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Stunting and Child Development: Evidence from Pujo Basuki Village, Central Lampung

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ABSTRACT

Stunting remains a significant public health issue due to its long-term effects on child development, especially in low- and middle-income countries. This study aims to explore the impact of stunting on multiple developmental domains, including gross motor skills, fine motor skills, speech and language, socialization, and overall child development, using the Developmental Pre-Screening Questionnaire (*KPSP*) as a developmental assessment tool. We hypothesized that children with stunting would exhibit significantly lower developmental scores across all domains compared to non-stunted children, even after controlling for age and number of siblings. A comparative cross-sectional design was employed, and data were analyzed using independent t-tests, Multivariate Analysis of Covariance (MANCOVA), and Analysis of Covariance (ANCOVA). MANCOVA revealed significant effects of both stunting and age on most developmental domains, with stunting having a powerful impact on fine motor skills ($F=6.424$, $p=0.018$, $\eta^2=0.211$), speech and language skills ($F=11.924$, $p=0.002$, $\eta^2=0.332$), and overall KPSP scores ($F=46.874$, $p<0.001$, $\eta^2=0.661$). ANCOVA confirmed the unique effect of stunting after adjusting for age. These findings underscore the critical need for early nutritional interventions, as stunting not only affects physical growth but also hampers essential developmental milestones. Addressing stunting could significantly improve long-term developmental outcomes and reduce health disparities among children in affected populations.

INTRODUCTION

Stunting is a condition of a child's nutritional status, as measured by height compared to age, where the measurement results are two standard deviations or less below the World Health Organization assessment standards (WHO Child Growth Standards). A lack of nutrients before birth and during the first year of life can impact brain development. Children's brain development occurs rapidly, and the process of maturation and formation of connections within the neurological system progresses after birth until early childhood (Sudfeld et al., 2015).

The Indonesian Ministry of Health said that more than a third of Indonesian children were detected as stunted. This is closely related to the high number of babies with low birth weight (10.2%) and the high number of toddlers who are malnourished, resulting in low body weight (wasting) (Ministry of Health Republic Indonesia, 2023). The incidence of stunting in Indonesia is higher than in countries in Southeast Asia, such as Myanmar (35%), Vietnam (23%), and Thailand (16%) (Insani, 2020). Delayed fetal growth and premature birth are important risk factors for stunting in children. A study of low- and middle-income countries (LMIC) analyzed cohort data from 19 studies that compared the risk of stunting in babies born according to their mother's gestational age with that of babies born under other conditions (Wicaksono & Harsanti, 2020). The Indonesian Nutrition Status Survey (*SSGI*) states that the prevalence of stunting in Indonesia in 2022 is 21.6%. This figure remains high and has the potential to cause future losses for the country. In Lampung Province, 15.20% of children experience stunting. One of the stunting loci is in Pujobasuki Village, where 13 stunted children are among a total of 101 toddlers (Ministry of Health Republic Indonesia, 2022).

Many studies have described the negative impacts of developmental delays in children, including emotional, behavioral, and health problems later in life. While well-intentioned, excessive pampering and overprotection can inadvertently hinder the physical, cognitive, and social development of children with delays (Natarajan et al., 2025). A study in India shows that stunting affects children's motor development (Larson et al., 2017). The decline in motor function of stunted children without congenital abnormalities is related to the low mechanical ability of the triceps muscle, due to the slow maturation of muscle function. Research conducted on children aged 4-60 months in Jember District, Indonesia shows that Children with good nutritional status show more optimal developmental progress, while children with poor nutritional status tend to experience slower or inappropriate development for their age (Yuningsih et al., 2024).

Another research conducted at preschool children in Peru in 2011 showed that an increase in the height for age z-score (HAZ) measurement results by one standard deviation was associated with an increase in scores on the Peabody Picture Vocabulary Test (PPVT) by 2.35 points, which This means that children who are taller at their age have a larger vocabulary than those who are shorter. Children with a history of stunting in early childhood have a limited vocabulary and are at risk of having a low level of intelligence when attending school (Alderman et al., 2017). Stunting conditions can also affect children's personal and social abilities. The basic personal social skills that children aged 24-60 months must master include being able to carry out simple tasks independently, such as eating, dressing, and putting on shoes, as well as socializing effectively with their surroundings. Children with stunting conditions will also usually appear apathetic and tend to be reluctant to play with other people around them (Meylia et al., 2020).

The Developmental Pre-Screening Questionnaire (*KPSP*) is a screening tool required by the Ministry of Health for use at the primary healthcare level. Pre-Questionnaire Development Screening, also known as *KPSP*, is a brief list of questions addressed to parents, used as a tool for conducting preliminary screening and development assessments in children aged 3 months to 72 months. This instrument is intended not only for health workers at the Community Health Center and their staff, but also for strategic partners, such as caregivers and early childhood education teachers. The purpose of using *KPSP* is to determine whether the child's development is normal or if there are any deviations. Seeing the numerous impacts caused by stunting, researchers are interested in exploring and analyzing the impact of stunting on the motor development, speech, and psychosocial abilities of toddlers at the Pujo Basuki Stunting Locus in Central Lampung. The study site was purposively chosen as it is designated as a stunting locus, with a disproportionately high stunting rate compared to the total under-five population.

METHOD

The study design employed in this research is an analytical observational study with a cross-sectional design, utilizing a purposive sampling technique to select children under 5 years old from the Pujobasuki Village area in Central Lampung. The independent variables included in this study include 1) Sample characteristics, including gender, current age, weight, height, and number of siblings; 2) Exclusive breastfeeding; 3) Complete immunization; 4) Parental Education; 5) Parents' Occupation; 6) fine motor skills; 7) Gross motor skills; and 8) Speech and Language Abilities. This assessment uses the Pre-Screening Development Questionnaire (KPSP) instrument issued by the Indonesian Ministry of Health. Data analysis included independent t-tests to compare mean differences in developmental scores between stunted and non-stunted children. To further explore the effects of stunting, age, and number of siblings on child development, a MANCOVA (Multivariate Analysis of Covariance) was conducted, allowing for control of covariates. Following this, ANCOVA (Analysis of Covariance) was performed to examine the impact of stunting on each developmental domain while adjusting for age. Statistical significance was set at $p<0.05$, and effect sizes were reported using Partial Eta Squared (η^2) to assess the magnitude of stunting's effect on child development.

The process of sample selection adhered to ethical standards and received approval from the University's Health Research Ethics Committee (KEPK), specifically Tanjung Karang Ministry of Health Polytechnic, with letter number No. 439/KEPK-TJK/VIII/2023. Additionally, formal approval for conducting the research was obtained. The selection of samples was meticulously executed according to predetermined inclusion and exclusion criteria established by the researcher. The measurements were conducted at two distinct locations: the posyandu and the respondent's home.

The sampling methodology employed in this study utilized total sampling, encompassing all children identified with stunting status as participants. For the control group, participants were selected based on matching age criteria with those in the stunting group to mitigate age-related bias. The respondents included in this research comprised toddlers with stunting, and anthropometric measurements were conducted at the Pujo Basuki Posyandu. This study employs total sampling, as all cases were considered part of the sample. The sample size for this study comprised 28 toddlers, aged between 13 months and 56 months. The assessment of fine motor skills, gross motor skills, language and speech abilities, as well as independence and social utilization, was conducted using the Pre-Screening Development Questionnaire (*KPSP*), which the Indonesian Ministry of Health has ratified.

Univariate analysis was employed to analyze categorical scale data collected during the research process. The distribution frequency of the data was calculated as a preliminary step before proceeding to bivariate analysis. A normality test, specifically the Kolmogorov-Smirnov test, was conducted prior to bivariate analysis. Data analysis included independent t-tests to compare mean differences in developmental scores between stunted and non-stunted children. To further explore the effects of stunting, age, and number of siblings on child development, a MANCOVA (Multivariate Analysis of Covariance) was conducted, allowing for control of covariates. Following this, ANCOVA (Analysis of Covariance) was performed to examine the impact of stunting on each developmental domain while adjusting for age. Statistical significance was set at $p<0.05$, and effect sizes were reported using Partial Eta Squared (η^2) to assess the magnitude of stunting's effect on child development.

RESULTS

Table 1. Sample characteristics

Variable	Category	f	%
Stunting status	Normal	13	46.4
	Stunted	15	53.6
Child's age (Months)	13–24 months	5	17.8
	25–36 months	5	17.8
	37–48 months	10	35.8
	49–54 months	4	28.6
BMI status	Normal	20	71.4
	Mild–Moderate Malnutrition	8	28.6
Sex	Male	12	42.8
	Female	16	57.2
Mother's education	≤ SMA (Low–Middle)	22	78.5
	> SMA (Higher)	6	21.5
Father's education	≤ SMA (Low–Middle)	27	92.9
	> SMA (Higher)	2	7.1
Exclusive breastfeeding	Yes	23	82.2
	No	5	17.8
Number of siblings	0–2	16	57.2
	≥3	12	42.8
Peer interaction	Yes	21	75.0
	No	7	25.0

Table 1 presents the sample characteristics for a study investigating the effect of stunting on child development. The respondents consisted of 13 stunted toddlers and 15 non-stunted toddlers, with an age range of 13 to 56 months. There were 16 female respondents (57.2%) and 12 male respondents (42.8%). The education levels of the respondents' mothers and fathers varied from elementary school to bachelor's degree. A large segment of the sample population received breast milk during infancy (82.2%). Most participants in the sample come from households with siblings (67.8%) and had peers (75%) who played and interacted with them in their immediate environment.

The majority of respondents (67.8%) have siblings, a finding related to nutritional status and the incidence of stunting in children, according to research conducted in Ngandu, a settlement in Kenya. This research concluded that siblings have a significant influence on children's nutrition status, but the impact varies depending on the risk period. In general, older siblings (≥5 years) have a positive impact on siblings of the same age, whereas younger siblings (<5 years) have a negative impact on siblings between the ages of 2.5 and <10 years (Helfrecht & Meehan, 2016). Moreover, have peers in their environment (75%). All respondents actively checked their growth by visiting the posyandu. The completeness of immunization reached 100%, as all respondents had received immunizations according to their age (Cueto et al., 2016).

According to Table 1, the coverage of exclusive breastfeeding among all respondents was 82.2%. Research shows that exclusive breastfeeding is associated with the incidence of stunting in toddlers. This is in accordance with the results of research by Anita Sampe et al. (2020), who conducted a case-control study approach using 144 respondents, consisting of 72 case respondents and 72 control respondents, all of whom were parents of toddlers diagnosed with stunting or non-stunting. The results of the chi-square test were p=0.000 (0.000<0.05) which showed that there was a relationship between exclusive breastfeeding and the incidence of stunting in toddlers with a value of OR = 61 which means toddlers who were not given exclusive breast milk and toddlers who were given exclusive breast milk were 61 times more likely to more likely to experience stunting than toddlers who are given exclusive breast milk. It can therefore be concluded that exclusive breastfeeding reduces the risk of stunting (Sampe et al., 2020).

A child's development is strongly correlated with parental education, particularly in terms of academic achievement and success. Research has demonstrated that greater parental education is linked to children's academic success, both directly through increased child IQ and indirectly through improved family dynamics and parenting techniques (Semba et al., 2008). In addition to the cognitive benefits, parental education also affects the emotional and social development of children. Better-educated parents tend to foster positive family dynamics, promoting an environment of open communication, emotional support, and constructive discipline. Such environments encourage children to develop independence, self-regulation, and resilience skills that are critical for academic success and social adaptation. Furthermore, parents with higher educational backgrounds are often more engaged in their children's schooling, actively participating in school events, monitoring academic progress, and providing guidance on navigating academic challenges.

There are multiple ways in which a child's early motor development is related to parental education. Studies indicate that children with stronger motor skills are more likely to be physically active, play sports more frequently, and perform better academically in the future than children with weaker motor abilities. Early motor ability deficiencies in children (0-2 years old) have been associated with a higher chance of motor issues when they start school (Pedersen et al., 2023). To support their infant's motor development, parents play a crucial role. Through their interactions and the environment they create, parents have a substantial impact on their child's motor development during the first year of life. More educated parents would have a better understanding of the importance of motor development and are more likely to engage in activities that promote motor skills, such as playing with their child, providing stimulating toys, and encouraging physical activity.

Peers and sibling also have a significant impact on motor development in infancy. Research has shown that the presence and behaviors of people within the home and school environment and the motor performance of a child. This suggests that a stimulating environment, in terms of interactions with others, is beneficial for the motor performance of a child (Derikx et al., 2021).

This might be due to the enriched stimulation provided by the presence of siblings and peers. A study in Portugal has shown that in early age, children in a household with siblings, independent of their age and sex, have a greater chance of being classified in the high and average motor competence groups regarding their total motor competence, when compared to children without siblings (Rodrigues et al., 2021).

Table 2. Descriptive statistics

Items	Stunting Status	Mean	Std.Deviation	n
Gross motor skills	Normal	2.27	0.594	15
	Stunting	1.92	0.641	13
Fine motor skills	Normal	2.33	0.488	15
	Stunting	1.69	0.480	13
Speech and language skills	Normal	3.07	0.704	15
	Stunting	2.38	0.650	13
Socialization and independence skills	Normal	2.47	0.516	15
	Stunting	1.77	0.439	13
Overall KPSP score	Normal	10.13	0.516	15
	Stunting	7.77	1.092	13

The descriptive statistics provide an overview of the differences in child developmental scores between children with normal growth and those experiencing stunting, across various developmental domains assessed using the KPSP. For gross motor skills, children with normal growth exhibited a higher mean score (M=2.27, SD=0.594, n=15) compared to those with stunting (M=1.92, SD=0.641, n=13), suggesting that stunted children tend to have lower gross motor skill development. In terms of fine motor skills, the pattern is similar. Children with normal growth had a mean score of 2.33 (SD=0.488, n=15), while children with stunting had a lower mean of 1.69 (SD=0.480, n=13), indicating that fine motor development is also negatively impacted by stunting.

The speech and language skills domain showed a noticeable difference between the two groups, with normal children scoring higher (M=3.07, SD=0.704, n=15) compared to stunted children (M=2.38, SD=0.650, n=13), further emphasizing the impact of stunting on language development. Regarding socialization and independence skills, children with normal growth had a mean score of 2.47 (SD=0.516, n=15), whereas stunted children scored lower at 1.77 (SD=0.439, n=13), indicating that stunted children may face challenges in developing social and independent behaviors. Finally, the overall KPSP score, which represents the cumulative assessment across all developmental domains, revealed a substantial gap between the two groups. Children with normal growth had a significantly higher overall score (M=10.13, SD=0.516, n=15) compared to stunted children (M=7.77, SD=1.092, n=13). This underscores the pervasive impact of stunting on overall child development across multiple domains. These results suggest that stunting is associated with notable deficits in all assessed areas of development, particularly in fine motor skills, speech and language skills, and overall developmental outcomes.

Table 3. Results of an Independent t-Test on the mean difference in skill development between children with stunting and without stunting

Dependent variable	n	Control (non-stunting)		Stunting		Stunting Effect				
									95% Confidence Interval	
		Mean	SD	Mean	SD	t^a	df	p-value	Lower	Upper
Gross motor skills	28	2.27	0.594	1.92	0.641	1.473	26	0.153	-0.136	0.823
Fine motor skills	28	2.33	0.488	1.69	0.480	3.492	26	0.002*	0.264	1.018
Speech and language skills	28	3.07	0.704	2.38	0.650	2.648	26	0.014*	0.153	1.211
Socialization and independence skills	28	2.47	0.516	1.77	0.439	3.864	25.994	0.001*	0.326	1.068
Overall *KPSP* score	28	10.13	0.516	7.77	1.092	7.144	16.569	0.000*	1.665	3.064

*: Significantly different in skills development between the stunting group and the non-stunting group.

The results of the independent t-test revealed significant differences in several developmental domains between children with stunting and those without. Children with stunting showed markedly lower developmental scores, particularly in fine motor skills, speech and language skills, socialization, and overall development. For fine motor skills, the stunted group had a mean score of 1.69 (SD=0.480) compared to 2.33 (SD=0.488) in the non-stunted group, yielding a p-value of 0.002. This significant p-value indicates a substantial negative impact of stunting on fine motor tasks that require precision and coordination, such as grasping and manipulating objects. In terms of speech and language development, the stunted group scored a mean of 2.38 (SD=0.650) versus 3.07 (SD=0.704) for their non-stunted counterparts, with a p-value of 0.014. This statistically significant difference reflects the cognitive effects of malnutrition on language processing and communication abilities, emphasizing that stunted children face notable challenges in developing these essential skills.

Similarly, socialization and independence skills were significantly impacted, with the stunted group scoring a mean of 1.77 (SD=0.439) compared to 2.47 (SD=0.516) in the non-stunted group, resulting in a p-value of 0.001. This indicates that stunted children are likely to struggle with social interactions and developing autonomy, further illustrating the pervasive effects of stunting on their overall development. The overall KPSP score, which provides a comprehensive measure of child development, was significantly lower in the stunted group, with a mean score of 7.77 (SD=1.092) versus 10.13 (SD=0.516) in the non-stunted group. The p-value of 0.000 confirms this substantial difference, highlighting that stunting adversely affects multiple developmental domains and reinforces the importance of addressing malnutrition.

Interestingly, while gross motor skills showed a trend toward lower performance in the stunted group (mean=1.92, SD=0.641) compared to the non-stunted group (mean=2.27, SD=0.594), the p-value of 0.153 indicated that this difference was not statistically significant. This suggests that while stunted children may experience some challenges in gross motor development, the effects may be less pronounced than in other areas. Overall, these findings underscore the broad and significant developmental challenges faced by children with stunting, emphasizing the urgent need for early interventions to combat malnutrition and its far-reaching impacts on child development.

Tabel 4. MANCOVA results to see the effects of stunting, age, and siblings on skill developments (inter-subjects effect tests)

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared
Corrected model	Gross motor skills	4.407[a]	3	1.469	5.622	0.005	0.413
	Fine motor skills	3.280[b]	3	1.093	4.616	0.011	0.366
	Speech and language skills	8.358[c]	3	2.786	9.701	<0.001	0.548
	Socialization and independence skills	5.049[d]	3	1.683	9.224	<0.001	0.536
	Overall *KPSP* score	40.941[e]	3	13.647	20.440	<0.001	0.719
Siblings	Gross motor skills	0.055	1	0.055	0.209	0.651	0.009
	Fine motor skills	0.396	1	0.396	1.673	0.208	0.065
	Speech and language skills	0.235	1	0.235	0.818	0.375	0.033
	Socialization and independence skills	0.130	1	0.130	0.714	0.406	0.029
	Overall *KPSP* score	0.000	1	0.000	0.000	0.983	0.000
Age	Gross motor skills	3.579	1	3.579	13.697	0.001*	0.363
	Fine motor skills	0.040	1	0.040	0.168	0.685	0.007
	Speech and language skills	5.028	1	5.028	17.506	<0.001*	0.422
	Socialization and independence skills	1.596	1	1.596	8.744	0.007*	0.267
	Overall *KPSP* score	1.999	1	1.999	2.994	0.096	0.111
Stunting	Gross motor skills	0.474	1	0.474	1.814	0.191	0.070
	Fine motor skills	1.522	1	1.522	6.424	0.018*	0.211
	Speech and language skills	3.424	1	3.424	11.924	0.002*	0.332
	Socialization and independence skills	3.319	1	3.319	18.187	<0.001*	0.431
	Overall *KPSP* score	31.295	1	31.295	46.874	<0.001*	0.661

The results of the MANCOVA test provide important insights into the influence of age and stunting on various domains of child development. Regarding the effect of age, it was found that age significantly impacts both gross motor skills and speech and language skills. For gross motor skills, age showed a significant effect (F(1,38)=13.697, p=0.001), with 36.3% of the variance explained by age (Partial eta squared=0.363). Similarly, age had a significant impact on speech and language skills (F(1,38=17.506, p=0.000), accounting for 42.2% of the variance (Partial eta squared =0.422). These results suggest that developmental milestones in these areas are highly dependent on a child's age, as expected given the natural progression of motor and communication skills with age.

In terms of the effect of stunting, significant differences were observed across multiple developmental domains. Fine motor skills were significantly affected by stunting (F(1,38)=6.424, p=0.018), with 21.1% of the variance explained (Partial eta squared=0.211). Stunting also had a notable effect on speech and language skills (F(1,38)=11.924, p=0.002), explaining 33.2% of the variance (Partial eta squared=0.332). Additionally, stunting significantly impacted socialization and independence skills (F(1,38)=18.187, p=0.000), with a large effect size (Partial eta squared=0.431).

Most strikingly, the effect of stunting on the overall *KPSP* score was highly significant (F(1,38)=46.874, p=0.000), with stunting explaining 66.1% of the variance (Partial eta squared =0.661). These findings underscore the broad and substantial impact of stunting on child development, particularly in fine motor, language, and social skills, with stunting contributing to significant developmental delays in affected children. These results provide a strong case for conducting an ANCOVA as a follow-up analysis to further adjust for the effects of age, which plays a critical role in child development across all measured domains.

Table 5. ANCOVA test after adjusting for the effects of age

	Dependent variable	**Type III sum of squares**	**df**	**F**	**Sig.**	**Partial eta squared**	**R^2**	**aR^2**
Stunting	Gross motor skills	0.738	1	3.095	0.91	0.110	0.408	0.360
	Fine motor skills	2.856	1	11.740	0.002*	0.320	0.322	0.267
	Speech and language skills	3.332	1	11.687	0.002*	0.319	0.533	0.495
	Socialization and independence skills	3.440	1	19.071	<0.001*	0.433	0.522	0.483
	Overall KPSP score	39.123	1	61.039	<0.001*	0.709	0.719	0. 696

The ANCOVA results, after adjusting for age, provide valuable insights into the effects of stunting on various aspects of child development. In the gross motor skills domain, stunting did not show a statistically significant effect (p=0.091), though 11% of the variance was explained by stunting. The adjusted R-squared (aR^2=0.260) suggests that the model accounted for 26% of the variability in gross motor skills, indicating that age may play a more significant role in this domain than stunting. Conversely, fine motor skills were significantly impacted by stunting (p=0.002), with 32% of the variance explained by stunting after adjusting for age. The adjusted R-squared (aR^2=0.267) indicates that 26.7% of the variability in fine motor development is accounted for by both age and stunting, highlighting that stunted children face notable delays in coordination.

Similarly, speech and language skills were significantly affected by stunting (p=0.002), with 31.9% of the variance explained by stunting. The adjusted R-squared (aR^2=0.495) indicates that 49.5% of the variability in speech and language development is explained by the combined effects of stunting and age, highlighting the significant impact of stunting on communication abilities. Stunting had a substantial effect on socialization and independence skills (p=0.000), accounting for 43.3% of the variance. The adjusted R-squared (aR^2=0.483) indicates that 48.3% of the variability in these skills is explained by stunting and age, demonstrating the detrimental impact of stunting on social interactions and independence. Finally, the overall KPSP score showed a powerful effect of stunting (p=0.000), with 70.9% of the variance explained by stunting, and an adjusted R-squared (aR^2=0.694) showing that the model accounts for 69.4% of the variability in overall development.

These findings underscore the significant impact of stunting on child development, particularly in fine motor skills, communication, social skills, and overall developmental milestones, even after adjusting for age. The strong adjusted R-squared values across multiple domains further confirm that stunting plays a crucial role in developmental delays.

DISCUSSION

This study highlights a significant association between stunting and multiple domains of child development, including excellent motor coordination, speech and language, socialization, and overall developmental milestones. These findings are consistent with a growing body of literature demonstrating that chronic malnutrition not only impacts physical growth but also disrupts neurological development and cognitive functions in early childhood. Stunting, as a marker of chronic undernutrition, affects the brain's structural and functional maturation, thereby impairing a child's ability to achieve age-appropriate developmental tasks. The persistent developmental delays identified in fine motor and communication domains, even after controlling for age, suggest that stunting exerts a lasting and independent effect on neurodevelopmental outcomes. This finding aligns with previous research indicating that children who experience early-life nutritional deprivation often exhibit lower neurocognitive performance, reduced motor coordination, and delays in both expressive and receptive language skills. The current findings further validate these associations within the specific context of the studied population, underscoring the widespread and multidimensional impact of stunting beyond linear growth failure.

The role of age, which remains a significant covariate, particularly in gross motor skills, reaffirms the expected developmental progression of children over time. However, the fact that stunted children continue to score lower across multiple *KPSP* domains emphasizes that normal aging cannot compensate for the developmental deficits caused by early undernutrition. This supports the hypothesis that stunting alters the trajectory of brain development, potentially through mechanisms involving micronutrient deficiencies, systemic inflammation, and reduced synaptic plasticity (McCormick et al., 2019; Ocansey et al., 2019; Woldehanna et al., 2018). Importantly, the strong association between stunting and *KPSP* composite scores underscores the comprehensive effect of malnutrition on a child's global development, including cognitive, motor, and socio-emotional domains. These results support the conceptual framework of the "first 1,000 days" as a critical period during which nutritional deficits can have irreversible impacts on child health and development.

This study contributes to the ongoing discourse in public health and child development by reinforcing the necessity for early detection and intervention strategies targeting stunted children. It also calls attention to the urgency of strengthening community-based nutrition programs, particularly within high-risk populations, to prevent the long-term developmental consequences associated with chronic undernutrition. While the cross-sectional design of this study limits causal inference, the findings provide valuable evidence for the enduring influence of stunting on developmental outcomes. Future longitudinal research is essential for mapping developmental trajectories over time and clarifying the temporal relationships between early stunting and later developmental impairments. Moreover, integrating environmental and psychosocial variables such as parental education, economic status, and healthcare access may yield deeper insights into the complex interplay of factors shaping child development. Overall, these findings support a holistic view of child well-being, where nutrition, stimulation, and social environment are inextricably linked.

CONCLUSION

This study shows that stunting exerts a broad influence on early childhood development, particularly in domains related to fine motor coordination, communication, and social interaction. Beyond age-related changes in motor skills, chronic undernutrition emerges as a key determinant of developmental vulnerability. The overall pattern points to stunting as a persistent barrier to children’s physical, cognitive, and social growth. The findings underline the urgency of strengthening early nutrition programs and interventions for children under five to reduce the developmental disadvantages associated with stunting. By addressing malnutrition at its roots, communities can better safeguard children's potential and long-term well-being.

Future research should consider larger sample sizes and longitudinal designs to track the developmental trajectories of stunted and non-stunted children over time. Further studies should also investigate the specific mechanisms by which stunting affects different developmental domains and explore potential interventions that could mitigate these effects. Expanding research to include environmental factors, such as parental education, socioeconomic status, and access to healthcare, may provide a more comprehensive understanding of the multifactorial influences on child development.

AUTHOR'S DECLARATION

Authors' contributions and responsibilities

RA: Writing Original Draft, Visualization, Conceptualization; **IO:** supporting in writing original draft; **SW:** Leads supervision, validation, visualization, review, and editing.

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Availability of data and materials

All data are available from the authors.

Competing interests

The authors declare no competing interests.

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