JMCH Journal of Maternal and Child Health (2026), 11(03): 148-159
Master's Program in Public Health, Universitas Sebelas Maret

Research
Open Access

The Impact of Stunting on Children's Intelligence Levels in Indonesia: An Analysis of Indonesian Family Life Survey

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Received: March 30, 2026; Accepted: April 27, 2026; Available online: May 16, 2026

ABSTRACT

Background: Stunting reflects chronic malnutrition during early growth and may have long-term effects on cognitive development, including memory, decision-making, and problem-solving abilities. This study aimed to examine the effect of stunting on children's intelligence levels.
Subjects and Method: A prospective longitudinal analytical study was conducted using secondary data from the Indonesian Family Life Survey (IFLS) IV (2007/2008) and V (2014/2015). The study included 848 children aged 0–5 years with nutritional data in IFLS IV and cognitive data in IFLS V, matched using the Personal Identification Link (PIDLINK). Stunting was defined as height-for-age z-score <-2 SD. Intelligence was measured using Raven's Progressive Matrices (RPM). Demographic, socioeconomic, health, and sanitation variables were also analyzed. Data was assessed using independent t-tests, Pearson's correlation, and multiple linear regression.
Results: The incidence of stunting was found to be 16.2%. The average age of children in this study was 2.83 (SD= 1.57) years, a small number of children were born prematurely (3.7%), most of them (77.6%) had complete immunization status and no history of chronic illness (60.5%), 42% children came from poor families, most children whose unemployed parents (89.4%). The cognitive scores of stunted children were lower than those without stunting (Mean= 53.1; SD= 22.55 vs. Mean= 64.8; SD= 21.38; p=0.001). Cognitive scores were also related to the child's age, parental education and occupation, economic status, and immunization. Stunting status was not significantly associated with children's intelligence. Children's intelligence levels were associated with child's age, maternal education, and paternal occupation.
Conclusion: Improving children's intelligence levels should not only focus on improving nutritional status, but also need to consider family social factors, improving parental education and the caregiving environment.

Keywords: early age children, intelligence level, stunting

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Cite this as:
Cordita RN, Nugroho HW, Hafidh Y (2026). The Impact of Stunting on Children's Intelligence Levels in Indonesia: An Analysis of Indonesian Family Life Survey. *J Matern Child Health*. 11(3): 148-159. https://doi.org/10.26911/thejmch.2026.11.03.01.

BACKGROUND

Nutritional status represents chronic malnutrition during growth, which can be identified by measuring a child's length or height. The WHO defines stunting as a length or height below -2 standard deviation

(SD) (stunted) and -3 SD (severely stunted) (WHO, 2025). Stunting have immediate and long-term impacts, such as an increased risk of various diseases, stunted child development, low learning ability, and a higher risk of infections and non-communicable diseases in adulthood, as well as reduced economic capacity (De Sanctis *et al.*, 2021).

The global incidence of stunting has reached 23.2% in 2024, the highest prevalence found in African and Asian regions. The first nine regions with the highest prevalence of stunting include West and Central Africa (32.5%), South Asia (32.3%), Eastern and Southern Africa (32.1%), Middle East and North Africa (15.5%), East Asia and the Pacific (13.4%), Latin America and the Caribbean (12.4%), Eastern Europe and Central Asia (6.2%), North America (4.1%), and Western Europe (2.7%) (UNICEF, 2025). The basic health research 2018 reported an incidence of stunting around 31%. These trend remains above the WHO standard, which sets a normal limit of 21% (Ministry of Health of Indonesia, 2018). The global stunting rate is reported to have decreased from 26.4% in 2012 to 23.2% in 2024. However, the target of a 40% reduction by 2025 has not been met, leading to a five-year extension to 2030 (WHO, 2025).

Various studies have highlighted the impact of stunting on cognitive development (Alam et al., 2020) and even on children's quality of life (Astuti et al., 2025). A longitudinal study in South African involving children aged 2 to 3 years showed that stunting is a significant predictor of academic achievement, whose effects might be long lasting (Amusa et al., 2022). A meta-analysis involving 25 studies that published in 2015 to 2024 reported that stunting not only has an impact on short-term physical conditions, but also has significant consequences for human resource development in the long term (Awaludin et al., 2025). Stunting is related to impaired linear growth, worsening of various health outcomes in later life, and cognitive deficits. Overcoming stunting requires multisectoral strategies that focus on maternal and child nutrition, infection prevention, clean and healthy living behavior, also socioeconomic support (Mulyani et al., 2025).

Prevention and early intervention strategies to address stunting are crucial to minimizing its negative impact on children's school readiness and cognitive development. In children, cognitive development refers to the processes of remembering, decision-making, and problem-solving, which are closely related to intelligence. Various studies have demonstrated a relationship between stunting and intelligence. A cross-sectional study of 85 students in grades 4 to 6 from 5 elementary schools in the Air Betiti Community Health Center, Musi Rawas Regency, found a relationship between stunting and intelligence as assessed by an IQ test (56.5% of stunted children had below-average IQ scores, while 31.9% of non-stunted children did.

However, after adjusting for age, gender, grade, and parental education, stunting status had no effect on intelligence (Kurniati et al., 2018). A case-control study of 150 children from three sub-districts in Palembang City reported that stunted children were 4.5 times more likely to have below-average intelligence than normal children.

Intelligence in the study was measured using Colored Progressive Matrices (CPM) (Aurora et al., 2020). Another cross-sectional study of 92 children in Sampoinet District, Aceh Jaya Regency, showed that stunting impacts intelligence levels, which are also measured by the CPM test. Stunted children tend to have below-average intelligence (57.1%), while non-stunted children tend to have above-average intelligence

(40.8%); p = 0.009 (Fitraniar and Yusnaini, 2024). Determining a limited research location can have a major effect on the external validity of the study results, making them less representative for direct application to the general population. Furthermore, the cross-sectional approach used is also less able to explain causal relationships. Therefore, this study aims to examine the relationship between stunting and intelligence levels in children in Indonesia with a longitudinal approach using data from the Indonesia Family Life Survey (IFLS) in two waves or periods: wave IV (2007/2008) and wave V (2014/2015).

SUBJECTS AND METHOD

1. Study Design

An observational analytical study with a prospective, longitudinal approach. The study used secondary data from the Indonesia Family Life Survey (IFLS) IV and V, involving 13 provinces in Indonesia, representing approximately 83% of the national population.

2. Population and Sample

The study population was all children included in the Indonesia Family Life Survey (IFLS) wave IV in 2007/2008 and wave V (2014/2015). The target population was the portion of the population assessed for stunting in IFLS IV and cognitive scores in IFLS V. The study sample was all children aged 0-5 years recorded in the IFLS IV and V databases who had been matched with the personal identification link (PIDLINK). Children with incomplete data or having physical limitations or developmental disorders that could affect the results of the intelligence test, and children who were not living in Indonesia at the time of IFLS data collection were excluded. The missing data is handled by listwise deletion (drop rows) or deletes entire rows if even one value is missing. There were 848 children who were screened and met the sample requirements, and in terms of size also met the minimum sample size, where at least 300 children were needed for the use of alpha standard deviation and error limits of 5% each and a stunting proportion of 30%.

3. Study Variables

Stunting was the independent variable in this study, while intelligence was the dependent variable. Confounding variables included parental education, poverty status, parental occupation, residential sanitation, history of chronic illness, immunization status, and prematurity were also included.

4. Operational Definition of Variables

Stunting status is assessed from the height-to-age ratio (H/A) according to WHO growth standards, declared as stunting if the H/A z-score is <-2 SD.

The child's intelligence level is measured from the Raven's Progressive Matrices (RPM) test, a non-verbal intelligence test that assesses abstract reasoning, problem-solving, and logical thinking abilities as part of fluid intelligence.

Parental education is broken down by the length of formal education received by the father or mother.

Poverty status is assessed using the Engel ratio, which divides food expenditure by total household expenditure.

Households are considered poor if the Engel coefficient is greater than 0.59. Parental occupation is also broken down by whether the father or mother is employed.

Immunization status is assessed by the completeness of immunizations received in infants age, including BCG, DPT, polio, and measles immunizations.

Prematurity was assessed based on a history of premature birth according to gestational age, defined as premature if born before the 37 weeks of gestation.

Medical history was assessed based on the presence or absence of a history/diagnosis of chronic illness or recurrent infections. **Sanitation** was assessed by the presence of private toilet facilities and a septic tank.

5. Study Instruments

All data required in this study are sourced from the IFLS IV and V databases.

6. Data Analysis

Continuous data in this study are described in terms of mean, standard deviation, and median followed by minimum-maximum value, while categorical data are described in terms of frequency and percentage. The relationship between variables was analyzed using the Pearson correlation test for continuous vs continuous data, the independent t-test for categorical vs. continuous data, and multiple linear regression to identify the presence of confounding variables and to determine which factors/variables most dominantly influence intelligence levels. The factors included in the multiple linear regression model are factors that in the bivariate analysis have a p-value <0.25. Before conducting multiple linear regression, a classical assumption test included multicollinearity and F test was used to identify whether there is a relationship between the independent variables and to ensure the feasibility of the regression model. A regression model is said to be free from multicollinearity if it has a VIF value <10 and is said to be fit if the F statistic value has a p value <0.05.

7. Research Ethic

IFLS has been approved ethically by the ethics committee in the USA, namely the Institutional Review Boards at the Rand Corporation, Santa Monika, California.

RESULTS

1. Sample Characteristics

The characteristics of the sample in this research are presented in Table 1. The proportion of subjects by gender was comparable (50% each), the mean age of children was 2.8 (SD= 1.57) years with a median of 3 years and a range of 0-5 years, and stunting status was found in 16.2% of children. Most children came from non-poor families (58%), and the average length of education of fathers and mothers was relatively similar at 10.9 (SD= 5.34) years and 11.1 (SD= 5.07) years with a median of 12 years and a range of 0-16 years. The majority of children (84.8% and 89.4%) came from families where both their fathers and mothers were unemployed. A small proportion of children (3.7%) were born prematurely, majority of children (60.5%) had no history of chronic illness but had complete immunization status (77.6%). The majority lived in homes with private toilets (88.1%), and some (56.1%) had septic tanks.

Table 1. Baseline characteristics

Characteristics	n	%
Gender		
Boys	424	50.0
Girls	424	50.0
Age (years)	848	
Cognitive scores	Mean= 62.9 (SD= 20.9)	
Stunting status		
Stunting	137	16.2
Not stunting	711	83.8
Poverty status		
Poor	356	42.0
Not poor	492	58.0
Paternal education (years)	Mean= 10.91 (5.34)	
Maternal education (years)	Mean= 11.14 (5.07)	

Characteristics	n	%
Paternal occupation		
Working	129	15.2
Not working	719	84.8
Maternal occupation		
Working	90	10.6
Not working	758	89.4
Birth status		
Premature	31	3.7
Term	817	96.3
History of chronic illness		
Have	335	39.5
Not have	513	60.5
Immunization status		
Complete	658	77.6
Incomplete	190	22.4
WC ownership		
Yes	747	88.1
No	101	11.9
Septic tank ownership		
Yes	476	56.1
No	372	43.9

2. Bivariate analysis

Assessment of dichotomous or categorical factors related to intelligence level is shown in Table 2. Non-stunted children had significantly higher cognitive scores than stunted children (Mean= 64.8; SD= 21.38 and Mean= 53.1; SD= 22.55; p = 0.001). Other factors related to intelligence level were parental occupation, economic status, and immunization status. Children from unemployed fathers had significantly lower scores than those counterparts (Mean= 61.9; SD= 20.72 and Mean= 68.6; SD= 21.54; p < 0.001), and children of unemployed mothers also had lower scores than those of employed mothers (Mean= 62.3; SD= 20.92 and Mean= 68.2; SD= 20.73; p = 0.012). Children from poor families also had lower cognitive scores than those from non-poor families (Mean= 61.1; SD= 20.40 and Mean= 64.3; SD= 21.30; p=0.031).

Cognitive scores of children with incomplete immunizations were also lower than those with complete immunizations (Mean= 64.2; SD= 20.49 and Mean= 58.5; SD= 20.06; p= 0.002). Factors including gender, prematurity status, ownership of a toilet and septic tank, and medical history were not associated with children's intelligence levels (p>0.05).

Table 2. Comparison of Child's Cognitive Scores According to Gender, Stunting Status, Parental Education Level, and Parental Employment Status

Variables	Mean (SD)	p
Stunting status		0.001
Stunting	53.11 (22.55)	
No stunting	64.83 (21.38)	
Gender		0.285
Boys	62.17 (22.08)	
Girls	63.71 (19.79)	
Paternal occupation		<0.001
Not working	61.92 (20.72)	

Variables	Mean (SD)	p
Working	68.63 (21.54)	
Maternal occupation		0.012
Not working	62.32 (20.92)	
Working	68.17 (20.73)	
Premature birth		0.516
No	63.03 (21.02)	
Yes	60.53 (19.75)	
Economic status		0.031
Not poor	64.25 (21.30)	
Poor	61.12 (20.40)	
Immunization status		0.002
Complete	64.21 (20.49)	
Incomplete	58.54 (20.06)	
Septic tank ownership		0.242
Yes	63.68 (21.19)	
No	61.99 (20.68)	
Latrine ownership		0.168
Yes	63.27 (21.20)	
No	60.45 (19.08)	
History of chronic illness		0.072
No history	61.90 (21.18)	
History present	64.53 (20.58)	

The results of the bivariate relationship between continuous variables and cognitive scores are presented in Table 3. The analysis showed that the child's age and both paternal and maternal education were significantly positively correlated with cognitive scores. The strength of the correlation was weak for child's age (r= 0.338; p= 0.001) and very weak for paternal education (r= 0.109; p= 0.002) and maternal education (r= 0.125; p= 0.001).

Table 3. Results of bivariat analysis between continous variables and cognitive score (Pearson correlation)

Variables	r	p
Child's age	0.34	0.001
Paternal education period (years)	0.11	0.002
Maternal education period (years)	0.13	0.001

3. Multivariate analysis

Table 4 showed that stunting status had no significant effect on intelligence levels (p = 0.685), similar to the length of paternal education (p = 0.093), maternal occupation (p = 0.549), economic status (p = 0.352) and complete immunization (p= 0.840). Meanwhile, child's age, maternal length of education and paternal occupation were independent predictors of intelligence levels. These three factors each have a positive influence on the level of intelligence of children, with the most dominant factor being the child's age (b= 4.73; 95% CI = 3.66-5.81; p<0.001) followed by the paternal occupation (b= 4.66; 95% CI = 0.45-8.88; p = 0.026), and the maternal length of education (b= 0.33; 95% CI = 0.04-0.54; p=0.030).

Table 4. Multiple linear regression of factors related to child's intelligence level

Variables	b	95% CI		p
		Lower limit	Upper limit	
Stunting status	0.98	-4.21	6.17	0.685
Age	4.73	3.66	5.81	<0.001
Maternal education period	0.33	0.04	0.64	0.030
Paternal education period	0.25	-0.05	0.56	0.093
Maternal occupation	1.37	-3.13	5.88	0.549
Paternal occupation	4.66	0.45	8.88	0.02 6
Economic status	-1.3 3	-4.13	1.46	0.352
Complete immunization	-0.37	-3.79	3.03	0.840

DISCUSSION

The average age of children in this study was 2.83 (SD= 1.57) years with a median of 3 years (0–5 years), which corresponds to the age range focused on cognitive development studies in toddlers (Permana et al., 2024; Aghniya, 2022). The prevalence of stunting found was 16.2%, lower than some national reports, but still indicates that some children experience suboptimal linear growth. Previous studies have also reported that although the prevalence of stunting has decreased over the past decade, stunting remains a major risk factor for delayed cognitive development in children(Aghniya, 2022; Silalahi et al., 2023).

Cognitive scores of stunted children were found to be lower than those of non-stunted children, indicating that stunting is associated with a clinically substantial decline in cognitive abilities. This finding aligns with a longitudinal study by Lestari et al(2024) that found individuals with a history of stunting had significantly lower educational and cognitive outcomes into adulthood ($p < 0.05$). A longitudinal study by Georgiadis et al. (2017)Georgiadis et al. (2017) also showed that children who experienced stunting at an early age had cognitive scores that were 5–11 points lower at school age ($p < 0.05$). A study by Prado and Dewey (2018) also stated that children with stunting had cognitive scores that were approximately 0.4 to 0.7 standard deviations lower than children with normal nutritional status.

Several meta-analyses and systematic reviews also show a negative association between stunting and cognitive outcomes or intelligence levels. A systematic review of 18 studies from 2000 to 2018 reported that stunting decreased the level of children's intellectual intelligence (Ginting and Pandiangan, 2019). Sideropoulos et al. (2025) also reported that stunting was associated with a decrease in cognitive scores of −0.12 standard deviations (95% CI: −0.18 to −0.06; $p < 0.001$). Pizzol et al. (2021) found that chronic malnutrition was associated with a significant decrease in cognitive function in children ($p < 0.01$).

A systematic review and meta-analysis of 12 articles published between 2012 and 2022, retrieved from PubMed, ProQuest, and Google Scholar, found that stunted children have significantly lower cognitive performance than non-stunted children. Specifically, stunting was associated with a 2.14-fold higher likelihood of lower IQ scores compared to non-stunted peers (aOR= 2.14; 95% CI= 1.14 to 4.01; p= 0.020) (Maulina et al., 2023). Stunting in children can impair the growth and development of central nervous system cells, thereby reducing cognitive capacity, as reflected in lower intellectual performance scores. (Ginting and Pandiangan, 2019).

In addition to stunting status, child age, parental education are also associated with cognitive scores. This suggests that biological developmental factors and the family environment play an important role in improving children's cognitive abilities. This finding aligns with research by Black et al. (2017) which showed that age and environmental stimulation, including parental education, were significantly associated with children's cognitive development ($p < 0.001$). Fernald et al. (2017) also reported that children from supportive environments can have cognitive scores 0.5–1 standard deviation higher than children from less stimulating environments. Research by Jeong et al. (2017) also reported that parental education contributed to increase children's cognitive development scores with a significant regression coefficient ($\beta = 0.21$; $p < 0.01$). The pathway of maternal education's influence on cognitive development was mediated by the quality of parenting and child stimulation (Jeong et al., 2017). This is reinforced by research by Richter et al. (2017) which showed that a good parenting environment can significantly improve children's cognitive development scores.

Immunization status, paternal occupation, maternal occupation, and economic status also showed significant associations with cognitive scores. These results suggest that a child's socioeconomic and health conditions play a role in supporting cognitive development. Children with complete immunizations had higher cognitive scores, which is consistent with research showing that children with a low history of infection have better cognitive development ($p < 0.05$) (Leroy et al., 2023). Research by Bradley and Corwyn (2017) showed that children from families with higher socioeconomic status had cognitive scores up to 4–7 points higher than those from lower socioeconomic groups ($p < 0.05$). Systematic reviews from 136 studies showed that low socioeconomic status is related to lower cognitive performance and academic achievement due to lower intelligence levels. A positive association between parental education and children's cognitive stimulation is particularly evident in households with limited resources. Cognitive stimulation in early childhood can positively impact children's intelligence (Rakesh et al., 2025).

Gender, prematurity, and history of chronic illness were not associated with cognitive scores in this study. This is in line with previous study, that even though girls have higher IQ scores than boys, as long as both are still in the developmental stage, the difference becomes insignificant because children's intelligence changes with age (Buczyłowska *et al.*, 2019). While prematurity is linked to a higher risk of cognitive challenges, it does not guarantee lower intelligence. Many preterm children could have normal range IQs when obtained positive environmental stimulation, better family socioeconomic status, and medical care improvement (Turpin *et al.*, 2019). Although chronic illness can theoretically affect cognitive development through nutritional deficiencies and increased metabolic demands, several studies have shown that the impact becomes insignificant after accounting for environmental factors and quality of care (Black et al., 2017).

Regarding sanitation, toilet ownership and septic tank use were also unrelated to cognitive scores. This is in line with research showing that the influence of sanitation on cognitive development is indirect, primarily through infection and nutritional status. Therefore, the effect may diminish after controlling for socioeconomic and household environmental factors (Pickering et al., 2019).

Stunting status, however, was not shown to be an independent predictor of intelligence levels. These results are consistent with research by Georgiadis et al. (2017) which showed that the relationship between nutritional status and cognitive development became insignificant after controlling for socioeconomic factors and family environment. Another study by Crookston et al. (2016) also showed that the effect of stunting on cognition was significantly reduced after including parental education and household stimulation variables in the model. Research by Lestari et al. (2024) also showed that the relationship between nutritional status and cognitive outcomes became weaker after considering family education and socioeconomic factors. Children's intelligence is essentially the result of a complex interaction between biological and environmental factors. Environmental factors such as the quality of developmental stimulation at home, parental education, family socioeconomic conditions, and access to health and education services play a significant role in determining children's cognitive development (Black et al., 2017). Therefore, the impact of stunting on cognitive development can be modified by various environmental factors that occur after the early period of life.

Meanwhile, child age, maternal education, and paternal occupation are independent predictors of early childhood intelligence. Increasing age is associated with increased cognitive abilities. As age increases, the central nervous system matures, accompanied by the development of cognitive abilities such as language, memory, attention, and increasingly complex problem-solving skills (Black et al., 2017). Furthermore, mothers with higher levels of education generally have better knowledge about child health, nutrition, and developmental stimulation. Previous research has shown a significant correlation between parental education levels and children’s IQ, with higher levels of parent’s education predicting higher children’s IQ score. Maternal education particularly can explaining 18.23% of the variance in children’s overall intelligence (Sajewicz-Radtke et al., 2025). . Maternal education can play a crucial role in creating a nurturing environment that supports child development. Regarding paternal occupation, more stable employment is typically associated with better family socioeconomic conditions. Better economic conditions can enable families to provide more adequate resources to support children's growth and development, including meeting nutritional needs, a better learning environment, and access to education and health services (Bradley & Corwyn, 2017).

Children's cognitive development is influenced by various interacting factors and is not determined by a single factor. Other factors such as the quality of school education, developmental stimulation at home, and genetics can also play a role in determining children's cognitive development, but not all of these factors could be measured in this study (Black et al., 2017).

Overall, the results of this study indicate that although there are differences in cognitive scores between stunted and non-stunted children in the bivariate analysis, family environmental factors, particularly maternal education and paternal occupation, play a more dominant role after controlling various confounding variables. Therefore, efforts to improve children's cognitive development should not only focus on improving nutritional status but also consider family social factors, parental education, and a nurturing environment that supports child development from an early age.

This study, however, has limitations, including limited variables in the dataset, where the IFLS data does not include all potentially confounding factors, such as the quality of home stimulation, parental education, school quality, and genetic factors. Another limitation is that socioeconomic factors are only represented by poverty status, parental education and occupation, and household expenditure, which may not fully reflect socioeconomic status comprehensively. Handling missing data with complete case analysis (only involving subjects with complete data) can also potentially introduce selection bias, making it less representative of the entire population. Finally, there is the potential for bias in assessing intelligence levels due to unknown conditions during testing (e.g., fatigue or the testing environment).

AUTHOR CONTRIBUTION

Author Raka contributed to conceptualization, methodology, data collection or investigation, data analysis and interpretation, and manuscript drafting. Author Hari Nugroho contributed to conceptualization, methodology, critical revision and editing, supervision or project administration, and Final approval of the manuscript. Author Yulidar contributed to critical revision and editing, manuscript revision and supervision. All authors reviewed and approved the final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest.

FUNDING AND SPONSORSHIP

None.

ACKNOWLEDGEMENT

None.

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