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Salıva pH, Carıes and OHI-S Score in Stuntıng Pre-School Chıldren in The Swamp Area

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Abstract: Stunting remains a major global health issue and is associated with impaired physical and cognitive development, as well as increased susceptibility to oral diseases such as dental caries. Environmental factors, including acidic peatland water, may further aggravate oral health conditions among children living in swamp areas. This study aimed to analyze the relationship between salivary pH, dental caries severity (def-t index), and oral hygiene status (OHI-S) in preschool children with stunting living in peatland regions of South Kalimantan, Indonesia. An analytical observational study with a cross-sectional design was conducted involving 32 preschool children aged 2–5 years residing in the working area of the Martapura Timur Public Health Center. Data collection included clinical examination of caries using the WHO criteria, salivary pH measurement with a Krisbow digital pH meter, and assessment of oral hygiene using the Simplified Oral Hygiene Index (OHI-S). Statistical analysis was performed using the Spearman correlation test. The results showed that salivary pH ranged from 5.5 to 7.0, def-t scores ranged from 2 to 8 (mean = 5.34 ± 1.78), and OHI-S scores were 0.00 in 22 children (68.7%) and >0.00 in 10 children (31.3%). A significant association was found between salivary pH and dental caries severity ($p = 0.005$; $\alpha = 0.05$), indicating that lower salivary pH is associated with higher caries prevalence. In conclusion, stunted preschool children in peatland areas exhibited acidic salivary conditions and a high caries burden despite relatively good oral hygiene status. These findings highlight the importance of integrating nutritional rehabilitation and oral health education programs to reduce the risk of dental caries in children living in environmentally vulnerable swamp regions.
Keywords: Dental caries; def-t index; preschool children; swamp area; salivary pH.

INTRODUCTION

Stunting remains a major global public health concern and continues to pose a significant challenge to child health and development. Each year, approximately 1.3 million children are affected by stunting, with an estimated 149 million children under the age of five experiencing this condition worldwide (WHO, 2024). Stunting reflects a failure of linear growth, defined as a height-for-age index below −2 standard deviations (SD) from the median of the WHO Child Growth Standards (Badruddin et al., 2021). It is primarily the consequence of chronic undernutrition and has far-reaching implications for physical development, cognitive capacity, educational attainment, and susceptibility to infectious diseases (Delgado-Angulo et al., 2013).

In Indonesia, stunting remains a major nutritional problem among children. The 2024 Indonesian Nutritional Status Survey (SSGI) reported a national stunting prevalence of 19.8% (SSGI, 2024). The etiology of stunting is multifactorial,

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encompassing maternal education and knowledge, household socioeconomic status, inappropriate infant and young child feeding practices, particularly the lack of adherence to exclusive breastfeeding for the first six months of life, as well as a high incidence of infections and poor child health conditions (Badruddin et al., 2021; Yohana et al., 2023). The Province of South Kalimantan consistently records stunting rates exceeding the national average. According to the 2024 SSGI report, the prevalence in this province was 22.9%, indicating a decline from previous years but remaining higher than the national mean (19.8%) (SSGI, 2024). This underscores that stunting in South Kalimantan remains a priority issue requiring targeted and accelerated interventions.

Beyond its systemic effects, stunting has also been linked to oral and dental health outcomes. Several studies have demonstrated a significant association between nutritional status and dental caries in children (Satria et al., 2023). Children with stunting are at greater risk of developing dental caries, as growth retardation may alter tooth structure and impair salivary gland function (Umamei et al., 2023). Research by Novia et al. (2020) reported that stunted children exhibit a higher prevalence of dental caries in primary teeth compared with those exhibiting normal growth patterns. A systematic review by Setijanto et al. (2025) further confirmed a bidirectional association between stunting and oral health, with eight out of ten studies reporting higher caries prevalence among stunted children. Two studies even identified a direct relationship between severe caries and the progression of stunting (Setijanto et al., 2025).

The mechanisms underlying this association are multifactorial. Nutritional deficiencies during critical growth periods can disrupt ameloblast function during enamel formation, leading to enamel hypoplasia that predisposes teeth to bacterial colonization and demineralization. Furthermore, stunting may impair salivary gland development, resulting in decreased salivary flow rate, buffering capacity, and natural oral cleansing ability—key protective factors against caries (Aulia et al., 2019; Setijanto et al., 2025). This condition is exacerbated by evidence showing that 71% of stunted children have poor oral hygiene, as indicated by high Oral Hygiene Index Simplified (OHI-S) scores. Conversely, severe dental caries can interfere with food intake due to pain and impaired mastication, further aggravating a child's nutritional status (Fitri et al., 2023).

Saliva plays an essential role in maintaining the ecological balance of the oral cavity. The optimal salivary pH ranges from 6.5 to 7.5, and any reduction below this threshold promotes enamel demineralization and accelerates caries development (Suratri, 2017). Stunting has been shown to impair salivary gland function, leading to reduced salivary flow and buffering capacity (Nursal et al., 2025; Arsad et al., 2024). When the salivary pH falls below the critical value of 5.5, hydroxyapatite crystals begin to dissolve, initiating the process of enamel demineralization (Pandit et al., 2024). A study by Nursal et al. (2025) reported that stunted children have significantly lower salivary pH levels (5.79–5.87) compared to their well-nourished peers (6.93–7.48).

In addition to biological determinants, environmental factors play an important role in oral health. Peatland regions, for instance, are characterized by highly acidic surface water, with pH levels ranging from 3.98 to 4.25 (Rezki et al., 2024). Chronic exposure to such acidic water can accelerate enamel demineralization due to sustained external acid contact (Ridho et al., 2020). A study conducted in Maliku District, Pulang Pisau Regency, revealed that children who brushed their teeth using river water exhibited a higher caries index than those using clean water sources (Haraguchi, 2008; Indra Sukmana et al., 2020).

Despite growing evidence on the association between stunting and dental caries, there remains a paucity of research specifically evaluating salivary characteristics, particularly salivary pH, and their relationship with oral hygiene and caries severity among stunted children in peatland areas. These regions present unique environmental conditions, including poor water quality and limited access to clean water, which may further affect children's oral health. Therefore, the present study aims to investigate salivary acidity, dental caries severity, and OHI-S scores among preschool-aged children with stunting in peatland areas, to provide a more comprehensive understanding of the interplay between stunting and oral health in this distinctive ecological context.

MATERIALS AND METHODS

Research Design

This study employed an analytical observational design with a cross-sectional approach. The research was conducted among preschool children aged 2–5 years residing in peatland areas within the working area of Martapura Timur Public Health Center, Banjar District, South Kalimantan Province, Indonesia.

The study site was selected based on its distinctive environmental characteristics, specifically, the presence of acidic peatland water, which theoretically may influence both the prevalence of dental caries and stunting among children.

Population and Sampling

The study population consisted of 32 preschool children aged 2 to 5 years who resided in peatland areas within the working region of the Martapura Timur Public Health Center, Banjar District, South Kalimantan Province, Indonesia. A total sampling technique was employed, whereby all eligible children within the population were included as study participants. The inclusion criteria comprised children aged 2–5 years who had lived in the peatland area for at least six months prior to data collection. Exclusion criteria were children with systemic diseases unrelated to nutritional deficiencies and those undergoing medical treatments that could influence growth or oral health conditions (Rezki et al., 2024).

Data Collection Procedures

Data were collected through direct clinical examinations and structured questionnaires completed by parents or guardians. The following parameters were assessed:

1. Dental Caries Status (def Index)

Dental caries status was evaluated through intraoral examination using the WHO criteria for diagnosing caries in primary teeth. The def index (decayed, extracted, filled) was recorded by a trained dental health professional to determine the severity of caries in each participant.

2. Salivary pH Level

The acidity level of saliva (salivary pH) was measured using a Krisbow digital pH meter (model KW 06-744) under controlled temperature conditions. The instrument was calibrated prior to each measurement to ensure accuracy. Saliva samples were analyzed immediately after collection to evaluate the potential acidity of saliva as a risk factor for dental caries.

3. Oral Hygiene Status (Oral Hygiene Index Simplified / OHI-S)

The oral hygiene status of each participant was assessed using the Simplified Oral Hygiene Index (OHI-S) to evaluate the accumulation of debris or dental plaque. The examination was performed on six index tooth surfaces of primary teeth, including the labial surfaces of teeth 54, 61, and 64, as well as the lingual surfaces of teeth 82, 75,

and 85. Each surface was examined visually under adequate illumination, and debris scores were recorded according to the standardized OHI-S criteria. The recorded scores were then categorized into two levels of oral hygiene: Good (score = 0.00) and Fair–Poor (score > 0.00).

4. Questionnaire

A structured parental questionnaire was administered to collect information regarding the socioeconomic characteristics of the participants' families. The questionnaire included items related to parental education, occupation, and household income to provide contextual background for interpreting the nutritional and oral health status of the children.

Data Analysis

Data were analyzed using statistical software (IBM SPSS software). Descriptive statistics were employed to summarize the demographic characteristics of the sample and the prevalence of dental caries. Bivariate analysis using the Spearman correlation test was conducted to assess the relationship between salivary pH and the severity of dental caries (def index). The Spearman correlation was selected because clinical variables such as caries severity are often non-normally distributed, making non-parametric testing more appropriate for this dataset.

Ethical Approval

This study received ethical approval from the Ethics Committee of the Health Polytechnic, Ministry of Health, Banjarmasin, under approval number 163/KEPK-PKB/2025. Written informed consent was obtained from all parents or legal guardians prior to data collection. Confidentiality and anonymity of all participants were strictly maintained throughout the research process.

RESULTS AND DISCUSSION

Socioeconomic characteristics

The distribution of respondents based on socioeconomic characteristics is presented in Table 1. The table includes information on residence, gender, age group, and parental occupation, which provides an overview of the respondents' demographic and social background.

The respondents resided in Sungai Kitano Village (47%) and Tambak Anyar Ilir Village (53%), both of which are located within the working area of Martapura Timur District, Banjar Regency, South Kalimantan Province, Indonesia. The number of respondents from the two villages was relatively balanced, reflecting the geographic and administrative proximity of these communities. Both villages are situated in lowland peat areas characterized by swampy environments, consistent with the research context focusing on stunting among preschool children in peatland regions. This even distribution confirms the appropriateness of the selected study sites and supports the representativeness of the sample for the target population in similar ecological conditions.

The gender distribution among respondents was equal, consisting of 16 males (50%) and 16 females (50%). Achieving a balanced gender composition minimizes potential bias and ensures that the results accurately represent both sexes. Prior studies have emphasized that maintaining gender balance is essential for studies involving preschool-aged children, as sex-related biological and behavioral differences may influence growth patterns and oral health outcomes (Atkins, 2023; Dönertaş, 2023). The balanced gender distribution in this study, therefore, strengthens the validity and generalizability of the findings.

In terms of age, the respondents ranged from 6 months to 5 years, with the

largest group being 5 years old (31%). This age range aligns with the preschool developmental stage typically used in stunting and oral health research. According to Rosana et al. (2025), preschool age is a critical period for assessing nutritional status and early oral health indicators such as saliva pH and caries prevalence. The predominance of 5-year-olds is plausible, as children at this age are more accessible for observation and capable of cooperating during clinical examination. This distribution supports a comprehensive assessment of the relationship between stunting and oral health during early childhood.

Tabel 1. Distribution of Socioeconomic Characteristics of Respondents

Variabel	Category	Number (n)	Percentage (%)
Place of Residence	Sungai Kitano Village	15	47
	Tambak Anyar Ilir Village	17	53
Gender	Male	16	50
	Female	16	50
Child Age	6 months	1	3
	1 years old	1	3
	2 years old	5	16
	3 years old	7	22
	4 years old	8	25
	5 years old	10	31
Father's Occupation	Laborers	6	19
	Farmers	5	16
	Traders	4	13
	Private employees	3	9
	Tailors	3	9
	Cleaning Services	2	6
	Online motorcycle taxis	2	6
	Jobless	7	22
Mother's Occupation	Housewife	20	63
	Laborers	4	13
	Tailors	4	13
	Private Employees	4	13

The occupations of respondents' fathers varied widely, including laborers (19%), farmers (16%), traders (13%), private employees (9%), tailors (9%), cleaning service workers (6%), and online motorcycle taxi drivers (6%), while 22% were unemployed. This occupational diversity reflects the socioeconomic variability typical of rural and semi-urban communities in Indonesia. Previous studies have shown that paternal occupation strongly influences family income, food security, and children's nutritional outcomes, where irregular income sources such as daily labor or farming are often associated with a higher risk of stunting (Sugianti et al., 2024; Has et al., 2022; Boibalan et al., 2025; Wulansari & Ibrahim, 2024).

Regarding maternal occupation, most respondents' mothers were housewives (63%), followed by laborers (13%), tailors (13%), and private employees (13%). The

predominance of housewives aligns with common demographic patterns in rural Indonesia, where mothers are typically the primary caregivers. Although maternal unemployment may limit family income, it can also enhance caregiving and nutrition supervision at home. Conversely, working mothers in low-income settings may face challenges balancing employment and childcare, potentially influencing child nutrition. These findings are consistent with recent studies reporting that maternal employment, income stability, and caregiving dynamics are significant determinants of childhood stunting (Rahayuwati et al., 2023; Suhaeni et al., 2024; Fatmawati et al., 2024). Overall, the socioeconomic profile presented in Table 1 accurately represents the rural peatland community context and provides a meaningful framework for interpreting the relationship between stunting, salivary pH, and oral health indicators.

Salivary pH in Children with Stunting

Based on the results of salivary pH examination, only one respondent (3.0%) exhibited a normal salivary pH, while 31 respondents (97.0%) presented with acidic saliva (Table 2). Among children with stunting, saliva tends to be more acidic due to inadequate nutritional intake, which impairs salivary gland function, decreases buffering capacity, and enhances the colonization of acidogenic bacteria within the oral cavity (Prasetyowati et al., 2024).

Table 2. Distribution of Respondents by Saliva pH Score

Saliva pH Score	Number (n)	%
5.5	1	3.1
5.7	1	3.1
5.8	1	3.1
5.9	3	9.4
6.0	2	6.3
6.1	4	12.5
6.2	5	15.6
6.3	4	12.5
6.4	3	9.4
6.5	5	15.6
6.6	2	6.3
7.0	1	3.1
Total	**32**	**100**

These findings are consistent with the study conducted by Rahman et al. (2016), which reported that children with malnutrition experience salivary gland atrophy and a reduction in salivary flow rate, resulting in diminished buffering ability and decreased self-cleansing capacity of saliva, thereby increasing susceptibility to dental caries. Similarly, Amperawati et al. (2025) found that stunted children had significantly lower mean salivary pH levels (mean = 5.79) compared to non-stunted children (mean = 6.93) in Hulu Sungai Utara District, South Kalimantan. Comparable results were reported by Nursal et al. (2025), who observed a mean salivary pH of 5.87 (SD = 0.22) among stunted children and 7.48 (SD = 0.35) among normal children ($p = 0.001$). These results suggest that chronic nutritional deficiencies may lead to a decline in salivary gland function and reduced buffering capacity of saliva.

Environmental conditions in peatland regions further exacerbate this problem. Children living in such areas often use peat water with a pH ranging from 3.5 to 4.5 for daily activities, including toothbrushing, which prolongs exposure to an acidic oral environment (Dewi et al., 2023; Priskila et al., 2023). Clinically, when salivary pH drops

below the critical threshold of 5.5, enamel demineralization occurs due to the dissolution of calcium phosphate minerals within hydroxyapatite crystals. Persistent acidic conditions establish a cariogenic oral ecosystem, which is difficult to restore through hygiene or dietary interventions alone (Sivakumar & Narayanan, 2024).

Furthermore, Sari et al. (2024) emphasized that a decrease in salivary pH not only increases the risk of dental caries but also worsens nutritional status, as impaired masticatory function may hinder adequate nutrient intake. Taken together, these findings underscore the multifactorial interplay between malnutrition, salivary physiology, and oral environmental factors in shaping the oral health outcomes of children with stunting, particularly in ecologically challenging settings such as peatland regions.

Severity of Dental Caries (def-t Index)

Examination of all 32 children (100%) revealed that every participant exhibited dental caries. The def-t index ranged from 2 to 8, with a mean value of 5.34 ± 1.78, indicating a moderate to high level of caries severity. The largest proportion of respondents had a def-t score of 5 (25.0%), followed by a score of 6 (18.8%) (Table 3).

Table 3. Def-t Scores in Stunted Children in the Study Area

def-t Index	Number (n)	%
2	2	6.3
3	3	9.4
4	5	15.6
5	8	25
6	6	18.8
7	5	15.6
8	3	9.4
Total	**32**	**100**

These findings are consistent with those reported by Rafilia et al. (2024), who documented a mean def-t index of 6.46 among stunted children in Bandung Regency, which was classified as a high caries category. The elevated prevalence of dental caries in stunted children reflects a multifactorial interaction among biological, structural, and environmental determinants.

From a biological perspective, low salivary pH disrupts enamel mineral homeostasis and accelerates the demineralization process (Nursal et al., 2025). Structurally, primary teeth are composed of approximately 97% mineral, 2% organic material, and 1% water, resulting in a thinner enamel layer that is more susceptible to damage than that of permanent teeth (Lacruz et al., 2017). Furthermore, chronic nutritional deficiencies may impair ameloblast activity during enamel formation, leading to enamel hypoplasia, a developmental defect that increases vulnerability to colonization by cariogenic bacteria (Mubaraki, 2019).

Environmental factors specific to peatland regions also contribute substantially to caries development. Peat water with an average pH of 4.02 fails to meet potable water quality standards and may enhance oral microbial colonization. Additionally, the dietary pattern commonly observed in peatland communities characterized by low protein intake and high consumption of simple carbohydrates further reinforces the cariogenic environment. The combination of acidic saliva, fragile enamel structure, and sugar-rich dietary habits creates an oral ecosystem highly conducive to caries formation (Priskila et al., 2023; Rezki et al., 2024).

Association Between Salivary pH and Dental Caries

The results of the Spearman correlation test revealed a significant association between salivary pH and the severity of dental caries among preschool children with stunting living in peatland areas ($p = 0.005$; $\alpha = 0.05$). The significant *p*-value indicates that lower salivary pH levels are associated with higher caries severity.

This finding is consistent with that of Amperawati et al. (2025), who reported a positive correlation between reduced salivary pH and increased enamel susceptibility to demineralization. Similarly, a systematic review by Setijanto et al. (2025). found that eight out of ten studies documented a higher prevalence of dental caries among stunted children. Setiawan et al. (2022) further noted that neonatal stunting and early childhood caries share a common nutritional etiology, namely micronutrient deficiencies that disrupt enamel formation and salivary gland function.

These results suggest that a decrease in salivary pH is not merely a consequence of malnutrition, but also an active contributing factor to the pathogenesis of dental caries among stunted children particularly those living in environmentally extreme settings such as peatland regions. The interplay between nutritional status, salivary biochemistry, and environmental exposure underscores the need for multifaceted prevention strategies that integrate nutritional rehabilitation and oral health promotion.

Oral Hygiene Status (OHI-S)

Analysis of the Simplified Oral Hygiene Index (OHI-S) showed that the majority of children demonstrated good oral hygiene status. Among the 32 participants, 22 children (68.7%) had an OHI-S score of 0.00, indicating the absence of debris or calculus on the index tooth surfaces, while 10 children (31.3%) exhibited scores > 0.00, reflecting varying degrees of plaque or calculus accumulation (Table 4).

Table 4. OHI-S in Stunted Children in the Study Area

No	OHI-S	Number (n)	%
1	0,00	22	68,7
2	>0,00	10	31,3
Total		32	100

These results suggest that most children had adopted basic oral hygiene practices, likely due to community-based dental health education programs implemented by local public health workers (Andriyani et al., 2023). However, despite relatively good oral hygiene, the high prevalence of dental caries indicates that biological factors, such as low salivary pH and nutritional deficiencies, play a more dominant role in caries pathogenesis (Putri et al., 2023).

Additionally, limited parental knowledge regarding proper toothbrushing techniques and frequency may contribute to this phenomenon. Andriyani et al. (2023) reported that most parents of stunted children had not yet adopted effective oral hygiene practices. Therefore, educational interventions must be integrated with nutritional improvement programs and environmental quality enhancement to achieve a comprehensive and sustainable reduction in caries risk among children in peatland regions.

This study has several limitations. The cross-sectional design restricts causal inference between salivary pH, nutritional status, and caries severity. The small sample size (n=32) limits generalizability to broader populations. Additionally, dietary habits, water quality, and oral hygiene practices were not fully controlled, and biochemical parameters such as buffering capacity and salivary microbiota

composition were not analyzed. Future longitudinal studies with larger samples are recommended to clarify causal mechanisms and environmental interactions.

CONCLUSION

Salivary pH ranged from 5.5 to 7.0, def-t scores ranged from 2 to 8, and OHI-S scores were 0.00 in 22 children (68.7%) and >0.00 in 10 children (31.3%). The Spearman correlation test showed a significant association between salivary pH and dental caries severity among preschool children in peatland areas ($p = 0.005$; $\alpha = 0.05$). These findings confirm the high burden of dental caries among stunted Indonesian preschoolers and underscore the importance of integrated oral health and nutritional interventions to reduce caries risk in swamp-region communities.

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CONFLICT OF INTEREST

Conflict of interest means individually things regarding the publication of this paper. Usually we need to reasking about this thing if there is a conflict of interest on this article.

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