariogenic dietary patterns and dental caries among elementary school students. The study was carried out at SDN 3 Panjer, Denpasar, Bali, Indonesia, on June 4, 2024. The study population comprised students enrolled at SDN 3 Panjer. Participants were recruited through a simple random sampling technique, resulting in a final sample of 50 fifth-grade students. Eligible participants were fifth-grade students of SDN 3 Panjer who were present during data collection and willing to participate in the study. Students were excluded if they were not enrolled in the fifth grade at SDN 3 Panjer, declined participation, or were absent on the day of data collection.

Participation was entirely voluntary. Before data collection began, the objectives and procedures of the study were explained using language appropriate to the children's

age and level of understanding. Written informed consent was obtained from parents or legal guardians, and each child's willingness to participate was respected throughout both the dietary assessment and oral examination. These procedures were intended to maintain methodological rigor while ensuring that the privacy, dignity, and comfort of the participating children were preserved.

The independent variable was the cariogenic dietary pattern, while dental caries served as the dependent variable. Sociodemographic characteristics, including age and sex, were recorded to describe the study population. Cariogenic dietary patterns were defined as habitual consumption of foods and beverages containing fermentable carbohydrates, particularly sugar-rich and retentive foods that may remain in prolonged contact with tooth surfaces. Since the cariogenic potential of food is influenced not only by its composition but also by the frequency of exposure, dietary assessment emphasized how frequently the students consumed selected cariogenic foods and beverages. Food-frequency-based methods are commonly used to characterize cariogenic dietary exposure among children and adolescents, although standardized scoring remains important for reliable interpretation (Angelopoulou, Seremidi, et al., 2024).

Dietary intake was assessed using a Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ). This instrument offers a practical means of evaluating habitual dietary exposure among school-age children because it captures the frequency of food consumption over a specified period rather than reflecting intake on only a single day. The use of age-appropriate food frequency questionnaires in children has also been supported by recent methodological studies (Jung et al., 2023). The questionnaire covered foods and beverages with recognized cariogenic potential that commonly occur in children's daily diets, including sweets, candies, chocolate, biscuits, cakes or sweet breads, sweetened snacks, and sugar-sweetened beverages (Cahyani et al., 2025).

Several procedures were implemented to enhance consistency during data collection. The same operational definitions and dietary-frequency classifications were applied to all participants, and questionnaire items were administered using standardized wording to minimize interviewer-related variability. Oral examinations were likewise performed according to consistent clinical criteria. Because dietary assessment depends partly on participants' ability to remember previous food consumption, recall bias could not be completely avoided. To reduce this possibility, the questions focused on familiar foods commonly consumed by schoolchildren and used concrete examples relevant to the local dietary environment. The SQ-FFQ was particularly useful because it emphasized habitual frequency of consumption rather than requiring participants to recall the exact amount of every food consumed on a specific day. Nevertheless, no single dietary assessment method can fully capture children's exposure to dietary sugars, and this limitation should be considered when interpreting cariogenic dietary scores (Angelopoulou, et al., 2024).

Dental caries was evaluated through direct oral examination using the Decayed, Missing, and Filled Teeth (DMF-T) index for permanent dentition. This index represents cumulative caries experience by recording the number of permanent teeth that were

decayed (D), missing because of caries (M), or filled (F), and was calculated as $DMF-T = D + M + F$. The DMF-T index remains one of the most widely used epidemiological measures for describing dental caries experience and facilitating comparison across populations (Angelopoulou, et al., 2025; WHO, 2013).

Prior to data collection, ethical approval was obtained through the Faculty of Dentistry, Universitas Mahasaraswati Denpasar, and institutional permission was secured from SDN 3 Panjer, Denpasar. The study received ethical approval under number K.557/A.17.01/FKG-Unmas/VI/2024. Particular attention was given to the ethical requirements of research involving children, including protection of privacy, respectful communication, age-appropriate explanations, voluntary participation, and appropriate safeguards for young participants. These principles are consistent with those emphasized in the 2024 revision of the Declaration of Helsinki (World Medical Association, 2025).

The association between cariogenic dietary patterns and dental caries severity was examined using the Fisher–Freeman–Halton exact test, an extension of Fisher's exact test for contingency tables larger than 2×2 . This exact method was selected because more than 20% of the cells in the 3×3 contingency table had expected frequencies below five, indicating that the assumptions required for the Pearson Chi-square approximation were not sufficiently fulfilled. Statistical significance was defined as a two-sided p-value < 0.05 .

RESULTS AND DISCUSSION

The present study identified a statistically significant relationship between cariogenic dietary patterns and the severity of dental caries among fifth-grade students at SDN 3 Panjer, Denpasar (Table 1). This finding is consistent with (Martalinda et al., 2026), who reported that consumption of cariogenic foods was associated with a markedly higher occurrence of dental caries, reaching approximately sevenfold in their study population. A clear distributional pattern was observed across dietary categories. Among students classified as having a poor dietary pattern, 37.5% were in the very-low DMF-T category, while 33.3% had low and 29.2% had moderate caries experience. In comparison, students with a good dietary pattern were predominantly classified as having very low DMF-T scores (84.6%), with only 7.7% experiencing moderate caries. Students in the moderate dietary-pattern group showed an intermediate profile, with 76.9% falling within the very-low DMF-T category. Taken together, these findings indicate a consistent tendency for students with less favorable cariogenic dietary habits to show a greater degree of caries experience. Conversely, healthier dietary patterns appeared to be more frequently associated with very low levels of dental caries, supporting the importance of everyday dietary behavior as one of the modifiable factors related to dental health in elementary school students. This is consistent with the research findings of (Mulyati et al., 2022)

Table 1. Association Between Cariogenic Dietary Patterns and Dental Caries Severity

Cariogenic Dietary pattern	Very Low DMF-T, n (%)	Low DMF-T, n (%)	Moderate DMF-T, n (%)	Total, n (%)	p- value
Poor	9 (37.5)	8 (33.3)	7 (29.2)	24 (100)	0.020*
Moderate	10 (76.9)	3 (23.1)	0 (0.0)	13 (100)	
Good	11 (60.0)	1 (7.7)	1 (7.7)	13 (100)	
Total	30 (60.0)	12 (24.0)	8 (16.0)	50 (100)	

Source: Data processed, 2026

The association observed in this study is biologically reasonable and is supported by current evidence on the role of diet in dental caries. Cariogenic foods and beverages, particularly those containing free and fermentable sugars, provide readily available substrates for oral microorganisms. Through bacterial metabolism, these sugars are converted into organic acids, which repeatedly lower plaque pH and create conditions that favor the demineralization of enamel and dentine (Pombo-Lopes et al., 2026). The World Health Organization also identifies free sugars as a major dietary contributor to dental caries and emphasizes that repeated exposure over time contributes to the cumulative burden of disease. For this reason, WHO continues to recommend limiting free-sugar intake to less than 10% of total daily energy intake, with a further reduction to below 5% providing additional protection against caries development (Dao et al., 2026; World Health Organization, 2025; Xu et al., 2026).

Current evidence also suggests that the frequency of sugar exposure may be as important as, or in some situations even more relevant than, the total amount of sugar consumed. A systematic review by (Pombo-Lopes et al., 2026), which included 37 studies involving 59,383 children and adolescents, found that 32 studies (86%) reported a significant positive association between sugar intake and dental caries. The review further indicated that frequent sugar consumption was a more consistent predictor of caries than total sugar quantity alone. This finding is highly relevant to school-age children, whose daily routines often include repeated consumption of sweet snacks, biscuits, candies, and sugar-sweetened beverages between regular meals.

A similar pattern was reported by (Angelopoulou et al., 2024) in a systematic review evaluating cariogenic dietary assessment among children. Higher sugar intake and poorer dietary scores were generally associated with greater caries experience, whereas healthier dietary patterns tended to correspond with lower caries indices. These findings support the view that dental caries should not be understood as the result of a single episode of eating sweet food. Rather, caries develops through repeated dietary exposures that become embedded in children's everyday habits over time.

Evidence from population-based studies provides additional support for this interpretation. (Cheever et al., 2025), in an analysis of 3,658 children aged 6–12 years

from the United States National Health and Nutrition Examination Survey, found a significant association between free-sugar intake and dental caries. Their findings also highlighted the contribution of socioeconomic and parental factors, underscoring that children's dietary behaviors are not formed independently. Food choices are influenced by what is available at home and school, parental feeding practices, socioeconomic circumstances, and the broader social environment. Therefore, a child's cariogenic dietary pattern should be viewed not simply as an individual preference, but as a behavior shaped by the environment in which the child lives and grows.

The results from SDN 3 Panjer, Denpasar are also in line with recent local evidence from Denpasar. (Cahyani *et al.*, 2025), in a study involving elementary school students at SDN 14 Dauh Puri, Denpasar reported that 62.5% of participants had dental caries, while 50.0% were categorized as frequently consuming cariogenic foods. Among children with frequent cariogenic food consumption, 81.3% experienced dental caries. Although the study was descriptive and did not evaluate the association analytically, its findings provide an important local perspective and reinforce the concern that repeated exposure to cariogenic foods remains a relevant dental health issue among school children in Denpasar.

The relevance of these findings becomes more apparent when viewed within the wider context of dental health in Indonesia. A systematic review and meta-analysis published in 2024, involving 8,840 Indonesian children from 27 studies, estimated the overall prevalence of dental caries at approximately 76%. Among studies that assessed caries using DMFT-based criteria, the pooled prevalence reached 78% (Hasan *et al.*, 2024). This high prevalence indicates that dental caries should not be regarded solely as an individual dental condition, but rather as a persistent public health concern that may influence children's comfort, nutritional intake, participation at school, and overall quality of life.

Although the present study demonstrated a significant association between dietary patterns and dental caries, dietary behavior should not be considered the only factor involved in the development of caries. Dental caries is a multifactorial disease that develops cumulatively over time. In this study, one child with a good dietary pattern still experienced moderate caries, whereas several children with poorer dietary patterns remained within the very-low DMF-T category. Such differences illustrate the complexity of caries development, which may also be influenced by previous dietary exposures, dental plaque accumulation, toothbrushing practices, fluoride availability, salivary characteristics, individual tooth susceptibility, access to oral health services, and socioeconomic circumstances. The World Health Organization similarly recognizes that inadequate plaque control and insufficient fluoride exposure may intensify the cariogenic effects of free sugars. Therefore, the findings of this study should be interpreted as evidence of an association rather than a direct cause-and-effect relationship.

This consideration is particularly important given the cross-sectional design of the present study. Dietary patterns and dental caries status were assessed during the same study period, while the DMF-T index reflects accumulated caries experience over time.

Consequently, the dietary habits reported at the time of data collection may not fully represent the dietary exposures that contributed to carious lesions developing earlier in life. Future longitudinal studies would therefore be useful to clarify whether changes in the frequency and type of cariogenic food consumption are associated with the subsequent development or progression of dental caries.

Cariogenic foods commonly consumed by children include products rich in glucose or sucrose, such as chewing gum, chocolate, sweet cakes and pastries, potato chips, frozen sweet products, sugar-sweetened beverages, candies, and especially packaged snacks, which have been reported as one of the most frequently consumed cariogenic food groups among children (Alfiah *et al.*, 2018; Rehena *et al.*, 2020). Their cariogenic potential is related to the presence of fermentable carbohydrates, particularly glucose and sucrose. Oral bacteria metabolize these carbohydrates and produce acids, leading to a reduction in plaque pH. When this acidic environment persists or occurs repeatedly, mineral loss from the tooth surface may exceed remineralization, thereby promoting enamel demineralization and the development of dental caries (Reca, 2018).

From a practical perspective, these findings also carry an important message for oral health promotion in schools. Encouraging healthier dietary habits in children should not simply be understood as forbidding sweet foods. A more sustainable approach involves helping children and their families understand how often sugary foods and drinks are consumed, encouraging healthier alternatives, reducing repeated sugar exposure between meals (Dao *et al.*, 2026; Xu *et al.*, 2026), maintaining regular toothbrushing with fluoride toothpaste, and seeking preventive dental care when needed. Schools provide an especially valuable setting for these efforts because they are places where children repeatedly make food choices and establish habits that may persist into adolescence and adulthood.

Within this context, the significant association identified among students at SDN 3 Panjer, Denpasar, supports a more integrated approach to caries prevention. Oral health education may be strengthened when it is combined with nutrition education, parental participation, and the creation of a healthier school food environment. Such an approach moves prevention beyond the traditional focus on treating cavities after they have developed and instead promotes daily behaviors that support both oral and general health. Improving children's dietary habits is therefore not only about protecting their teeth, but also about helping them eat comfortably, sleep without dental discomfort, participate fully in school activities, and grow with a better quality of life (Rippin *et al.*, 2020).

CONCLUSION

This study identified a significant relationship between cariogenic dietary patterns and the severity of dental caries among fifth-grade students at SDN 3 Panjer, Denpasar, Bali. Students with less favorable dietary habits tended to experience a higher level of caries, while those with healthier eating patterns were more commonly found in the very-low DMF-T category. These findings highlight that children's oral health is closely linked to the dietary choices they make in their daily lives. Preventing dental caries should

therefore not be limited to managing existing lesions, but should also focus on fostering healthier eating habits from an early age. Strengthening school-based oral health education, improving the availability of healthier food choices, involving parents, encouraging regular toothbrushing with fluoride toothpaste, and ensuring access to appropriate dental care may collectively contribute to more sustainable improvements in children's oral health and overall well-being.

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Declaration Statement

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Ethical Approval

Ethical approval for this study was obtained from the Faculty of Dentistry, Universitas Mahasaraswati Denpasar, with ethical clearance number K.557/A.17.01/FKG-Unmas/VI/2024. The study was conducted in accordance with ethical principles for research involving human participants, with particular attention to the protection, dignity, privacy, and well-being of child participants.

Conflict of Interest

The authors declare that there are no conflicts of interest related to the conduct, analysis, interpretation, or publication of this study.

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