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Association of Provincial Sugary Food Consumption with Dental and Oral Health Problems in Indonesia: An Ecological Study

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Abstrak

Permasalahan kesehatan gigi dan mulut masih menjadi salah satu isu kesehatan masyarakat yang penting di Indonesia. Meskipun konsumsi makanan manis telah diketahui sebagai faktor risiko penyakit gigi dan mulut, bukti empiris mengenai hubungan keduanya pada tingkat provinsi masih terbatas. Penelitian ini bertujuan untuk menganalisis hubungan antara konsumsi makanan manis dan masalah kesehatan gigi dan mulut di Indonesia. Penelitian menggunakan desain studi ekologi dengan memanfaatkan data sekunder dari Survei Kesehatan Indonesia (SKI) 2023 dan Badan Pusat Statistik (BPS), yang mencakup 34 provinsi di Indonesia. Variabel dependen adalah proporsi penduduk yang mengalami masalah kesehatan gigi dan mulut, sedangkan variabel independen utama adalah proporsi penduduk yang mengonsumsi makanan manis lebih dari satu kali sehari. Perilaku menyikat gigi, rata-rata lama sekolah, dan tingkat kemiskinan digunakan sebagai variabel kovariat. Analisis data dilakukan menggunakan uji korelasi *Spearman* dan regresi linear berganda. Hasil penelitian menunjukkan bahwa konsumsi makanan manis memiliki hubungan positif dan signifikan dengan masalah kesehatan gigi dan mulut ($\beta = 0{,}509$; $p = 0{,}002$). Model regresi secara keseluruhan menunjukkan signifikansi statistik ($F = 3{,}734$; $p = 0{,}014$) dan mampu menjelaskan 34,0% variasi masalah kesehatan gigi dan mulut ($R^2 = 0{,}340$). Sementara itu, variabel kovariat lainnya tidak menunjukkan hubungan yang signifikan. Penelitian ini menyimpulkan bahwa tingginya proporsi konsumsi makanan manis pada tingkat provinsi berhubungan secara signifikan dengan meningkatnya proporsi masalah kesehatan gigi dan mulut di Indonesia setelah memperhitungkan variabel kovariat. Temuan ini menegaskan pentingnya pengendalian konsumsi gula melalui strategi promosi kesehatan gigi dan mulut berbasis populasi.

Kata kunci: kesehatan gigi dan mulut; konsumsi makanan manis; studi ekologi; Indonesia; data sekunder.

Abstract

Dental and oral health problems remain a significant public health issue in Indonesia. Although consumption of sugary foods is a recognized risk factor for oral diseases, ecological evidence at the provincial level remains limited. This study aimed to examine the association of provincial sugary food consumption with dental and oral health problems in Indonesia. An ecological study was conducted using secondary data from the 2023 Indonesian Health Survey (SKI) and Statistics Indonesia (BPS). The analysis included 34 Indonesian provinces. The dependent variable was the provincial proportion of individuals reporting dental and oral health problems. The primary independent variable was the provincial proportion of residents consuming sugary foods more than once daily. Toothbrushing behavior, mean years of schooling, and poverty rate were included as covariates. Spearman's rank correlation and multiple linear regression were performed. Consumption of sugary foods was significantly associated with dental and oral health problems ($\beta = 0.509$; $p = 0.002$). The regression model was statistically significant ($F = 3.734$; $p = 0.014$) and explained 34.0% of the variation in dental and oral health problems ($R^2 = 0.340$). Other covariates were not significantly associated

with the outcome. Higher provincial consumption of sugary foods was independently associated with a greater proportion of dental and oral health problems in Indonesia, highlighting the importance of reducing sugar consumption through population-based oral health promotion strategies.

Keywords: dental and oral health; ecological study; Indonesia; sugary food consumption; secondary data
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INTRODUCTION

Dental and oral diseases remain among the most prevalent non-communicable diseases worldwide and continue to pose a substantial public health challenge. According to the World Health Organization (WHO), oral diseases affect approximately 3.5 billion people globally, with untreated dental caries in permanent teeth representing the most common health condition. Poor oral health is associated with pain, impaired mastication, reduced quality of life, school absenteeism, decreased work productivity, and considerable healthcare costs, particularly in low- and middle-income countries where access to preventive oral healthcare remains limited (1–3).

Oral diseases share common behavioral risk factors with other major non-communicable diseases, including unhealthy diets, tobacco use, harmful alcohol consumption, and inadequate oral hygiene. Among these, excessive consumption of free sugars has consistently been identified as one of the most important modifiable risk factors for dental caries. Consequently, reducing sugar intake has become a central recommendation within global oral health promotion strategies and the Common Risk Factor Approach (CRFA), which emphasizes addressing shared behavioral determinants to prevent multiple chronic diseases simultaneously (3,4).

Indonesia continues to experience a substantial burden of dental and oral health problems. The 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI) demonstrated considerable variation in the proportion of individuals reporting dental and oral health problems across provinces, indicating regional disparities in oral health status (1, 5, 6). Variations may influence these differences in dietary behaviors, oral hygiene practices, educational attainment, and socioeconomic conditions. Understanding these interprovincial variations is essential for developing targeted public health interventions and allocating health resources more effectively.

Frequent consumption of sugary foods promotes repeated acid production by oral biofilm following bacterial fermentation of fermentable carbohydrates. This process lowers plaque pH below the critical threshold for enamel demineralization, increasing the risk of dental caries and other oral diseases. Previous epidemiological studies have consistently demonstrated positive associations between sugar consumption and dental caries; however, most investigations have used individual-level data (5,6). Evidence describing these relationships at the population level, particularly using provincial data in Indonesia, remains limited.

Besides dietary behavior, oral hygiene practices and socioeconomic conditions are recognized determinants of oral health. Appropriate toothbrushing practices contribute to plaque removal and caries prevention, whereas higher educational attainment may improve oral health literacy and facilitate healthier behaviors. Likewise, poverty may affect access to preventive dental care and utilization of treatment. Nevertheless, the combined contribution of these factors has rarely been evaluated simultaneously using ecological data from Indonesia (3,7,8).

Ecological studies provide valuable evidence for identifying population-level patterns and geographical disparities that cannot be observed through individual-level analyses alone. Such information is particularly useful for policymakers in designing region-specific oral health promotion programs and preventive strategies. Therefore, this study aimed to examine the association between provincial sugary food consumption and dental and oral health problems in Indonesia, using secondary data from the 2023 Indonesian Health Survey and Statistics Indonesia.

METHODS

An ecological study was conducted using publicly available secondary data from Indonesian provinces to examine the association of provincial sugary food consumption with dental and oral health problems. The province served as the unit of analysis.

Data were obtained from two national databases. Information on the proportion of individuals reporting dental and oral health problems during the previous 12 months, the proportion of residents consuming sugary foods more than once daily, and the proportion of residents brushing their teeth at least twice daily was extracted from the 2023 Indonesian Health Survey (Survei Kesehatan Indonesia, SKI) (1). Provincial socioeconomic indicators, including mean years of schooling and the poverty rate, were obtained from Statistics Indonesia (Badan Pusat Statistik, BPS) (2,9). Four newly established provinces (South Papua, Central Papua, Highland Papua, and Southwest Papua) were excluded because comparable socioeconomic data were unavailable for the study period. Therefore, the final analysis included 34 provinces.

The dependent variable was the provincial proportion of individuals reporting dental and oral health problems during the previous 12 months. The primary independent variable was the provincial proportion of residents consuming sugary foods more than once daily. Additional explanatory variables included the provincial proportion of residents who brush their teeth at least twice daily, the mean years of schooling, and the provincial poverty rate. These variables were selected based on previous evidence identifying dietary behavior, oral hygiene practices, and socioeconomic conditions as important determinants of oral health (3,5,10).

Descriptive statistics were used to summarize the study variables. Data normality was assessed using the Shapiro–Wilk test. Because several variables were not normally distributed, Spearman's rank correlation was used to examine bivariate associations. Multiple linear regression analysis was subsequently performed to assess the independent association between sugary food consumption and dental and oral health problems, adjusting for toothbrushing frequency, mean years of schooling, and poverty rate. Regression assumptions were evaluated by assessing multicollinearity using the Variance Inflation Factor (VIF), normality of residuals using a normal probability (P–P) plot, and homoscedasticity using a scatterplot of standardized residuals against standardized predicted values (11). A two-sided p-value of <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics version 27.0.

This study analyzed publicly available aggregated secondary data without any individually identifiable information. Ethical approval was obtained from the Research Ethics Committee, Faculty of Dentistry, Universitas Muhammadiyah Surabaya, Indonesia (Approval No: 006639.2/KEP FKG UMSURA/2026).

RESULTS

A total of 34 provinces were included in the ecological analysis using secondary data from the 2023 Indonesian Health Survey (SKI) and Statistics Indonesia (BPS). Descriptive statistics of the study variables are presented in Table 1.

Table 1. Descriptive Statistics of Study Variables

Variable	Mean ± SD	Median (Min–Max)
Dental and oral health problems (%)	56.72 ± 5.85	46.50–68.40
Sugary drink consumption >1 time/day (%)	46.09 ± 7.68	46.50–68.40
Sugary food consumption >1 time/day (%)	34.99 ± 6.49	18.80–52.00
Toothbrushing ≥2 times/day (%)	72.86 ± 5.27	61.20–83.50
Mean years of schooling	9.30 ± 0.82	7.34–11.42
Mean years of schooling	10.09 ± 5.18	4.25–26.03

Spearman's rank correlation analysis demonstrated that sugary food consumption was positively associated with dental and oral health problems ($r = 0.550$, $p = 0.001$). Sugary drink consumption also showed a weaker but statistically significant positive correlation ($r = 0.340$, $p = 0.049$). No significant correlations were observed for toothbrushing frequency, mean years of schooling, or poverty rate (Table 2).

Table 2. Spearman's Rank Correlation Between Dental and Oral Health Problems and Independent Variables

Variable	Correlation coefficient (r)	*p*-value
Sugary drink consumption >1 time/day	0.340	0.049
Sugary food consumption >1 time/day	0.550	0.001
Toothbrushing ≥2 times/day	0.245	0.162
Mean years of schooling	–0.100	0.572
Poverty rate	0.272	0.119

Multiple linear regression analysis showed that the overall model was statistically significant ($R^2 = 0.340$, Adjusted $R^2 = 0.249$, $F = 3.734$, $p = 0.014$). After adjustment for toothbrushing frequency, mean years of schooling, and poverty rate, sugary food consumption remained the only variable independently associated with dental and oral health problems ($\beta = 0.509$, $p = 0.002$) (Table 3).

Table 3. Multiple Linear Regression Analysis of Factors Associated with Dental and Oral Health Problems

Variable	B	SE	β	*t*	*p*-value
Sugary food consumption >1 time/day	0.459	0.137	0.509	3.351	0.002
Toothbrushing ≥2 times/day	–0.272	0.197	–0.245	–1.377	0.179
Mean years of schooling	–0.902	1.168	–0.126	–0.772	0.447
Poverty rate	–0.080	0.215	–0.071	–0.371	0.713

Model statistics: $R = 0.583$; $R^2 = 0.340$; Adjusted $R^2 = 0.249$; $F = 3.734$; $p = 0.014$.

DISCUSSION

This ecological study demonstrated that provincial consumption of sugary foods was independently associated with the proportion of individuals reporting dental and oral health problems in Indonesia. Provinces with a higher proportion of residents consuming sugary foods more than once daily tended to report a greater proportion of dental and oral health problems. After adjustment for toothbrushing frequency, mean years of schooling, and provincial poverty rate, sugary food consumption remained the only significant predictor. These findings indicate that dietary behavior may contribute more substantially to interprovincial differences in oral health than the socioeconomic indicators included in this analysis.

The association observed in this study is biologically plausible and consistent with current evidence regarding the pathogenesis of dental caries. Frequent intake of sugary foods supplies fermentable carbohydrates that are metabolized by cariogenic bacteria within the dental biofilm, leading to repeated acid production and prolonged reductions in plaque pH. When the oral environment remains below the critical pH for extended periods, enamel demineralization exceeds remineralization, thereby increasing susceptibility to dental caries. Consequently, the frequency of sugar exposure is considered more critical than the total amount consumed because repeated intake results in multiple acid attacks throughout the day (1,5,6,12)

Our findings are consistent with previous international studies demonstrating that excessive sugar consumption is strongly associated with poor oral health outcomes. Moynihan and Kelly reported that reducing free sugar intake substantially lowers the incidence of dental caries across all age groups (6). Similarly, Sheiham and James concluded that limiting free sugar intake is fundamental for effective caries prevention and supports the WHO recommendation to reduce free sugar consumption to less than 10% of total daily energy intake, with additional benefits observed when intake is below 5% (5). Although most previous studies evaluated individuals, the present ecological analysis suggests that similar patterns are also evident across Indonesian provinces.

The marked variation in sugary food consumption among Indonesian provinces may reflect differences in dietary culture, food availability, urbanization, and socioeconomic transition. Rapid changes in dietary patterns, accompanied by increased accessibility of processed and sugar-rich foods, may have contributed to regional differences in oral health status. These findings underscore the importance of tailoring oral health promotion strategies to local dietary patterns rather than implementing a uniform national approach.

Interestingly, toothbrushing frequency, mean years of schooling, and provincial poverty rate were not independently associated with dental and oral health problems. This finding should be interpreted with caution because the present study used an ecological design in which provinces, rather than individuals, were the unit of analysis. Province-level indicators may not accurately represent individual oral hygiene behaviors or socioeconomic circumstances. Moreover, oral health is influenced by multiple factors that were unavailable in the present dataset, including fluoride exposure, utilization of dental services, oral health literacy, and access to preventive care. Therefore, the absence of statistical significance does not imply that these factors lack importance at the individual level (3,10,12).

The present findings also support the Common Risk Factor Approach, which advocates addressing shared behavioral determinants to prevent multiple chronic diseases simultaneously.

Because excessive sugar consumption contributes not only to dental caries but also to obesity, type 2 diabetes mellitus, and cardiovascular diseases, interventions promoting healthier dietary behaviors may provide broader public health benefits beyond improving oral health alone (7,8).

This study has several strengths. It utilized nationally representative datasets from the Indonesian Health Survey and Statistics Indonesia, enabling standardized comparisons across provinces. The ecological approach also provides valuable evidence for identifying regional disparities and informing population-level health planning. Nevertheless, several limitations should be acknowledged. First, the ecological design precludes causal inference and is susceptible to ecological fallacy. Second, the study relied on aggregated secondary data, preventing adjustment for important confounding variables such as fluoride exposure, dental service utilization, household income, and oral health literacy. Finally, the outcome variable was based on self-reported dental and oral health problems rather than clinical examination.

Overall, the findings suggest that reducing frequent consumption of sugary foods should be prioritized in comprehensive oral health promotion strategies in Indonesia. Integrating nutrition education into existing oral health programs may help reduce regional disparities and improve oral health at the population level.

CONCLUSION

Provincial consumption of sugary foods was independently associated with the proportion of individuals reporting dental and oral health problems in Indonesia. In contrast, toothbrushing frequency, mean years of schooling, and poverty rate were not significant after multivariable adjustment. These findings highlight the importance of addressing excessive consumption of sugary foods as a key behavioral risk factor in oral health promotion strategies. Public health interventions that integrate dietary modification with oral health education may help reduce regional disparities in oral health. Future individual-level studies are warranted to validate these ecological findings and provide stronger evidence for causal inference.

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