Journal of Maternal and Child Health (2020), 05(04): 402-412
Masters Program in Public Health, Universitas Sebelas Maret

Research

The Associations between Anemia, Stunting, Low Birthweight, and Cognitive Ability in Indonesian Children: An Analysis from Indonesian Family Life Survey

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ABSTRACT

Background: Stunting, anemia, and Low Birth Weight (LBW) are the most common child health problem in Indonesia. These three factors can affect the nutritional status of children both in the short and long term. These disorders will affect children growth and development. One of the long-term developmental disorders in children that occur due to stunting, anemia, and LBW is cognitive impairment.
Subjects and Method: This was a cross-sectional study. This study was conducted by analyzing the secondary data of the 3rd, 4th, and 5th Indonesian Family Life Survey (IFLS). The study was conducted from June to July 2020. The study subjects were 3563 children aged 7-14 years. The sample was collected using a total random sampling technique after clearing the data. The dependent variable was cognitive ability. The independent variables were anemia, stunting, and Low Birth Weight (LBW). The data were analyzed using the Chi-square method and logistic regression.
Results: The prevalence of stunting was 35.92%, anemia was 36.21%, children with a history of LBW were 7.69%, and children who had cognitive abilities below the average were 37.22%. Children who did not experience stunting improved their cognitive abilities (OR=1.32; 95%CI=0.88 to 1.18; p<0.001).
Conclusion: Children who do not experience stunting improve their cognitive abilities.

Keywords: Anemia, stunting, Low Birth Weight, cognitive

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Cite this as:
Tampy ST, Nugroho HW, Syuadzah R, Kartikawati D (2020). The Associations between Anemia, Stunting, Low Birthweight, and Cognitive Ability in Indonesian Children: An Analysis from Indonesian Family Life Survey. J Matern Child Health. 05(04):402-412. https://doi.org/10.26911/thejmch.2020.05.04.07.

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BACKGROUND

Stunting was a condition that indicates a chronic undernutrition status during growth and development since the early 1000 days of life (Ni'mah & Nadhiroh, 2015). The World Health Organization (WHO) defines stunting as a condition of body length or height according to age <-2 of standard deviations from the WHO growth standard median (World Health Organization, 2009).

Prevention of stunting in children is the first of the six global goals in the Global Nutrition Target in 2025 and an indicator in the Sustainable Development Goal of Zero Hunger (Beal et al., 2018). According to (Indonesian Pediatric Society, 2016), Indonesia is the fifth-largest contributor to stunting in the world. In Indonesia, the data of stunting was obtained from Basic Health Research. It showed that stunting occurred around 36.8% in 2007 and decreased to

35.6% in 2010. In 2013, it increased to 37.2%, while in 2018, it decreased from 6.4% to 30.8% (National Institute of Health Research and Development, Ministry of Health RI, 2018).

Stunting in children is a chronic nutritional problem that affects various aspects. Stunting affects mortality and morbidity of life, poor learning capacity and child development, increases the risk of infection and non-communicable diseases and decreases productivity and the economy of life (Stewart et al., 2013). Children with a history of stunting had a higher long-term risk of experiencing poor cognitive development (Fajaryah & Hidajah, 2020).

Anemia is a condition where the number of red blood cells or hemoglobin levels is fewer than normal according to age and sex (Indonesian Pediatric Society, 2016). The incidence of anemia in children in Indonesia is increasing over time. Based on the data obtained from Basic Health Research in 2013, there were 28.1% of children under five who had anemia (Indonesian Health Research and Development Agency, Ministry of Health, 2013). However, the incidence of anemia in children under five in 2018 increased to 38.5% (National Institute of Health Research and Development, Ministry of Health RI, 2018).

Anemia affects the growth and development of children under five. Based on a study conducted in Nigeria, children with Sickle Cell Anemia had lower Intelligence Quotients (IQ), working memory, and processing speed than healthy children (Oluwole et al., 2016). In addition, anemia also caused delayed growth (Arafah et al., 2019).

Another factor that affects cognitive development is the birth weight of the infants. Low Birth Weight (LBW) is body weight at birth of <2500 grams. Infants with LBW had the potential to experience slower cognitive development than infants with normal birth weight (Sujianti, 2018). It occurred because infants with LBW experienced Neurodevelopmental Disorders (PDF) associated with injury to the cerebral white matter, cystic periventricular leukomalacia, intraventricular hemorrhage, and decreased number of brain cells and myelin (Upadhyay et al., 2019).

Due to the important role of nutritional status, where the chronic deficiency condition was shown in stunting, and anemia played a role in children's cognitive development, as well as the history of birth weight affected nutritional status in the future, the researchers were interested in analyzing stunting and anemia and the effect on the cognitive value of children in Indonesia.

SUBJECTS AND METHOD

1. Study Design

This study was an observational analytic study with a cross-sectional approach. This study was an analysis of secondary data taken from Indonesian survey data, namely the Indonesian Family Life Survey (IFLS) (Rand Corporation, 2014; Permatasari, 2019).

IFLS was a longitudinal survey using a stratified random sampling of households and communities using questionnaires and anthropometric measurements that represented 83% of the population in Indonesia. The IFLS survey was conducted in five periods: 1993, 1997, 2000, 2007, and 2014. The IFLS survey was conducted under a supervisory agency called the Rand Corporation (Rachmi et al., 2016). This study was conducted from June 2020 to July 2020.

2. Population and Sample

The population of this study was children. This study used total sampling technique. The sample of this study was children aged 7-14 years in 2014 (IFLS 5) who had conducted cognitive tests and had data of hemoglobin level in 2014. Based on that group, the data of children who had body length at the age of 0-

5 years in data for 2007 (IFLS 4) and 2000 (IFLS 3) and children who had data on birth weight in the data of IFLS 3, IFLS 4, and IFLS were sorted. The number of the sample obtained after cleaning the data was 3.563 sample.

Figure 1 shows the process of cleaning data carried out from all IFLS 3, 4, and 5 data. Based on preliminary data, there were 8166 children aged 7-14 years in 2014 at IFLS 5 as the sample who have taken cognitive tests. In addition, cleaning for 7221 sample that had complete data on hemoglobin, age, and sex was carried out. Besides, 3707 children as the sample who had stunting data in 2007 (IFLS 4) and 2000 (IFLS 3) were found. Furthermore, the researchers searched for the sample who had complete birth weight data; the researchers found 3.553 sample.

3. Location of the Study

The IFLS survey was carried out in several enumeration areas selected from several provinces in Indonesia. The data used in IFLS represented 83% of the population in Indonesia which were obtained from several enumeration areas representing provinces in Indonesia (Pasaribu, 2019; Rachmi et al., 2016).

4. Study Variables

The dependent variable was cognitive. The independent variables were anemia, stunting, Low Birth Weight, age, and sex.

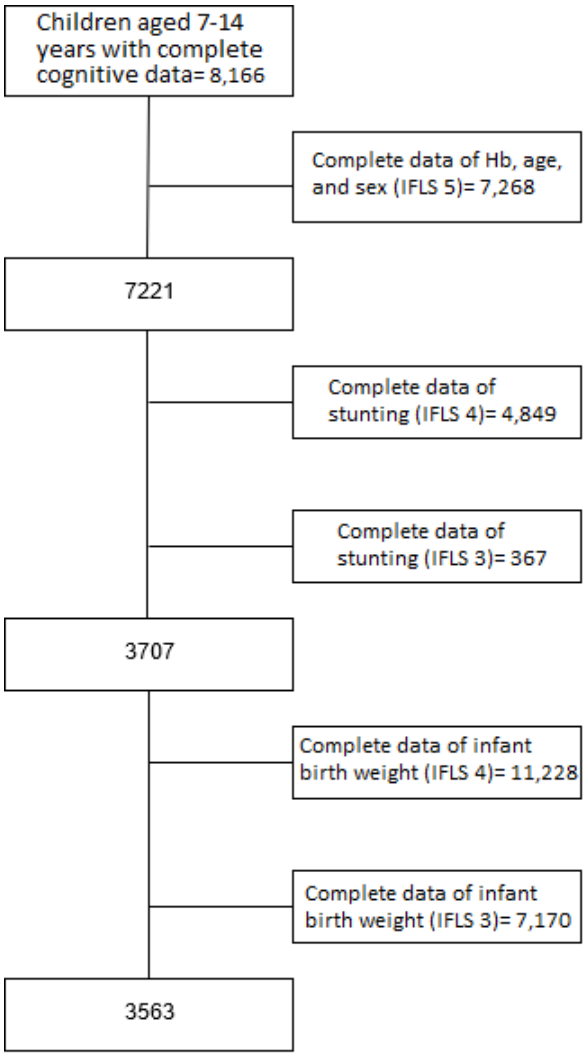

Figure 1 The Flowchart of the Cleaning Data Process

5. Operational Definition of Variables

Cognitive was the ability of attention, memory, consideration, problem-solving, and executive abilities such as planning, assessing, monitoring, and evaluating. In this study, children's cognitive function was measured using the method of Raven's Colored Progressive Matrice Test. It measured cognitive abilities generally and more specifically in assessing conflict and non-verbally (Lúcio et al., 2017). In this method, the cognitive test was classified into 2 age groups, namely 7-14 years and 15-24 years. At the age of 7-14 years, the test consisted of 12 questions, while at the age of 15-24 years, there were 8 questions. The assessment of this method was by giving 1 score if the answer was wrong and 3 scores if the answer was correct. The test result was the total score of all the questions (Pasaribu, 2019). The interpretation of the results was taken based on the average of the age group, which was above and below average.

Anemia was a condition where the number of red blood cells or hemoglobin levels in the body was not sufficient for the body's physiological needs. To determine anemia, hemoglobin levels were determined by the age group. Anemia occurred at the age of 12-59 months if the Hb level was <11.0 g/dL. In addition, anemia occurred at the age of 6-12 years if the Hb level was <12.0 g/dL (World Health Organization, 2011).

Stunting was a condition that indicated a chronic undernutrition status during growth and development since early life. Stunting was determined based on height for age at z-scores <-2 SD based on WHO standards (Ni'mah & Nadhiroh, 2015).

Low Birth Weight (LBW) was the weight of the infants at birth. If the birth weight was ≥2500 grams, the infant did not have LBW. Besides, if the birth weight was <2500 grams, the infant had LBW. The history of birth weight was obtained from the interviews with the mothers.

6. Data Analysis

This study used univariate, bivariate, and logistic regression test analysis. Univariate analysis was conducted to determine the characteristics of the sample based on each variable. Bivariate analysis was conducted to determine the prevalence of the subjects based on the association between two variables using the Chi-square method. The logistic regression model used in multivariate analysis was the Binary Logit model because the dependent variable had a nominal or ordinal measurement scale and only consisted of two qualitative selection categories (Junaidi, 2015).

The data analysis was conducted using STATA 15 software. Based on the anthropometric measurements, the z-score was found; it was processed using zscore06 according to height/age in STATA 15 software (Leroy, 2011).

7. Research Ethics

IFLS has been approved ethically by the ethics committee in the USA, namely the Institutional Review Boards at the Rand Corporation, Santa Monika, California. IFLS has also passed the ethics commission in Indonesia at Gajah Mada University (UGM), University of Indonesia (UI), and the Ethics Commission of the Faculty of Medicine, Airlangga University (UNAIR) (Fajariyah & Hidajah, 2020; Rachmi et al., 2016).

RESULTS

1. Sample Characteristics

Table 1 shows the characteristics of the sample of the categorical data. The number of boys was 1848 (51.87%) and the number of girls was 1715 (48.13%).

Table 1 shows the number of children with stunting was 1280 children (35.92%). Children who had cognitive abilities above the average were 2237 children (48.13%).

The prevalence of anemia in children including the respondents of this study was 36.21%. Children with history of low birth weight were 7.69%.

Table 2 shows that the mean of the age of children was 9 years (Mean=9.48; SD=1.99) with the youngest age was 7 years old and the oldest age was 14 years old.

Table 1. The characteristics of the sample (categorical data)

Variable	n	%
Sex		
Male	1848	51.87
Female	1715	48.13
Stunting		
Stunting	1280	35.92
Non-stunting	2283	64.08
Cognitive		
<Average	1326	37.22
Average	2237	48.13
Anemia		
Anemia	1290	36.21
Non-anemia	2273	63.79
LBW		
Non-LBW	3289	92.31
LBW	274	7.69

Table 2. The distribution of the characteristics of the sample of the continuous data

Variable	n	Mean	SD	Minimum	Maximum
Age (year)	3563	9.48	1.99	7	14

2. The result of bivariate analysis

Bivariate analysis was carried out by determining the relationship between one independent variable and one dependent variable using the Chi-square test.

Table 3 shows the association between age, sex, anemia, stunting, Low Birth Weight, and cognitive ability in children. Table 3 shows that the percentage of children aged ≥9 years (65.11%) had cognitive ability above the average than children aged <9 years (58.-66%), and it was statistically significant (p<-0.001).

The percentage of non-stunting children (65.35%) had higher average cognitive ability than stunting children (58.20%), and it was statistically significant (p<0.001).

The percentage of children with normal birth weight (63.27%) had cognitive ability above the average than children with low birth weight (56.93%), and it was statistically significant (p=0.037).

There was no difference between boys (63.37%) and girls (62.16%) on cognitive ability in children, p=0.456.

There was no difference between children with anemia (61.32%) and non-anemia (63.62%) on cognitive ability in children, (p=0.173).

Table 4 shows the association between low birth weight and stunting. Children with normal birth weight (64.88%) did not experience stunting compared to children with low birth weight (54.38%), with p=0.001.

3. The result of multivariate analysis

Table 5 shows the multiple logistic regression analysis of the association between age, sex, stunting, anemia, low birth weight, and cognitive ability. Table 5 shows that the age of ≥10.5 years in children improved cognitive ability in children (OR=1.10; 95%CI=1.06 to 1.14; p<0.001). There was no difference between the sex of female and male on

cognitive ability (OR=1.06; 95%CI=0.93 to 1.22; p=0.368).

Table 3. The association between age, sex, anemia, stunting, LBW, and congnitive ability in children

Independent variable	Cognitive Ability				p
	<average		>average		
	n	%	n	%	
Age					
<9 years	532	41.43	755	58.66	<0.001
≥9 years	794	34.89	1,482	65.11	
Sex					
Male	677	36.63	1171	63.37	0.456
Female	649	37.84	1066	62.16	
Anemia					
Yes	499	38.68	791	61.32	0.173
No	827	36.38	1446	63.62	
Stunting					
Yes	535	41.80	745	58.20	<0.001
No	791	34.65	1492	65.35	
LBW					
Yes	118	43.07	156	56.93	0.037
No	1208	36.73	2081	63.27	

Table 4. The association between LBW and stunting

LBW	Stunting				OR	p
	Yes		No			
	n	%	n	%		
Yes	125	45.62	149	54.38	1.55	0.001
No	1155	35.12	2134	64.88		

Table 5. The multiple logistic regression analysis of the association between age, sex, stunting, anemia, LBW, and cognitive ability

Independent Variable	OR	CI 95%		p
		Lower limit	Upper limit	
Age of Children (≥10.5 years)	1.10	1.06	1.14	<0.001
Sex (Female)	1.06	0.93	1.22	0.368
Stunting	1.32	0.88	1.18	<0.001
Anemia	1.02	1.14	1.52	0.811
LBW	1.25	0.97	1.60	0.086

DISCUSSION

1. The Association between Anemia and Cognitive Ability

Anemia was a condition where the number of red blood cells or hemoglobin levels, hematocrit, or the number of red blood cells per liter was less than normal according to age, sex, race, and environmental condition (Gebreweld et al., 2019). The prevalence of anemia in children in the world reached 47.4% in the preschool age group and 25.4% in the school-age group (Allali et al., 2017). In this study, the prevalence of anemia was 36.21%. Children aged 7-14 years, as the respondents of this study, were included in the school-age group. Based on the prevalence found in this study, it tended to be higher than the prevalence of school-age children globally.

Iron deficiency anemia is the most common type of anemia worldwide and one of the largest contributors to global disease (McKee

et al., 2017). Iron is needed to form hemoglobin, which is an important substance for binding oxygen. Therefore, if the iron is reduced, organs and tissues cannot get adequate oxygen. It causes fatigue, decreased performance and immunity. Untreated iron deficiency could lead to serious problems such as delayed growth and development (Arafah et al., 2019).

Larson et al, in 2017, conducted a study by providing iron supplementation for the prevention of anemia in children below 2 years of age. It was assessed whether there were differences in cognitive development and language expression in children given iron supplements and placebo. Based on the result of the study conducted by Larson et al. (2017), there was a significant effect on the cognitive development of children with anemia who were given iron supplements. However, giving iron supplements did not affect the cognitive development of children who did not have anemia (Larson et al., 2017).

Based on the result of a study conducted by Arafah (2019), there was no significant association between anemia and cognitive development in children. This is in line with the result of this study that anemia did not significantly affect cognitive development in children.

2. The Association between Stunting and Cognitive Ability

Stunting is a condition of failure to thrive in children under five years old due to chronic undernutrition. Therefore, children are too short for their age. Chronic undernutrition experienced by stunting children occurred in the womb and the early stages after birth (Rahmadini, 2020; National Team for the Acceleration of Poverty Reduction, 2017). According to WHO, stunting was described as a condition of body length or height according to age fewer than -2 standard deviations from the WHO growth standard median (World Health Organization, 2009). The Minister of Health RI, in 2020, in the Minister of Health Regulation Number 2 of 2020 regarding child anthropometric standards defines stunting as a condition of children under five with a z-score of <-2 SD (stunted) and <-3 SD (severely stunted).

The prevalence of stunting in Indonesia was the fifth highest in the world (Indonesian Pediatrician Society, 2016). In Indonesia, the data of stunting was obtained from Basic Health Research. It showed that stunting occurred around 36.8% in 2007. In 2010, it decreased to 35.6%. In 2013, it increased to 37.2%, while in 2018, it decreased from 6.4% to 30.8% (National Institute of Health Research and Development, Ministry of Health RI, 2018). This data was not much different from the data in this study that the prevalence of stunting of all respondents was 35.92%.

Various factors could affect the development of children in developing countries, both cognitive, language, and motor development. These factors included poverty, malnutrition, poor sanitation, and lack of environmental stimulation (Ministry of Health RI, 2009).

Cognitive is a thought process. Cognitive in children was the ability to connect, assess, and consider things. Cognitive development is related to the intellectual ability of children in thinking and making decisions in learning and solving existing problems. Aspects covered in cognitive development in knowledge were general knowledge, science, the concept of forms, numbers, letters, and symbols (Rahmadini, 2020).

In this study, the cognitive aspects were measured using Raven's Colored Progressive Matrice Test in combination with a numerical test. This cognitive test measured cognitive ability generally and more specifically in assessing conflict and non-verbal (Lúcio et al., 2017).

According to a study conducted by Muhoozi in 2016, stunting that occurred in

children aged 0-2 years could interfere with the cognitive, language, and motor development of the children. However, improvement of nutrition and catch-up growth also showed an increase in development after stunting (Muhoozi et al., 2016). Based on a study conducted by Arafah on elementary school children, stunting children had a risk of 2,992 times experiencing cognitive ability disorder (Arafah et al., 2019). Based on the cohort study conducted by Ala et al. (2020), children who had experienced stunting and had catch-up growth to normal also had a significantly lower cognitive score than children who had never experienced stunting yet.

This study is in line with the study conducted by Ala et al. Based on this study, stunting could affect children's cognitive. Stunting children tended to have cognitive scores below average than their peers.

According to another study conducted in 2012, chronic lack of nutritional intake could change cell numbers, cell migration, myelination, synaptogenesis, hippocampal formation, and neurotransmission in the brain structure of rats, thus disrupting cognitive development (Alamy & Bengelloun, 2012).

According to the time of occurrence, the growth rate of the human brain reaches a peak at 2 times, namely when the period pregnancy is 15-20 weeks and at the 30th week of pregnancy until the baby is 18 months old. One of the nutrients that played a role in disrupting brain development was the lack of intake of omega 3 essential fatty acids (Rahmadini, 2020). Therefore, chronic nutrient intake that occurred during the prenatal period and at the beginning of life which caused stunting, would also disrupt brain growth.

3. The Association between Low Birth Weight (LBW) and Cognitive Ability

Low Birth Weight (LBW) is an indicator for predicting short and long term outcomes in newborns. Birth weight was also an indicator of conditions that occurred during pregnancy (Pasaribu, 2019). LBW was a baby with a birth weight of <2500 grams (Upadhyay et al., 2019).

Infants with LBW will have slower growth and development because while in the womb, the infant has intra-uterine growth retardation. The slowdown will continue until birth. Children with LBW will experience slower growth and development than children with normal birth weight. Indigestion also occurs in infants with LBW. Digestion in infants with LBW could not absorb fat and digest protein, thus causing a lack of nutrient reserves in the body (Rahmadi, 2016). If it is not immediately addressed, it will lead to chronic problems and stunting.

According to a systematic review conducted in 2016 involving 137 developing countries, infants with LBW were a risk factor for stunting under 2 years of age (Danaei et al., 2016). Another study conducted in South Korea stated that infants with a history of very low birth weight affected poor cognitive (Kim et al., 2020). Based on a meta-analysis study conducted by Upadhyay, infants with LBW showed significant cognitive and motor deficits at school age and adolescence (Upadhyay et al., 2019).

Central nervous development disorders in infants with LBW were associated with defects in the substance of cerebral alba, cystic periventricular leukomalacia, intraventricular hemorrhage, reduced brain volume, changes in the volume and structure of the cortex, decreased number of cell, and myelination disorders (Upadhyay et al., 2019).

These scientific studies were not in line with this study that children with a history of LBW were not associated with stunting and did not affect cognitive in the future.

The result of this study is in line with a study conducted by Pasaribu that LBW did not affect children's nutritional status and

children's cognitive abilities (Pasaribu, 2019). This study is supported by another study that there was no association between LBW and the incidence of stunting in children aged 12-59 months in Lampung province. It occurred due to the length of time after measuring the birth weight, thus causing various kinds of interventions to increase LBW. Infants who experienced LBW would also gain weight more quickly as if catching up on their weight. If at 6 months the children under five could catch up with growth, the infants would grow normally like other infants (Rahmadi, 2016).

Based on the analysis of the result of this study, it can be concluded that children's cognitive abilities can be affected by various factors, including a history of stunting when the children are under 5 years old. However, the history of LBW and anemia did not affect children's cognitive abilities.

AUTHOR CONTRIBUTION

Safitri Tia Tampy as the main researcher looking for ideas, formulating the data, designing the study, and compiling results of this study. Dwiana analyzed the data. Rahmi Syuadzah compiled the results of the study. Hari Wahyu Nugroho gave suggestions for the discussion of the study.

CONFLICT OF INTEREST

None.

FUNDING AND SPONSORSHIP

The source of fund came from the main researcher.

ACKNOWLEDGEMENT

The researchers would like to thank all parties so that this study could be carried out well.

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