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The association between frequency of consumption of gluten-containing foods and caries index in children with ADHD: A cross-sectional study

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ABSTRACT

Introduction: Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder characterized by inattention, hyperactivity, and impulsivity, which may influence dietary behaviors and oral health, particularly the risk of dental caries. Gluten-containing foods are commonly consumed by children and may contribute to cariogenic exposure, especially in children with ADHD who tend to have irregular eating habits and may have poorer oral hygiene, including less frequent toothbrushing. In addition, stimulant medications commonly prescribed for ADHD may reduce salivary flow and potentially affect salivary buffering capacity. This study aimed to assess the association between the frequency of consumption of gluten-containing foods and caries index in children with ADHD. **Methods:** A cross-sectional study involving 34 children aged 6–12 years diagnosed with ADHD was conducted in special needs schools in Surabaya. The frequency of consumption of gluten-containing foods was assessed using a semi-quantitative Food Frequency Questionnaire, while dental caries was assessed using the DMF-T index based on WHO criteria. Data analysis was performed using Spearman's rank correlation test to determine the association between the frequency of consumption of gluten-containing foods and caries index. **Results:** The majority of children demonstrated a moderate level of consumption of gluten-containing foods and a moderate to high caries index. Statistical analysis revealed a strong and significant positive correlation between the frequency of consumption of gluten-containing foods and caries index ($r = 0.989$; $p < 0.05$), indicating that more frequent consumption of gluten-containing foods was associated with higher dental caries index in children with ADHD. **Conclusion:** This study showed a significant association between the frequency of consumption of gluten-containing foods and caries index in children with ADHD, suggesting that dietary habits may contribute dental caries. These findings support the importance of integrating dietary management and oral hygiene education into preventive strategies for children with ADHD.

KEYWORDS

Gluten, attention-deficit/hyperactivity disorder, dental caries, DMF-T index, oral health

INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) is a long-term neurodevelopmental disorder characterized by persistent symptoms of inattention, hyperactivity, and impulsivity that begin in childhood. The global prevalence of ADHD is around 5–7% in children, with a higher prevalence in boys than girls.[1,2] In Indonesia, prevalence data are still limited and most studies have been conducted in specific regions; therefore, the national prevalence remains unclear. ADHD has broad implications for daily functioning, including oral health, which is often overlooked in research and clinical management. This creates an

urgency to further examine the specific risk factors that affect dental and oral health in children with ADHD.[1,3]

Children diagnosed with ADHD are more likely to experience dental caries than those without the disorder.[4] Contributing factors include irregular toothbrushing habits, short brushing duration, and a diet that tends to be high in carbohydrates and less structured.[5,6] In addition, stimulant medications that are often prescribed, such as methylphenidate, can decrease salivary flow, thereby increasing the risk of xerostomia and caries.[7] This combination of behavioral, biological, and iatrogenic factors places children with ADHD at increased risk for caries, but studies specifically assessing the effect of diet on dental health remain limited.[5]

Gluten is a component of protein found primarily in wheat and related grains and is present in various gluten-containing foods, such as bread, cakes, noodles or pasta, pizza, wafers, and breaded products. In children with ADHD, the digestion of gluten can lead to the formation of opioid peptides such as gliadomorphine, which may worsen behavioral symptoms.[8,9] Some studies suggest that a gluten-free diet may affect behavioral symptoms in certain children with ADHD, although the evidence is still inconclusive.[8,9] Nonetheless, association between the frequency of consumption of gluten-containing foods and oral health in children with ADHD remains understudied. It is not gluten itself that is cariogenic, but rather the fermentable carbohydrates in gluten-containing foods that can be metabolized by oral bacteria into acids, resulting in decreased salivary pH and enamel demineralization.[10,11,12] Previous research indicates that adopting a low-gluten or gluten-free diet may reduce the intake of simple carbohydrates and lower caries risk, as demonstrated by a significant correlation between the frequency of consumption of gluten-containing foods and caries index in children with autism, highlighting the need to investigate this relationship specifically in children with ADHD given their distinct dietary and behavioral risk profile.[13]

Dental caries continues to be a serious public health issue in Indonesia, particularly because of its high prevalence among elementary school children. Among children with specific healthcare needs, including children with ADHD, the likelihood of developing caries is nearly twice as high as in the general population.[14] This elevated risk is clinically significant because untreated dental caries in children with ADHD can exacerbate existing behavioral and attentional challenges through pain-related distraction, disrupted sleep, and reduced school performance, while also complicating dental treatment due to difficulties with cooperation during clinical procedures. Although the relationship between the frequency of gluten-containing food consumption and dental caries has been established in children with autism spectrum disorder, this association remains largely unexplored in children with ADHD despite their comparable dietary irregularities and oral hygiene challenges. Determining whether this relationship exists in the ADHD population would provide novel evidence to inform targeted dietary counseling and preventive oral health strategies.[15] Nevertheless, research specifically examining the association between the frequency of consumption of gluten-containing foods and caries index in children with ADHD remains scarce. This highlights an important research gap, as most previous studies have focused on behavioral factors or the effect of a gluten-free diet on ADHD symptoms rather than on dental and oral health outcomes.[9,13]

Building on this background, this research aims to assess the association between the frequency of consumption of gluten-containing foods and caries index in children with ADHD. An observational analytic study with a cross-sectional approach was employed. The participants were school-aged children diagnosed with ADHD. The frequency of consumption of gluten-containing foods was assessed using a semi-quantitative Food Frequency Questionnaire, while dental caries was assessed using the DMF-T index based on WHO criteria. The correlation between the frequency of consumption of gluten-containing foods and the DMF-T index was then analyzed using Spearman's rank correlation test.[16,17] As a community-based cross-sectional study, this research is expected to provide new

scientific insights into association between the frequency of consumption of gluten-containing foods and oral health in children with ADHD and may serve as a foundation for developing more comprehensive dietary and dental health education strategies.

The novelty of this research lies in its examination of the specific dietary consumption pattern associated with caries experience, namely the relationship between the frequency of consumption of gluten-containing foods and caries index in children with ADHD, which has not been sufficiently addressed in prior studies. Accordingly, this study evaluates the association between the frequency of consumption of gluten-containing foods and the caries index in children with ADHD.[18]

METHODS

A cross-sectional study design within an analytic observational framework was used in this study. The study population consisted of children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and enrolled in special education schools in Surabaya, Indonesia. This study used a total sampling technique because the number of eligible children with ADHD available during the study period was limited, and all subjects who met the inclusion criteria were invited to participate. The source population consisted of all children aged 6–12 years with a confirmed diagnosis of ADHD enrolled in special education schools in Surabaya, Indonesia during September - October 2023, whose diagnosis was confirmed by a mental health professional or a pediatrician and whose parents or legal guardians provided informed consent. The exclusion criteria were children with incomplete questionnaire data and those who were uncooperative during oral examination. The final sample size included in the analysis was 34 children.

Potential confounding variables were considered during study design and data collection by restricting the sample to children within a narrow age range (6–12 years), using a uniform diagnostic category (ADHD), and applying the same inclusion and exclusion criteria to all participants. In addition, oral examinations were performed using standardized WHO criteria, and all participants were assessed with the same FFQ instrument. However, because of the cross-sectional design, residual confounding from factors such as oral hygiene practices, dietary habits beyond the consumption of gluten-containing foods, medication use, and socioeconomic status could not be completely excluded.

The frequency of consumption of gluten-containing foods was assessed using a modified FQ-Gluten4 questionnaire adapted from Hopman et al., consisting of 10 items asking about the weekly frequency of consuming gluten-containing foods (bread, noodles, cakes, and biscuits). Each item was rated on a 7-point Likert scale from never (1) to three or more times/day (7) and completed by parents. Item scores were summed into a total score (range 10–70) and categorized into low, moderate, and high consumption levels based on the theoretical mean (40) and standard deviation (10) of the score distribution. Validity was tested using Pearson's correlation coefficient and reliability was assessed using Cronbach's alpha (>0.6)[16] Dental caries status was evaluated using the DMF-T index in accordance with the World Health Organization (WHO) criteria for oral health surveys.[19] Clinical intraoral examinations were performed using a mouth mirror and dental explorer.[20] Dental caries status was assessed using the DMF-T index for oral health surveys.[19] Clinical intraoral examinations were performed by a single examiner under the supervision of a senior pediatric dentist specialist.

Statistical analysis was performed using Spearman's rank correlation test to assess the association between the frequency of consumption of gluten-containing foods and caries index, as the data were not normally distributed.[18] A p-value of less than 0.05 was considered statistically significant.

RESULTS

Among the 34 participants with ADHD, the findings of this study reveal a highly significant correlation between the consumption rate of gluten and the severity of tooth decay in children with ADHD. Data presented in Tables 1 through 7 offer a detailed depiction of respondents' characteristics, gluten intake frequency, oral hygiene habits, and caries severity measured using the DMF-T index. For instance, Table 1 displays the distribution of gluten consumption among participants, while Tables 3 and 5 indicate that higher frequencies of gluten intake are associated with elevated average caries index values. Furthermore, Table 7 supports these findings through a Spearman correlation analysis shows r = 0.989 and p = <0.001, indicating a significantly strong correlation and statistically significant positive relationship between gluten consumption and dental caries. Additionally, proper toothbrushing habits were found to play a crucial role in reducing the caries index, highlighting their importance in promoting oral health among children with ADHD.

These tables not only reinforce the study's primary findings but also offer a broader understanding of the various risk factors influencing dental and oral hygiene in children diagnosed with ADHD. Research findings highlight the possible role of a gluten-free diet as an intervention to help reduce the risk of dental caries, alongside educational efforts and the reinforcement of proper oral hygiene practices. Collectively, the findings and accompanying table analyses provide a comprehensive illustration of how dietary patterns and oral hygiene behaviors contribute to maintaining and managing the dental health of children with ADHD.

Table 1. Percentage of respondents according to frequency of consumption of gluten-containing foods (FFQ), n = 34

Frequency of Consumption of Gluten-Containing Foods	Number of Children	Percentage
Low = 10-29	19	56%
Mid = 30-49	14	41%
High = 50-70	1	3%

Table 2. Distribution of respondents according to daily toothbrushing frequency, n = 34

Daily Toothbrushing Habits	Number of Children	Percentage
1 time/day	7	21%
2 times/day	26	76%
3 times/day	1	3%

Table 3. Mean FFQ score for frequency of consumption of gluten-containing foods and dmf-t index according to daily toothbrushing habits, n = 34

Daily Toothbrushing Frequency	Number of Children	Mean FFQ Score	Mean DMF-T Index
1 time/day	7	32 (Mid)	5.2 (High)
2 times/day	26	29 (Low)	4.3 (Moderate)
3 times/day	1	15 (Low)	1 (Low)

Table 4. Overview of caries index (DMF-T), n = 34

Decay	DMF-T Missing	Filled	DMF-T Index Score Total
118 (78%)	33 (22%)	0 (0%)	151 / 34 = 4.4 (Moderate)

Table 5. Mean DMF-T index according to frequency of consumption of gluten-containing foods, n = 34

Gluten Consumption	Frequency	DMF-T Index
Low	19	2.2 (low)
Mid	14	6.9 (very high)
High	1	12 (very high)

Table 6. Shapiro–Wilk test for normality

Variable	Sig.
Frequency of Consumption of Gluten-Containing Foods	0.166
Caries Index in Children with ADHD	0.003

Table 7. Spearman's rank correlation between consumption of gluten containing food frequency and caries index in children with ADHD

Variable	Spearman's rho	*p*-value	n
Frequency of gluten consumption vs DMF-T	0.989	< 0.001	34

DISCUSSION

This study showed a strong positive correlation between the frequency of consumption of gluten-containing foods and caries index in children with ADHD, which may be explained by the cariogenic nature of processed gluten-containing foods and ADHD-related eating behaviors such as frequent snacking and irregular oral hygiene. However, the very high correlation coefficient should be interpreted cautiously because of the small sample size and the influence of individual observations. This finding is consistent with recent evidence showing that children and adolescents with ADHD tend to have poorer oral health outcomes than their peers.[21,22] The present study adds to this evidence by suggesting that frequent consumption of gluten-containing foods may be associated with a higher caries index in this population.[23]

According to the table results, most participants in this study had low to moderate frequency of consumption of gluten-containing foods, the observed pattern of higher DMF-T values among those with greater exposure may reflect the combined influence of dietary habits, oral hygiene, and other unmeasured factors rather than a direct causal relationship.[24,25] Processed gluten-containing foods are often consumed as snacks and may prolong carbohydrate exposure in the oral cavity, while children with ADHD may also have irregular eating patterns and less consistent oral hygiene, both of which can increase caries risk.[26] The higher caries burden observed in this study, with decay comprising the largest component of the DMF-T index, suggests substantial unmet treatment needs and is consistent with previous reports that children with ADHD often have poorer oral health and greater cariogenic exposure.[27]

As shown in Table 1, most participants had low to moderate frequency of consumption of gluten-containing foods, while only a small proportion had high consumption. However, Table 5 demonstrates a clear pattern in which higher categories of frequency of consumption of gluten-containing foods were associated with higher DMF-T values. This pattern is biologically plausible because many gluten-containing foods are often consumed as cariogenic snacks and may contribute to prolonged carbohydrate exposure in the oral cavity.[23,24] The overall caries experience in this study was moderate, and the decay component accounted for the largest proportion of the DMF-T index, indicating substantial unmet treatment needs. This finding is in line with previous studies showing that children with ADHD frequently present with poorer oral conditions, less favorable oral health behaviors, and greater treatment needs.[21,23,25]

Table 2 shows that most children brushed their teeth twice daily, whereas a smaller proportion brushed only once daily. Nevertheless, Table 3 indicates that children who brushed once per day had higher mean FFQ scores for the frequency of consumption of gluten-containing foods and higher mean DMF-T values than those who brushed more frequently. This suggests that oral hygiene practices may modify the relationship between dietary exposure and caries index.[26] A previous cross-sectional study also reported that children with ADHD had poorer oral health behaviors and higher cariogenic food consumption, supporting the interpretation that diet and brushing habits may act together in increasing caries risk.[27]

Table 4 further shows that within the DMF-T index, missing teeth accounted for 22% of the total score while no teeth had been filled, indicating that carious teeth may have more often remained untreated or progressed to tooth loss rather than being restored. This absence of restorative care reflects limited utilization of preventive and conservative dental services in this population, which may be attributable to behavioral barriers commonly faced by children with ADHD during dental treatment, such as difficulty cooperating with restorative procedures compared with simpler interventions like extraction. Table 6 confirms that the DMF-T index was not normally distributed (Shapiro-Wilk $p = 0.003$), whereas the frequency of consumption of gluten-containing foods was normally distributed ($p = 0.166$).

Table 7 shows a very strong positive correlation between the frequency of consumption of gluten-containing foods and DMF-T values (Spearman's rho = 0.989; $p < 0.001$; $n = 34$). This finding statistically supports the dose-response pattern already demonstrated in Table 5, in which higher frequency of consumption of gluten-containing foods was associated with higher DMF-T values. However, this result should be interpreted with caution, as it is influenced by the small sample size, given that only a single participant with high frequency of consumption of gluten-containing foods was available and willing to participate as a respondent. This condition may cause the correlation coefficient to appear higher than it actually is, and this finding still requires further investigation.

Children with ADHD are at increased risk of dental caries not only because of behavioral factors but also because of treatment-related and physiological factors. Difficulties in self-regulation may affect routine toothbrushing, dietary control, and dental attendance.[28,29] This combination may create an oral environment that is more susceptible to caries development, especially in children with frequent exposure to processed gluten-containing foods.[30]

The findings of this study should also be interpreted in the context of current dietary literature. Although gluten itself is not cariogenic, gluten-containing ultra-processed foods are commonly rich in refined carbohydrates and are often consumed repeatedly throughout the day.[24,31] Therefore, the observed association in this study may reflect not only gluten exposure itself but also the broader pattern of processed food intake linked to caries development.

Nevertheless, this study has limitations. The limitation of this study is that its cross-sectional design does not allow causal conclusions to be drawn. In addition, the frequency of consumption of gluten-containing foods was assessed using a semi-quantitative FFQ, which depended on parental recall and may therefore be subject to reporting bias. The relatively small sample size and the inclusion of participants from a limited school setting may also reduce the generalizability of the findings. Future studies with larger samples, longitudinal designs, and more detailed assessment of total dietary sugar, processed food intake, fluoride exposure, and salivary factors are needed to clarify the mechanisms underlying the association between the frequency of consumption of gluten-containing foods and dental caries in children with ADHD.

CONCLUSION

This study found a strong association between the frequency of consumption of gluten-containing foods and caries index in children with ADHD, indicating that higher frequency of consumption of gluten-containing foods was associated with a higher caries index. The implication of this study is that dietary exposure, together with oral hygiene practices, should be considered in caries prevention efforts for children with ADHD. These findings support the need for routine oral hygiene education and dietary counseling as part of comprehensive preventive care. However, because this was a cross-sectional study, causal effects cannot be inferred, and further longitudinal research is needed to determine whether

changes in the frequency of consumption of gluten-containing foods are associated with oral health outcomes in this population.

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Institutional Review Board Statement: The study was conducted in accordance with the ethical principles of the Universitas Airlangga Faculty Of Dental Medicine Health Research Ethical Clearance Commission. Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Dental Medicine, Universitas Airlangga (Number: 726/HRECC.FODM/VI/2023). All procedures involving human participants were reviewed and approved to ensure the safety, confidentiality, and welfare of the respondents. The ethical clearance confirmed that the research met national and international standards for research involving human subjects.

Informed Consent Statement: Informed consent was obtained from the parents or guardians of all participants prior to their inclusion in the study

Data Availability Statement: All data generated or analyzed during this study are included in this published article. Further inquiries can be directed to the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

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