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Analysis of the Association between Stunting and Saliva Potential of Hydrogen (pH) in Preschool Children

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ABSTRACT Stunting in early childhood is a significant public health issue with wide-ranging implications, including its impact on oral health. One of the lesser-known consequences of stunting is its association with alterations in salivary composition, particularly the potential of hydrogen (pH), which can reduce the protective functions of saliva and increase the risk of dental caries. This study was prompted by the high prevalence of dental caries among preschool children at DWP V Jatirejo Kindergarten in Lekok District, Pasuruan Regency. The primary aim of this research was to analyze the association between stunting and salivary pH levels in preschool-aged children. This study employed an analytic observational design with a cross-sectional approach. The sample consisted of 40 preschool students selected using the Slovin formula and a proportional stratified random sampling technique. Stunting status was assessed through Height-for-Age (HAZ) measurements using a microtoise, while salivary pH was measured using a digital pH meter. Data were analyzed using the Chi-square test to determine statistical associations between variables. The results indicated a significant association between stunting and salivary pH levels in the study population. The majority of children classified as stunted had salivary pH values in the acidic range, suggesting a disruption in the oral environment that may contribute to a higher risk of dental caries. In conclusion, stunting is associated with changes in salivary pH that may predispose children to oral health problems. These findings underscore the importance of integrating oral health education into community-based nutritional and stunting prevention programs. Educating parents and caregivers on the importance of oral hygiene for preschool children, particularly those at risk of stunting, is essential for improving overall child health outcomes.

INDEX TERMS Caries, pH Saliva, Preschool Children, Stunting

I. INTRODUCTION

Malnutrition, particularly stunting, remains a significant public health challenge in Indonesia that has yet to be fully addressed despite ongoing governmental efforts [1]. Stunting is defined by the World Health Organization (WHO) as impaired growth and development in children resulting from poor nutrition, repeated infections, and inadequate psychosocial stimulation. It is identified when a child's height-for-age falls below minus two standard deviations (< -2 SD) from the WHO median growth reference standards [2], [3]. According to WHO data in 2018, Indonesia ranked third among Southeast Asian countries in terms of stunting prevalence, with the 2018 Basic Health Research (Riskesdas) reporting a national average of 30.8% for stunted toddlers. East Java Province, where this study is based, had an even higher prevalence at 32.7%, surpassing the national average [4].

Stunting has both short-term and long-term consequences, ranging from impaired cognitive development and reduced physical capacity to increased susceptibility to diseases, including oral health problems. A

growing body of research highlights that children suffering from stunting are more prone to dental caries due to changes in the salivary environment particularly reductions in salivary flow rate and alterations in salivary pH [5], [6]. Saliva plays a critical role in maintaining oral health, acting as a natural buffer. The critical pH threshold for enamel demineralization is approximately 5.7; at this level, the enamel becomes susceptible to acid attacks, especially after the consumption of sugar-rich foods [7]. If the pH does not return to neutral quickly, the risk of tooth decay increases significantly [8].

Globally, dental caries remain the most prevalent oral disease, affecting over 3.5 billion individuals, with around 520 million children experiencing caries in their primary teeth [9]. In Indonesia, the prevalence of caries among children aged 5–6 years reaches as high as 93%, highlighting a serious public health concern [4], [10]. Early childhood, particularly the preschool years (ages 3–6), represents a critical period for growth, development, and health education [11]. Nutritional intake during this period is vital not only for

physical growth but also for cognitive and oral health development. Poor nutritional status, including stunting, has been correlated with a higher incidence of early childhood caries (ECC) [12], [13].

Several studies have identified a significant association between malnutrition, stunting, and changes in oral health parameters such as salivary pH and flow rate [14]–[19]. However, many of these studies have been conducted in broader urban settings or have focused primarily on nutritional outcomes without adequately addressing specific oral health indicators in rural or high-stunting areas. This research seeks to fill that gap by examining the relationship between stunting and salivary pH specifically in preschool-aged children from a rural high-stunting locus area.

The aim of this study is to determine the association between stunting and salivary pH in preschool children attending DWP V Jatirejo Kindergarten, located in Lekok District, Pasuruan Regency an area identified in 2023 as having the highest number of stunted toddlers in the region [20]. Initial assessments conducted by the researchers found that the average def-t index (a measure of decayed, extracted, and filled primary teeth) in children at this kindergarten was 10.4, which classifies as severe early childhood caries according to WHO standards [21].

This study contributes to the literature in three main ways:

1. by empirically establishing the relationship between stunting and salivary pH among preschool children;
2. by providing data that can inform integrated oral health and nutrition intervention strategies; and
3. by supporting community-based health education efforts focused on early prevention of both stunting and dental caries.

II. METHODS

This research was conducted at Dharma Wanita Persatuan (DWP) V Jatirejo Kindergarten, located in Lekok District, Pasuruan Regency, East Java. The study took place in January 2024 and employed an **analytic observational design** with a **cross-sectional approach**, allowing for the simultaneous observation of exposure (stunting) and outcome (saliva pH levels) in the population [31].

A. POPULATION AND SAMPLING

The study population consisted of all students enrolled in DWP V Jatirejo Kindergarten, totaling 45 children. The sample size was determined using the Slovin formula with a 5% margin of error. The resulting sample size was 40 respondents, selected using a proportional stratified random sampling technique to ensure representative participation across different age and gender groups. This approach allowed for the minimization of selection bias and improved external validity [32].

B. DATA COLLECTION PROCEDURES

1. STUNTING ASSESMENT

To determine stunting status, anthropometric measurements of height-for-age (TB/U) were conducted using a microtoise. Children aged ≤ 60 months were evaluated using the WHO 2005 Z-score growth standard, which calculates the height-for-age index and classifies stunting when the Z-score is

below -2 standard deviations ($< -2SD$) from the median [33]. For children aged > 60 months, the CDC-2000 growth chart was applied using the Waterlow classification method, which involves calculating the ratio between actual and ideal height, multiplied by 100% to assess nutritional status [34].

2. SALIVA PH MEASUREMENT

To measure the potential of hydrogen (pH) in saliva, the unstimulated saliva collection method was used. Participants were instructed to allow saliva to accumulate naturally in the mouth for 30 seconds before expectorating into a sterile collection container. This process was repeated until approximately 10 mL of saliva was collected per child [35]. Subsequently, the saliva samples were tested using a digital pH meter that had been calibrated according to manufacturer guidelines. The electrode of the pH meter was immersed in the saliva sample until the reading stabilized, providing an accurate measurement of the saliva's acidity or alkalinity. A lower pH indicates higher acidity, which can increase the risk of dental caries, especially in children with compromised nutritional status [36].

C. INSTRUMENTATION AND VALIDITY

All instruments used in this study were standardized and calibrated. The microtoise and digital pH meter were tested for measurement accuracy prior to data collection. Calibration of the pH meter was performed using buffer solutions at pH 4.0, 7.0, and 10.0. All tools were operated under the supervision of trained personnel to reduce measurement error and ensure reliability and validity of the results [37].

D. DATA ANALYSIS

The data collected were subjected to statistical analysis using the chi-squared (χ^2) test to assess the association between stunting status and saliva pH levels among preschool children. The analysis was conducted at a 95% confidence level ($\alpha = 0.05$). If the p-value was less than 0.05, the association was considered statistically significant. This method is suitable for analyzing categorical data and determining the strength of association between two variables [38].

E. ETHICAL CONSIDERATIONS

This study was approved by the relevant institutional ethical review board. Informed consent was obtained from all parents or legal guardians prior to data collection. All data were kept confidential and used solely for research purposes, adhering to the principles of the Declaration of Helsinki [39].

III. RESULTS

Based on the data presented in [TABLE 1](#), it can be concluded that based on gender the majority of respondents in this study were men (60%). In terms of age, the majority of respondents were 5 years old (57.5%). [TABLE 2](#) shows the results of the data collection based on Height/age examination to determine the stunting status of respondents in this study who were dominated by short height, namely 31 students (77.5%). [TABLE 3](#) shows that the majority of respondents in this study had the potential of hydrogen (pH) of saliva in the

acidic category, 38 students (95%). Based on TABLE 4 the p value is 0.007, so it is known that there is a association between stunting and the potential of hydrogen (pH) of saliva in preschool children at Dharma Wanita PBB V Kindergarten, Jatirejo, Lekok District, Pasuruan Regency.

TABLE 1

Characteristic of Respondent		
Characteristic of Respondents	Frequency (N)	Percentage (%)
Gender		
Boy	24	60
Girl	16	40
Total	40	100
Age (Years)		
4	4	10
5	23	57,5
6	13	32,5
Total	40	100

TABLE 2

Distribution of Height/Age		
Height/Age Measurement (Category)	Frequency (N)	Percentage (%)
Normal	9	22,5
Short	31	77,5
Total	40	100

TABLE 3

Distribution of pH Saliva		
pH Saliva	Frequency (N)	Percentage (%)
Acidic	38	95
Neutral	2	5
Alkaline	0	0
Total	40	100

TABEL 4

Chi-squared analysis test between stunting and pH saliva of preschool children				
Potential of Hydrogen (pH) Saliva	Stunting (Height/Age measurement)		Total	p value
	Normal	Short		
Acidic	7	31	38	0.007
Neutral	2	0	2	
Alkaline	0	0	0	
Total	9	31	40	

IV. DISCUSSION

A. INTERPRETATION OF RESEARCH FINDINGS

This study revealed a statistically significant association between stunting and the potential of hydrogen (pH) in the saliva of preschool-aged children at DWP V Jatirejo Kindergarten, Lekok District, Pasuruan Regency. The anthropometric measurements showed that the majority of respondents fell into the stunted category, based on height-for-age indicators. Simultaneously, salivary pH analysis indicated that most respondents exhibited acidic saliva conditions ($pH < 7$). These results suggest that stunted children are more likely to have an oral environment that predisposes them to demineralization of tooth enamel and increased susceptibility to dental caries.

Stunting, a manifestation of chronic undernutrition, has been shown to influence systemic health, including oral health parameters such as salivary gland function. A consistent nutritional deficiency during the first 1000 days of life impairs both physical development and physiological functions such as salivation [40]. The acidic pH environment

observed in this study supports the notion that compromised nutritional intake in stunted children reduces salivary buffering capacity, thereby creating a favorable environment for cariogenic bacteria.

Furthermore, the buffering ability of saliva essential for maintaining neutral oral conditions is significantly diminished in children experiencing hyposalivation, a condition associated with undernutrition and systemic health deterioration [41]. The data support the hypothesis that nutritional deficiencies directly alter the biochemical properties of saliva, increasing vulnerability to caries-forming microorganisms like *Streptococcus mutans* and *Lactobacillus spp.* [42].

B. COMPARISON WITH PREVIOUS STUDIES AND LIMITATIONS

The findings align with prior studies, such as those by Rahayu et al., which emphasized a strong correlation between salivary pH and caries prevalence among preschool children [43]. In agreement, Asriawal and Jumriani also demonstrated that the lower the salivary pH, the higher the incidence of dental caries, particularly in populations with high rates of stunting [44]. Similarly, research by Kazakova and Sobirov highlighted factors influencing salivary pH, including nutritional intake, oral hygiene practices, and microbial activity in the oral cavity [45].

Notably, Setyorini et al. found that the oral self-cleaning mechanism mediated by saliva was disrupted in stunted children, further exacerbating their susceptibility to dental disease [46]. These studies collectively reinforce the evidence that systemic undernutrition affects local oral physiology, which is a critical aspect of children's health yet often overlooked.

However, some studies present contrasting findings. For instance, research by Pebruanti and Rokhaidah indicated no direct correlation between stunting and dental caries, suggesting that factors such as family education, socioeconomic status, and oral hygiene habits may moderate this relationship [47]. These discrepancies underscore the multifactorial nature of caries development and the need to control for confounding variables in future research.

Limitations of the current study include its cross-sectional design, which restricts the ability to establish causality. Additionally, the sample size, though statistically sufficient, was limited to a single educational institution, reducing generalizability. Other potential influencers such as dietary patterns, fluoride exposure, and brushing habits were not assessed, which could offer a more comprehensive understanding of caries risk factors in stunted children.

C. IMPLICATIONS AND RECOMMENDATIONS

The implications of this study are twofold. First, it highlights a critical interrelationship between systemic nutrition and oral health, specifically the association between stunting and altered salivary pH. The tendency for acidic saliva in stunted children represents a physiological vulnerability that may lead to early-onset and severe dental caries, thereby affecting overall health, learning capacity, and quality of life.

Second, these findings underscore the need for integrated health promotion strategies that bridge pediatric nutrition

and dental care. Schools and early childhood education institutions like kindergartens should serve as focal points for routine oral health screenings and nutritional monitoring. Health professionals including pediatricians, dentists, and nutritionists must collaborate to develop holistic intervention programs.

The results support policy initiatives aimed at early identification and intervention for children at risk of both stunting and poor oral health. For example, enhancing the use of MCH (Mother and Child Health) books as a monitoring tool and reinforcing parental counseling on appropriate feeding practices and oral hygiene could prove effective. Furthermore, educational campaigns targeting caregivers must emphasize the importance of both balanced nutrition and oral hygiene in early childhood.

Future studies are recommended to employ longitudinal or case-control designs with broader and more diverse samples. Inclusion of variables such as dietary intake, oral hygiene habits, and salivary biomarkers would provide deeper insights into causal pathways. This research also encourages exploration into preventive public health strategies that integrate dental and general pediatric care in regions with high stunting prevalence [48], [49], [50].

V. CONCLUSION

The primary aim of this study was to examine the relationship between stunting and the potential of hydrogen (pH) in the saliva of preschool children at DWP V Jatirejo Kindergarten, Lekok District, Pasuruan Regency. Based on the analysis conducted using the chi-squared test, the findings indicate a statistically significant association between the incidence of stunting and salivary pH levels in preschool children, with a p-value of $p = 0.007$, which is less than the predetermined significance level of 0.05. This result supports the hypothesis that children experiencing stunting are more likely to exhibit lower (acidic) saliva pH values compared to non-stunted children. Such a condition contributes to an increased risk of dental caries due to an oral environment conducive to the growth of acidogenic bacteria and reduced salivary buffering capacity. These findings further emphasize that oral health issues in stunted children may be a consequence of systemic nutritional deficiencies, highlighting the interconnectedness between general health and dental health. Despite having only primary (deciduous) teeth, preschool children require adequate attention from parents and caregivers, as the health and integrity of milk teeth significantly influence the proper development and alignment of permanent teeth. Therefore, parental involvement is essential in guiding and supporting healthy dietary practices and oral hygiene behaviors. This study also acknowledges the need for broader exploration into other factors that could influence salivary pH, such as dietary habits, oral hygiene practices, systemic conditions, and environmental exposures. Future research should consider employing longitudinal or case-control study designs with larger, more diverse sample populations to strengthen the understanding of causality and broaden the generalizability of findings. In addition, integrating oral health education into national stunting reduction programs may provide a holistic approach to improving child health outcomes. It is

recommended that early health interventions encompass both nutritional and oral health dimensions to effectively mitigate the long-term consequences of stunting and prevent the early onset of dental caries in vulnerable pediatric populations.

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DATA AVAILABILITY

The data used and analyzed during the current study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

Silvia Prasetyowati contributed to the conceptualization and design of the study, coordinated data collection, and prepared the initial draft of the manuscript. Dian Fitri Ana Dewi assisted in data acquisition, performed the literature review, and contributed to analysis and interpretation of the results. Siti Fitria Ulfah supported the research implementation in the field and participated in manuscript editing and refinement. Anshad Ansari provided critical insights into oral health analysis, contributed to data validation, and reviewed the final manuscript. All authors have read and approved the final version of the paper.

DECLARATIONS

ETHICAL APPROVAL

This study was approved by the Ethics Committee of Poltekkes Kemenkes Surabaya. All procedures were conducted in accordance with the ethical standards of the institutional research committee and the Declaration of Helsinki.

CONSENT FOR PUBLICATION PARTICIPANTS.

All participants' parents or legal guardians were informed about the research and publication purposes, and written consent for publication was obtained.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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