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The Association Between Maternal Nutritional Status During Pregnancy and Delayed Primary Tooth Eruption in Stunted Toddlers

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ABSTRACT This study addresses the pervasive issue of delayed primary tooth eruption among stunted toddlers and examines the potential influence of maternal nutritional status during pregnancy on this dental development delay. Recognizing that nutritional status is integral to optimal growth and developmental outcomes in early childhood, this research seeks to elucidate the relationship between maternal nutrition and dental eruption patterns in toddlers exhibiting stunting, thereby contributing to the broader understanding of factors affecting child health and development. The research employs a retrospective analytical cross-sectional design conducted at the Umbulsari Public Health Center in January 2024. The study sample comprises 78 mothers and their toddlers aged 24 to 52 months, selected through purposive sampling to meet specific inclusion criteria such as documented nutritional status during pregnancy and toddlers' presence at the posyandu. Maternal nutritional status was assessed based on Body Mass Index (BMI) recorded during the first prenatal visit in the Maternal and Child Health (KIA) book. Concurrently, dental examinations were performed to determine the eruption status of primary teeth in the toddlers. Data analysis involved the Spearman correlation test to evaluate the relationship between maternal BMI and the timing of tooth eruption. The results revealed that the majority of mothers maintained an optimal BMI within the normal range (18.5–24.9 kg/m²), yet a significant proportion of stunted toddlers exhibited delayed tooth eruption, with 66.7% showing such delays. Importantly, statistical analysis demonstrated a significant association between maternal nutritional status and the timing of primary tooth eruption ($\rho = 0.035$, $p < 0.05$), indicating that suboptimal maternal nutrition may contribute to delayed dental development in stunted children. The findings underscore the importance of adequate maternal nutrition during pregnancy as a determinant of proper dental emergence in toddlers. These results highlight the need for comprehensive nutritional interventions and public health strategies aimed at improving maternal dietary intake, which may, in turn, enhance early childhood growth and development outcomes.

INDEX TERMS Maternal nutrition, Delayed tooth eruption, Stunting, Pregnancy, Childhood development.

I. INTRODUCTION

Malnutrition during pregnancy remains a critical global health challenge, particularly in low- and middle-income countries, where the prevalence of maternal undernutrition significantly contributes to adverse fetal and child health outcomes [1], [2]. Among these outcomes, stunting in children under five years of age is a widespread issue, characterized by impaired growth and development resulting from chronic nutritional deficiencies [3], [4]. Stunting not only affects physical growth but can also lead to long-term consequences such as cognitive impairment, reduced productivity, and increased susceptibility to illness [5], [6]. The importance of maternal nutritional status during pregnancy has been well recognized for its influence on fetal development and subsequent childhood outcomes [7], [8]. Adequate intake of macro- and micronutrients during this crucial period supports optimal fetal growth, organ development, and overall health [9], [10]. Conversely, maternal malnutrition, even in subtle forms, is associated with increased risks of low birth weight, preterm birth, and developmental delays [11], [12]. Recent studies have underscored the link between maternal nutrition and not only birth outcomes but also postnatal developmental milestones, including dental health [13], [14]. Despite the significant evidence emphasizing maternal nutrition's role, gaps persist in understanding its specific impact on secondary developmental processes such as tooth eruption in children, particularly in populations with high stunting prevalence. Evidence suggests that delayed tooth eruption, a common dental developmental anomaly, is influenced by various factors, including nutritional status, systemic health, and environmental conditions [15], [16]. However, research exploring the direct correlation between maternal nutritional profiles during pregnancy and subsequent primary tooth eruption in stunted children remains limited, especially within specific regional contexts [17], [18]. The existing

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body of work predominantly focuses on general growth indicators or birth outcomes, with less attention paid to oral developmental parameters. Furthermore, many studies are constrained by cross-sectional designs, limited sample sizes, and regional focus, leading to challenges in generalizability and application in broader public health strategies [19], [20].

Therefore, there's a pressing need for comprehensive investigations that address these limitations, integrating maternal nutritional assessments with postnatal developmental milestones such as dental eruption. While the influence of maternal nutrition on birth weight and growth is extensively documented, the association between maternal nutritional status during pregnancy and delayed primary tooth eruption in stunted toddlers remains underexplored [21]. This gap is particularly evident in rural and underserved populations where nutritional deficiencies are prevalent, and health resource disparities are pronounced. Additionally, existing studies often neglect the multifactorial nature of dental developmental delays, which involve systemic, genetic, environmental, and socioeconomic factors [22]. Therefore, this study aims to investigate the correlation between maternal nutritional status during pregnancy and the occurrence of delayed primary tooth eruption in stunted toddlers. The research seeks to elucidate whether maternal nutritional deficiencies serve as significant predictors for delayed dental development, considering potential confounding variables such as socioeconomic status, environmental health factors, and toddler health indicators. This research is expected to contribute to the existing literature in multiple ways:

1. Clarification of the relationship between maternal nutrition and dental development: providing evidence for integrated health policies that encompass maternal and child health, including oral health considerations.
2. Enhancement of public health interventions: informing targeted nutritional programs and educational campaigns aimed at pregnant women in high-risk populations.
3. Advancement of research methodologies: demonstrating an effective combination of anthropometric, nutritional, and dental assessment tools to study developmental delays.
4. Policy development implications: supporting the formulation of comprehensive maternal and child health policies that incorporate oral developmental health as a key component.

The paper is organized into the following sections: Section II reviews relevant literature about maternal nutrition, stunting, and dental development. Section III details the methodology, including the research design, sampling approach, data collection procedures, and analytical methods. Section IV presents the results and discusses the findings about existing studies. Finally, Section V concludes the paper with implications, limitations, and recommendations for future research.

II. METHOD

This study employed a retrospective correlational design to investigate the relationship between maternal nutritional status during pregnancy and the timing of primary tooth eruption in stunted toddlers. The research was conducted at the Umbulsari Public Health Center in Jember Regency, East Java, Indonesia, from January to March 2024. The methodological framework was designed to facilitate accurate data collection, reliable analysis, and reproducibility, aligned with standard epidemiological research protocols [23].

A. STUDY POPULATION AND SAMPLE SECTION

The target population comprised mothers of toddlers aged 24 to 52 months who visited the Posyandu (integrated health service post) at the Umbulsari Public Health Center. A total of 162 mothers fitting this criterion were identified during the study period. To ensure representative sampling, the study utilized purposive sampling, a non-probability sampling technique that enables the selection of participants based on specific inclusion and exclusion criteria relevant to the research objectives [24]. Inclusion criteria were: (1) mothers with toddlers aged 24-52 months; (2) mothers who regularly attended Posyandu visits; (3) toddlers diagnosed with stunting based on anthropometric measurements; and (4) mothers willing to participate and provide informed consent. Exclusion criteria encompassed: (1) mothers with chronic illnesses or conditions affecting nutritional status; (2) toddlers with congenital anomalies or systemic diseases influencing dental development; and (3) incomplete or missing data in maternal or child health records. A sample size of 78 respondents was determined based on the prevalence of stunting and dental delays observed in preliminary assessments, with consideration for statistical power and significance levels ($\alpha = 0.05$). The sample size was further justified by G*Power calculations to detect a moderate correlation effect size with 80% power [25].

B. DATA COLLECTION AND DATA ANALYSIS

Data collection involved several structured steps to ensure a comprehensive and accurate assessment of relevant variables:

1. Review of Maternal Health Records: The primary data on maternal nutritional status during pregnancy was extracted from the KIA (Kesehatan Ibu dan Anak) books, specifically focusing on the first antenatal visit. The Body Mass Index (BMI) was calculated based on recorded weight and height during this visit, following WHO guidelines [26]. Maternal BMI was categorized into the normal range (18.5–24.9 kg/m²) and non-normal categories (underweight < 18.5 kg/m², overweight ≥ 25 kg/m²).
2. Measurement of Toddler Nutritional Status: Anthropometric data such as height and weight were obtained from the Posyandu records and cross-verified with the KIA books. The z-scores for height-for-age (H/A) were calculated using WHO Anthro software [27]. Toddlers with length/height-for-age z-scores below -2 SD were classified as stunted.
3. Dental Examination for Tooth Eruption: A trained pediatric dentist conducted intraoral examinations to determine the eruption status of primary teeth. The

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presence or absence of erupted teeth was documented, noting cases of delayed eruption based on age-appropriate eruption charts [28].

4. Data Recording and Management: All collected data were recorded on standardized forms and entered into a secure database. Quality control was maintained through double data entry and validation procedures to minimize errors and ensure data integrity.

The analysis focused on exploring the association between maternal nutritional status and primary tooth eruption in stunted toddlers. Descriptive statistics summarized demographic variables, nutritional statuses, and dental findings. Bivariate analysis employed Spearman's rank correlation tests to evaluate the relationship between maternal BMI during pregnancy and the age of tooth eruption, given the ordinal and non-parametric nature of the data [29]. A p-value of less than 0.05 was considered statistically significant. Data processing and analysis were performed using SPSS version 25.0 (IBM Corp., Armonk, NY), ensuring adherence to statistical best practices for correlational studies. This methodological approach aligns with recent epidemiological studies examining prenatal factors and dental developmental outcomes [30], [31]. The use of purposive sampling enables targeted investigation of high-risk groups such as stunted children, while standardized measurement protocols enhance reproducibility [32]. The retrospective data collection from existing health records facilitates efficient resource utilization and minimizes participant burden [33].

C. LIMITATIONS AND BIAS MINIMIZATION

Several methodological limitations may influence the interpretation of findings. Potential recall bias represents a primary concern, as maternal self-reporting of pregnancy nutritional status relies on retrospective memory, which may be subject to inaccuracies. Additionally, missing medical records could have affected data comprehensiveness. These limitations were mitigated through cross-verification using multiple data sources, including Posyandu documentation and standardized anthropometric measurements. The cross-sectional design limits the ability to establish definitive causal relationships between maternal nutritional status and dental eruption patterns. Selection bias may have occurred through purposive sampling, potentially limiting generalizability. The inclusion of trained healthcare professionals and adherence to standardized assessment protocols minimized measurement bias and ensured data reliability. Future research should implement prospective longitudinal designs with larger sample sizes to establish causality more definitively. Incorporating biochemical markers and detailed dietary assessments could provide more objective nutritional status measures [34].

D. ETHICAL CONSIDERATIONS

Before data collection, ethical approval was obtained from the Institutional Review Board of the Department of Dental Health, Poltekkes Kemenkes Surabaya (Reference No. 045/Poltekkes/2024). Participants provided written informed consent after being briefed on the study objectives, procedures, confidentiality, and their right to withdraw at any stage without repercussions.

III. RESULTS

The demographic composition of the Umbulsari Public Health Center catchment area encompasses 42,174 residents, with a gender distribution of 21,449 males and 20,725 females. Educational attainment within this population is characterized by a predominance of individuals with limited formal schooling, with the majority having either not attended school or not completed primary education. The primary occupation among residents is agricultural labor. Regarding infrastructure and lifestyle patterns, the community predominantly relies on shallow well water sources for domestic use and utilizes motorcycles as the primary mode of transportation. The healthcare infrastructure within the Umbulsari Public Health Center service area comprises one primary health center, two auxiliary health centers (Pustu), one village maternity clinic (Polindes), two village health centers (Ponkesdes), and one mobile health unit. These facilities collectively serve to enhance community health outcomes and provide accessible healthcare services to the local population. Epidemiological data reveal that the most prevalent morbidity patterns observed at Puskesmas Umbulsari include hypertension, acute respiratory infections, cephalgia, pyrexia, pulpitis, myalgia, type II diabetes mellitus, cough, dyspepsia, and paranoid schizophrenia. The prevalence of these conditions, coupled with the sociodemographic characteristics of the population, suggests indicators consistent with lower socioeconomic status within the Umbulsari Public Health Center service area.

TABLE 1
Respondent Characteristics

Characteristics	Frequencies (n)	Percentages (%)
Mother's Age when Pregnant		
Younger than 18 years of age	0	0
18 to 23 years of age	36	46.2
24 to 29 years of age	29	37.2
30 to 35 years of age	11	14.1
Older than 36 years of age	2	2.6
Mother's Latest Education		
Primary education (SD)	22	28.2
Secondary education (SMP)	31	39.7
Senior high school (SMA)	25	32.1
University	0	0
Gender of Stunting Toddlers		
Boy	40	51.3
Girl	38	48.7
Age of Stunting Toddlers		
Less than 24 months	0	0
Between 24 and 30 months	15	19.2
Between 31 and 36 months	20	25.6
Between 37 and 43 months	24	30.8
Between 44 and 49 months	11	14.1
Greater than 50 months	8	10.3
Nutritional Status of Stunting Toddlers		
Short (-3 SD s/d < -2 SD)	59	75.6
Very Short (< -3 SD)	19	24.4

TABLE 1 demonstrates that the maternal demographic profile of stunted toddlers is predominantly characterized by mothers aged 18-23 years, with educational attainment

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limited to junior secondary level. The gender distribution among stunted toddlers reveals a higher prevalence in males compared to females, with the most affected age cohort being 37-43 months. These children are classified within the "short" category according to stunting nutritional status indicators. Through purposive sampling methodology, 78 participants were recruited based on predetermined inclusion criteria: mothers with children aged 24-52 months, mothers attending Posyandu (integrated health post) services, mothers of children diagnosed with stunting, and parental consent to participate in the study. TABLE 2 indicates that the majority of mothers of stunted toddlers maintained normal nutritional status during pregnancy, as evidenced by Body Mass Index (BMI) measurements ranging from 18.5-24.9 kg/m², which falls within the normal weight classification parameters.

TABLE 2
Nutritional status of mothers of stunted toddlers during pregnancy

Nutritional Status Of Mothers Of Toddlers During Pregnancy	Frequencies (n)	Percentages (%)
< 18,5 kg/m²	20	25.6
18,5 – 24,9 kg/m²	41	52.6
25 – 29,9 kg/m²	11	14.1
> 30 kg/m²	6	7.7
Total	78	100

TABLE 3
Eruption of Primary Teeth in Stunted Toddlers

Eruption of Primary Teeth in Stunted Toddlers	Frequencies (n)	Percentages (%)
Normal Eruption	26	33.3
Delayed Eruption	52	66.7
Total	78	100

TABLE 4
Data Analysis Results Using Spearman Correlation Test

Variable	r	ρ	n
Nutritional Status of Mothers with Stunted Toddlers based on BMI during Pregnancy	-0.239	0.035	78
Eruption Of Primary Teeth In Stunted Toddlers Aged 24-52 Months			

TABLE 3 reveals that the majority of stunted toddlers exhibit delayed dental eruption patterns. TABLE 4 presents the results of the Spearman correlation analysis conducted on 78 respondents, yielding a p-value of 0.035, which is below the significance threshold of $\alpha = 0.05$, with a correlation coefficient of $r = -0.239$. These statistical findings indicate a significant negative correlation between maternal nutritional status during pregnancy and dental eruption timing in stunted toddlers within the Umbulsari Public Health Center catchment area in 2024. Consequently, the alternative hypothesis (H1) is accepted, while the null hypothesis (H0) is rejected, establishing a statistically significant relationship between these variables.

IV. DISCUSSION

The findings of this study demonstrate a significant association between maternal nutritional status during pregnancy and the eruption of primary teeth in stunted toddlers [35]. Specifically, the data revealed that 52.6% of mothers maintained a normal nutritional status, categorized within the BMI range of 18.5–24.9 kg/m², yet a notable 66.7% of their children exhibited delayed primary tooth eruption. The statistical analysis employing Spearman's correlation indicated a significant relationship ($\rho = 0.035$, $p < 0.05$) between maternal nutritional status and tooth eruption timing, underscoring the influence of prenatal nutritional conditions on early childhood dental development. This correlation suggests that maternal nutrition during pregnancy serves as a pivotal factor affecting the odontogenic process in offspring, particularly in those experiencing stunting. The delayed eruption of primary teeth in these children signals underlying systemic and developmental disruptions likely rooted in intrauterine nutritional deficiencies. Such deficiencies may impair odontogenesis, leading to a lag in tooth emergence, which is consistent with the established understanding that early nutritional deficits interfere with tissue differentiation and development [36]. Furthermore, the high prevalence (66.7%) of delayed tooth eruption among stunted toddlers underscores the interconnectedness of nutritional status, growth, and developmental milestones. The findings suggest that even in cases where maternal BMI is within the normal range, other factors such as micronutrient deficiencies, intrauterine growth restriction, and postnatal nutritional environment might contribute to dental developmental delays. This complexity indicates that maternal BMI alone may not comprehensively reflect the nutritional adequacy affecting fetal and early childhood development, but it remains a valuable indicator.

The observed association aligns with and extends findings from recent research emphasizing the critical role of maternal nutrition in early childhood development. For instance, a study by Lee et al. [37] (2021) found that maternal micronutrient deficiencies, particularly iron and zinc, during pregnancy are significantly related to delayed tooth eruption in children aged 1-3 years. Similarly, Singh et al. [38] (2020) reported that intrauterine growth restrictions caused by poor maternal nutrition substantially impact the timing of primary dentition, corroborating the present findings. Contrastingly, some recent investigations have highlighted that other factors, such as genetic predisposition and environmental influences, also significantly contribute to eruption timing [39]. In a study by Wang et al. [40] (2022), the influence of socioeconomic status and environmental factors like fluoride exposure overshadowed the role of maternal BMI, suggesting that multi-faceted approaches are necessary to understand dental developmental delays comprehensively. These contrasting results emphasize the complexity of dental eruption and the need to consider a broad spectrum of determinants beyond maternal BMI alone. Moreover, the current study's focus on a specific population within the Umbulsari Public Health Center provides localized insights but may limit generalizability. Recent meta-analyses highlight that variations in genetic, environmental, and demographic factors influence eruption timing [41]. Therefore, while results are consistent with global trends regarding maternal nutrition and dental development, broader studies incorporating diverse populations and additional nutritional parameters are warranted to substantiate and expand upon these findings. While the study offers valuable insights into the relationship

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between maternal nutritional status and early childhood dental development, several limitations must be acknowledged. Firstly, the retrospective cross-sectional design constrains causal inference, as temporality cannot be definitively established. Longitudinal studies are essential to verify temporal relationships and evaluate causality comprehensively [42]. Secondly, the reliance on BMI as the sole indicator of maternal nutritional status may overlook the role of micronutrient deficiencies, dietary quality, and metabolic factors influencing fetal development [43].

Future research should incorporate more detailed nutritional assessments, including micronutrient profiling and dietary intake analysis. Thirdly, the sample size, although appropriate for preliminary analysis, remains relatively small, and the purposive sampling method introduces potential selection bias, limiting the study's external validity. Larger, randomized studies encompassing diverse demographics would enhance the robustness of these associations. Additionally, the study focused exclusively on mothers within a specific geographical region; socio-economic and cultural factors unique to this setting might influence outcomes. Considering socio-economic variables such as income, education, and access to healthcare can provide a more comprehensive understanding of the determinants of delayed tooth eruption. Despite these limitations, the findings hold significant implications for public health and clinical practice. Early identification of children at risk of developmental delays can guide interventions aimed at optimizing maternal nutrition during pregnancy. Emphasis on preconception and antenatal nutrition programs, including micronutrient supplementation and dietary counseling, could mitigate the risk of delayed dental development. Moreover, dental practitioners should be cognizant of the developmental milestones and nutritional histories of pediatric patients, facilitating early detection and management of potential anomalies [44]. From a policy perspective, integrating nutritional education within maternal and child health programs can have broad-reaching effects. The study underscores the importance of comprehensive prenatal care that prioritizes nutritional adequacy, not only for preventing stunting but also for ensuring timely dental development. Future policy initiatives could include routine nutritional screening during pregnancy and targeted interventions for populations vulnerable to malnutrition. On the research front, further studies are essential to elucidate the multifactorial etiology of dental eruption delays. Prospective cohort studies examining nutritional biomarkers, environmental exposures, genetic predispositions, and their interactions would deepen understanding. Investigations into the role of specific micronutrients, like calcium, vitamin D, and zinc, on odontogenesis could inform targeted nutritional interventions. Additionally, exploring long-term outcomes associated with delayed eruption, such as malocclusion, caries risk, and overall oral health, can inform comprehensive child health strategies [45].

V. CONCLUSION

The primary aim of this study was to investigate the association between maternal nutritional status during pregnancy and the delayed eruption of primary teeth in stunted toddlers at the Umbulsari Public Health Center. The findings demonstrated a significant relationship between these variables, with a notable proportion of mothers maintaining a nutritional status within the normal BMI range (18.5–24.9 kg/m²) in 52.6% of cases, while, concurrently, 66.7% of the examined stunted toddlers exhibited delayed primary tooth eruption. Statistical analysis revealed a correlation coefficient (ρ) of 0.035 with a p-value less than 0.05, indicating a weak yet statistically significant association between maternal nutritional status and the timing of tooth eruption in this population. These outcomes underscore the potential influence that maternal dietary adequacy during pregnancy exerts on the developmental milestones of oral health in children, particularly within a cohort vulnerable to stunting and growth retardation.

Despite these insightful results, the study is constrained by several limitations, including its retrospective design, small sample size, and geographic specificity, which may restrict the generalizability of the findings to broader populations. Furthermore, the reliance on historical data for nutritional assessment and the exclusion of other potentially influential factors such as genetics, overall health status, and environmental conditions suggest the need for a more comprehensive approach in future research endeavors. To deepen understanding and enhance the robustness of these findings, subsequent studies should incorporate prospective methodologies, larger and more diverse samples, and explore additional variables that may impact tooth eruption, such as genetic predispositions and socioeconomic factors. Longitudinal research could provide clearer insights into causal relationships and developmental trajectories over time. The implications of this research emphasize the importance of targeted nutritional interventions and health education programs aimed at improving maternal diet during pregnancy, which could potentially reduce the incidence of delayed tooth eruption and subsequent oral health complications in children. Ultimately, future research should aim to develop integrated intervention strategies that address multiple determinants influencing child growth and development, thereby fostering holistic improvements in child health outcomes. This study contributes valuable evidence indicating that maternal nutrition plays a crucial role in early childhood oral development, reinforcing the need for comprehensive prenatal care and nutritional monitoring as vital components of public health policy aimed at optimizing developmental milestones and preventing growth-related disparities in pediatric populations.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Nabila Rizqi Amalia conceptualized and designed the study, developed the research methodology for investigating maternal nutritional status and dental eruption patterns, conducted comprehensive data collection at Umbulsari Public Health Center and Posyandu facilities, and performed the statistical analysis, including the Spearman correlation test. She led the interpretation of findings and drafted the initial manuscript. Isnanto contributed to the study design and methodological framework, supervised the research implementation and data collection process, provided expertise in nutritional assessment protocols, and offered critical guidance throughout the analytical phases. He participated in manuscript review and provided substantial revisions to enhance the scientific rigor of the work. Sri Hidayati assisted with the comprehensive literature review, supported data collection activities and participant recruitment through purposive sampling, contributed to data organization and preliminary analysis, and participated in manuscript preparation and editing. She also provided valuable insights into stunting assessment methodologies and community health approaches. All authors collaborated in the interpretation of research findings, reviewed and approved the final version of the manuscript, and agreed to be accountable for all aspects of the work, ensuring the integrity and accuracy of the research conducted at the Umbulsari Public Health Center in 2024.

DECLARATIONS

ETHICAL APPROVAL

This study was conducted by the Declaration of Helsinki and received ethical clearance from the Institutional Review Board of the Department of Dental Health, Poltekkes Kemenkes Surabaya (Reference No. 045/Poltekkes/2024) prior to data collection commencement. All participants were provided with comprehensive information regarding the study's objectives, methodology, potential risks and benefits, data confidentiality measures, and their voluntary participation rights. Written informed consent was obtained from all participating mothers before enrollment, with explicit clarification of their right to withdraw from the study at any time without penalty or impact on their healthcare services. The research protocol ensured participant anonymity and data protection throughout the study period, with all collected information stored securely and used solely for research purposes as outlined in the approved ethical framework.

CONSENT FOR PUBLICATION PARTICIPANTS

All participants provided explicit written consent for publication of their anonymized data and research findings. Participants were informed about the intended publication and granted permission for the dissemination of de-identified information, with assurance that individual identities would remain confidential throughout the publication process.

COMPETING INTERESTS

The authors declare no financial, personal, or professional relationships that could potentially influence or bias this research. No competing interests exist that could compromise the objectivity and integrity of this investigation into maternal nutritional status and dental eruption patterns in stunted toddlers.

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