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ORIGINAL ARTICLE

Association between maternal anemia and low birth weight among stunting children 12–23 months in Dili, Timor Leste

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Abstract

Background: Stunting is a chronic malnutrition problem primarily occurring during the first 1000 days of life. Iron deficiency anemia during pregnancy can threaten fetal growth and may affect the baby's birth weight and length. According to the Timor-Leste Food and Nutrition Survey 2020, stunting in Timor-Leste is 47.1%.

Objectives: To determine the relationship between a history of anemia during the third trimester of pregnancy and low birth weight with the incidence of stunting in children aged 12-23 months in Dili city.

Methods: This study was a case-control design conducted in five health centers in Dili City, Timor-Leste. The sample consists of 180 children aged 12-23 months, with 90 stunted cases and 90 controls selected consecutively. Data collected encompasses both child-related and maternal information.

Results: Anemia during the third trimester of pregnancy OR 95%CI 7.18 (3.38-15.23) and low birth weight OR 95%CI 5.39 (2.09 – 13.90) are significantly associated with the incidence of stunting ($p < 0.01$). Based on logistic regression analysis, anemia during pregnancy and low birth weight are not significantly associated with an increased risk of stunting. However, there are characteristics of the mother and child that are significantly associated with the risk of stunting.

Conclusion: Children with a history of low birth weight are 5.3 times more likely to experience stunting, and children whose mothers had anemia during pregnancy are 7.2 times more likely to experience stunting. The results show that low birth weight and maternal anemia are related to the incidence of stunting in Timor-Leste.

Keywords: maternal anemia, low birth weight, stunted children

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Introduction

Linear growth is a good indicator of children's well-being, as it also reflects nutritional status in the past. Height-for-age is a commonly used measure to assess linear growth. Suboptimal health conditions and inadequate nutrition and care lead millions of children worldwide to fail to reach their linear growth potential. Globally, in 2020, a total of 149.2 million under five children experienced stunting, but there was a decrease in the prevalence of stunting in all regions except Africa.[1,2] Data from the Global Nutrition Report 2020 shows that Timor-Leste ranks first in the prevalence of stunting cases in Southeast Asia and fifth highest worldwide.[3] The World Health Organization (WHO) sets the maximum tolerance for stunting at 20% or one-fifth of the total number of toddlers, while Timor-Leste has a stunting prevalence of 47.1% according to data from the Timor-Leste Food and Nutrition Survey 2020 (TLFNS).[4]

The causes of stunting in toddlers are multifactorial. According to the United Nations Children's Fund (UNICEF) framework, there are several factors from mother and children contributing to stunting. Maternal factors play a crucial role in the occurrence of stunting, including anemia during pregnancy, early pregnancy, short birth intervals, multiparous pregnancies, and poor nutrition during pregnancy.[2] The prevalence of pregnant women with anemia worldwide in 2019 was 36.5%, and in Southeast Asia, it was 47.8%. Timor-Leste ranks as the fourth highest country in Southeast Asia with a prevalence of 38%, following Indonesia.[3]

Meanwhile, child-related factors associated with the occurrence of stunting include inadequate intake of energy and protein, recurrent infections, and not receiving exclusive breastfeeding. Several studies suggest a possible association between low birth weight (LBW) and stunting. The prevalence of LBW in Dili, the Capital city of Timor-Leste in 2019 was 12%, the highest among all districts, with the lowest level figured in Manatuto district at 2.1%.[5] As of now, there hasn't been any further research conducted on stunting and its risk factors in mothers and children in Timor-Leste.

This study aimed to identify the relationship between maternal anemia during pregnancy and low birth weight (LBW) with the occurrence of stunting among children aged 12-23 months in Dili, Timo-Leste.

Methods

This study was performed with a case-control study from December 2023 to March 2024. There are 180 subjects aged 12-23 months old from 5 Primary Health Care in Dili, Timor-Leste. All subjects were divided into two groups; case and control group. 90 children with confirmed stunting were included in the case group, while 90 matched healthy children served as the control group. Subjects were excluded if they did not have the Maternal and Child Health Monitoring Book, and were diagnosed with genetic or hormonal diseases that can affect growth. This information was obtained from the subject's medical records. The sample size was calculated based on unpaired t-test analysis. The research was approved by the Unit of Ethical Research and Development of Timor-Leste no.06/INSP-TL/UEPD/II/2024. All participants in this study were treated based on the Declaration of Helsinki and gave spoken, written informed consent before participating in this study.

The data used in this research were primary and secondary data. Six nutritionists with an educational background in nutrition assisted in this study. Anthropometric measurements, height-for-age z-scores were taken using the infantometer SECA 416 (Seca, Germany). A 24-hour food recall conducted through an interview with the mother was used to identify nutrient components, including energy and protein intake, to estimate the calorie intake consumed within the 24 hours prior to the interview. The hemoglobin level data, as a parameter for anemia, were secondary data obtained from the Maternal and Child Health monitoring book. All nutritionists involved in collecting anthropometric data, hemoglobin levels, and 24-hour food recalls had been trained before collecting data.

Data were analyzed using SPSS 26. Statistically significant differences between groups were analyzed using Chi-Square. Multiple Logistic

Regression analysis was performed in this study to examine the influence of subject characteristics as confounding variables

Results

A total of 180 children (90 children in each group) were enrolled in the study. **Table 1** showed the characteristics of children based on age, gender, birth weight, birth length, and breastfeeding status.

Table 1. Bivariate analysis of children's characteristics

Variable	Case (n=90)	Control (n=90)	OR (CI 95%)	p
Birth weight				
Low	25(80.6)	6(19.4)	5.39	<0.001
Normal	65(43.6)	84(56.4)	(2.09 – 13.90)	
Age (month)				
12-18	54(60)	58(64.4)	0.82	0.546
19-23	36(40)	32(35.6)	(1.50- 5.09)	
Gender				
Male	62(60.8)	40(39.2)	2.77	<0.001[a]
Female	28(35.9)	50(64.1)	(1.50- 5.09)	
Birth weight				
Low	25(80.6)	84(56.4)	5.39	<0.001[a]
Normal	65(43.6)	6(19.4)	(2.09 – 13.90)	
Birth length				
	46(82.1)	10(17.9)	5.39	<0.001[a]
Normal	44(35.5)	80(64.5)	(2.09 – 13.90)	
Breastfeeding status (BF)				
Not exclusive BF	52(61.2)	33(38.8)	2.36	0.005[a]
Exclusive BF	38(40,0)	57(60.0)	(1.30 – 4.30)	
Diarrhea history				
Yes	59(62.8)	35(37.2)	2.99	<0.001[a]
No	31(36.0)	55(64.0)	(1.63-5.48)	
Diarrhea in a month				
No	27(37.5)	45(62.5)		
<3 times	38(53.5)	33(46.5)		0.009
≥3 times	25(67.6)	12(32.4)		
Diarrhea in last 3 months				
Yes	28(68.3)	13(31.7)		0.008
No	62(44.6)	77(55.4)		
URTI history				
Yes	67(65.7)	35(34.3)	4.57	<0.001[a]
No	23(29.5)	55(70.5)	(2.42-8.64)	
URTI in a month				
No	24(30.0)	56(70.0)		<0,001[a]
<3 times	46(66.7)	23(33.3)		
≥3 times	20(64.5)	11(35.5)		
URTI in last 3 months				
Yes	45(77.6)	13(22.4)	5.92	<0.001[a]
No	45(36.9)	77(63.1)	(2.88-12.14)	
Energy intake				
<80% RDI	72(63.2)	42(36.8)		<0.001[a]
80-100% RDI	14(25.0)	42(75.0)		
>100% RDI	4(40.0)	6(60.0)		
Protein intake				
<80% RDI	62(79.5)	16(20.5)		<0.001[a]
80-100% RDI	19(31.7)	41(68.3)		
>100% RDI	9(21.4)	33(78.6)		

[a]Chi-square, significance (p<0.05)

The following characteristics among the mothers of the study are outlined in **Table 2**. A bivariate analysis was performed to investigate the relationship between third-trimester anemia during pregnancy and the incidence of stunting in children Table 3 shows a significant relationship between third-trimester anemia and stunting ($p < 0.001$). In the stunting group (cases), a higher percentage of mothers had anemia (Hb less than 11 g/dL) during the third trimester (80.4%) compared to mothers without anemia (36.3%). Mothers with a history of anemia during the third trimester had a 7.18 times greater risk of having a stunted child compared to mothers who did not experience anemia during pregnancy.

When analyzing the relationship between third-trimester anemia and stunting, it is crucial to consider the potential influence of various subject characteristics. Differences between the case group (children with stunting) and the control group (children without stunting) may affect the analysis results. Characteristics with a p-value of less than 0.25 were identified as potential confounding factors, indicating they may influence the relationship between third-trimester anemia and stunting.

Table 2. Bivariate analysis of mother's characteristics

Variable	Case (n=90)	Control (n=90)	OR (CI 95%)	p
Third-trimester anemia				
Yes	45(80.4)	11(19.6)	7.18	<0.001
No	45(36.3)	79(63.7)	(3.38-15.23)	
Age (year)				
At risk	32(61.5)	20(38.5)	1.93	0.048[a]
Non-risk	58(45.3)	70(54.7)	(1.00-3.72)	
Height				
Short	23(67.6)	11(32.4)	2.46	0.022[a]
Normal	67(45.9)	79(54.1)	(1.12-5.42)	
Education level				
Primary	13(92.9)	1(7.1)		<0.001[a]
Secondary	61(58.7)	43(41.3)		
Tertiary	16(25.8)	46(74.2)		
Income level				
Low	22(88.0)	3(12.0)	9.38	<0.001[a]
Sufficient	68(43.9)	87(56.1)	(2.69-32.6)	
MUAC during pregnancy				
Abnormal	48(70.6)	20(29.4)	4.00	<0.001[a]
Normal	42(37.5)	70(62.5)	(2.09-7.63)	
Multiparity				
Yes	19(73.1)	7(26.9)	3.17	<0.001[a]
No	71(46.1)	83(53.9)	(1.26-7.98	
Short interval between pregnancy				
Yes	26(56.5)	20(43.5)	1.42	0.305
No	64(47.8)	70(52.2)	(0.72-2.79	
Third-trimester anemia				
Yes	45(80.4)	11(19.6)	7.18	<0.001[a]
No	45(36.3)	79(63.7)	(3.38-15.27)	
Fe supplement during pregnancy				
Insufficient	26(63.4)	15(36.6)	2.03	0.051
Sufficient	64(46.0)	75(54.0)	(0.99-4.16)	

[a]Chi-square, significance ($p<0.05$)

The bivariate analysis identified several variables as potential confounders, including the child's gender, birth weight, birth length, history of exclusive breastfeeding, history of infections, energy and protein intake, as well as maternal characteristics such as maternal age, maternal height, maternal education, family income, maternal mid-upper arm circumference (MUAC), multiparity status, and iron supplementation during pregnancy, all of which had p-values less than 0.25. These variables were subsequently included in the multivariate analysis shown in Table 3 to demonstrate the relationship between third-trimester pregnancy anemia and the incidence of stunting while controlling for these confounding variables.

Table 3. Multivariate analysis between anemia during pregnancy and the incidence of stunting while controlling for confounding variables

Variable	p	OR	CI 95%
Third-trimester anemia	0.054	3.23	0.98-10.66
Gender	0.038*	3.01	1.06-5.87
Birth height	<0.001*	8.24	2.53-26.89
Breastfeeding status	0.433	1.50	0.54-4.15
History of diarrhea	0.954	1.03	0.35-3.08
URTI in last 3 months	0.017*	3.78	1.26-11.26
Energy intake	0.605	1.25	0.53-3.08
Protein intake	<0.001*	4.06	1.94-8.48
Mother's age	0.549	0.69	0.20-2.31
Mother's height	0.304	1.95	0.55-6.93
Education level	0.009*	3.97	1.29-11.09
Family income	0.792	1.38	1.27-15.38
MUAC in pregnancy	0.003*	5.14	1.75-15.06
Multiparity	0.910	1.10	0.18-6.60
Fe supplement during pregnancy	0.477	0.63	0.18-2.23

*Logistic regression, significance (p<0.05)

The bivariate analysis between low birth weight (LBW) and the incidence of stunting found a significant relationship between the two variables ($p < 0.001$). **Table 4** showed that a higher percentage of children with low birth weight, defined as less than 2500 grams, were present in the stunting group (80.6%) compared to children with normal birth weight (43.6%).

A multivariate analysis was conducted between subject characteristic data and the dependent variable, which were potential confounders (as shown in **Tables 3 and 4**). The results of the multivariate analysis were presented in **Table 4** below, indicating that there was no significant relationship between a history of LBW and the incidence of stunting. The significant confounding variables associated with the incidence of stunting in children aged 12-23 months included the child's gender, birth length, history of URTI, protein intake, maternal education, and mother's MUAC during pregnancy.

Discussion

In this study, the proportion of stunted children in Dili, Timor-Leste whose mothers had anemia during the third trimester of pregnancy is 80.4%. This study identified a significant association between

Table 4. Multivariate analysis between low birth weight and the incidence of stunting while controlling for confounding variables

Variable	P	OR	CI 95%
LBW	0.970	0.97	0.20-4.67
Gender	0.018*	3.47	1.24-9.74
Birth height	0.001*	8.19	2.44-27.52
Breastfeeding status	0.220	1.85	0.69-4.97
History of diarrhea	0.591	1.33	0.47-3.73
URTI in last 3 months	0.015*	3.79	1.30-11.08
Energy intake	0.563	1.26	0.53-2.93
Protein intake	<0.001*	4.04	1.95-8.34
Mother's age	0.729	0.81	0.25-2.60
Mother's height	0.303	1.97	0.54-7.16
Education level	0.009*	3.83	1.39-10.55
Wealthy level	0.678	1.60	0.17-15.00
MUAC in pregnancy	0.003*	4.97	1.70-14.57
Multiparity	0.522	1.77	0.30-10.25
Fe supplement during pregnancy	0.724	0.78	0.21-2.94

*Logistic regression, significance ($p<0.05$)

maternal anemia during pregnancy and the incidence of stunting in children. Specifically, it indicated that mothers with anemia were 3.2 times more likely to have stunted children compared to those without anemia. This finding differs from a study conducted in Indonesia that reported no significant association between maternal anemia and the incidence of stunting. However, it is consistent with another Indonesian study that found a significant association between maternal anemia and stunting, with a p-value of 0.001.[1] Iron intake is crucial in the third trimester, as most iron transfers to the fetus after 30 weeks.[6] Inadequate iron can lead to hemoglobin deficiency, affecting oxygen transport to both mother and fetus. Maternal anemia increases risks of premature birth, intrauterine growth restriction, and low birth weight, making children born to anemic mothers more likely to be stunted. Mei et al.[6] explain that anemia data was primarily from the first trimester, where iron needs are less critical.[6-8] Multivariate analysis revealed no significant relationship between a history of anemia during pregnancy and stunting, after controlling for confounding variables such as child's gender, birth length, ARI history, low protein intake, maternal education, and MUAC.

There was a significant relationship between birth length and stunting, indicating that children born shorter were 8.24 times more likely to experience stunting than those with normal length. This finding was consistent with Mei et al.[6] research in Indonesia, which also showed a shorter children are 3.62 times more at risk for stunting. The mother's condition during pregnancy significantly affects fetal development during the first 1,000 days of life. Nutritional deficiencies, including both macronutrients and micronutrients like iron, can lead to growth retardation in bones and soft tissues, with effects that may persist after birth.[9] There was a strong association between a mother with a MUAC of less than 23 cm and the incidence of stunting. This suggested that mothers with a MUAC less than 23 cm are 5.14 times more likely to have a stunted child. This finding aligned with research from

Ethiopia, which found that mothers with a MUAC under 23 cm are 2.54 times more likely to have stunted children.[10] Poor maternal nutrition during pregnancy can adversely affect fetal growth and limit nutrition available at birth and during breastfeeding, disrupting the child's linear growth. Bone elongation is a complex process influenced by various intrinsic factors (hormones, growth factors) and extrinsic factors (nutrition, environment). Adequate nutrition, alongside hormones and growth factors, is crucial for the elongation of limb bones.[11-12]

In this study, a significant relationship was found between low protein intake and the occurrence of stunting. This was consistent with research from Indonesia, which also identified a link between low protein intake and stunting, indicating that children with low protein intake were 3.07 times more likely to experience stunting compared to those with adequate intake. Studies from Guatemala, Congo, Zambia, and Pakistan showed that sufficient animal protein consumption was associated with lower stunting rates. Poor-quality protein diets were linked to stunting due to reduced circulation of essential amino acids, hindering growth by disrupting IGF-1 signaling at the growth plate.[12] The study also revealed a strong association between low maternal education (less than 9 years) and stunting, with mothers having low education levels being 3.97 times more likely to have stunted children compared to those with over 9 years of schooling. This finding aligned with Indonesian research indicating a significant relationship between low maternal education and stunting.[1] Meta-analyses in developing countries suggested that mothers with low education levels were 3.23 times more likely to have stunted children compared to those with higher education. Maternal education impacted mothers' knowledge and attitudes toward nutrition and health care for their families.[12-15]

Children's linear growth can be affected by both acute and chronic infections. A significant relationship was found between recurrent URTI and stunting, with a p-value of 0.01, indicating that children with URTI were 3.78 times more likely to be stunted. This aligned with research in Indonesia, which showed that a history of infections occurring more than three times consecutively in the past three months increased the risk of stunting by 3.44 times.[16] Other studies indicated that children frequently experiencing infections were 2.89 times more likely to be stunted.[17] Repeated infections can disrupt growth hormones, increase energy requirements to support immune responses, and hinder cell repair. They may also reduce appetite and cause malabsorption. Pathogens elevate cytokines TNF-α and IL-1, which are involved in inflammation, and these elevated cytokines can lower IGF-1 levels, a crucial growth hormone, thereby inhibiting children's linear growth.[18]

There was a significant relationship between gender and stunting, with male children being 3.01 times more likely to experience stunting compared to female children. This finding aligned with research in Indonesia, which showed that male children were 2.25 times more at risk of stunting than females.[19] Additionally, research from Ethiopia indicated a relationship between gender and stunting, with a p-value of 0.003. The study explained that nutritional needs are partially determined by gender due to differences in body composition, leading to varying nutritional requirements. Males typically have more muscle mass and less fat tissue than females, and muscle tissue is metabolically more active, requiring more energy.[20]

In this study, out of 180 samples, 31 children were born with LBW, while 149 children were born with normal birth weight. Among the 31 children with LBW, 80.6% experienced stunting. A significant association was found between low birth weight and the incidence of stunting, indicating that children with LBW were 5.4 times more likely to be stunted. This

finding was consistent with research from East Nusa Tenggara (NTT), which showed that children with LBW were 2.1 times more likely to experience stunting. Low birth weight is a predictor of stunting because growth delays begin in the womb. However, the relationship between a history of LBW and stunting was found to be non-significant after multivariate analysis, which controlled for confounding variables such as the child's gender, birth length, history of upper respiratory tract infections (URTI), low protein intake, maternal education, and maternal MUAC during pregnancy.

This preliminary study took place across several districts in Dili, the capital of Timor-Leste. Data were collected proportionally from all community health centers in Dili, making the results representative of the city. However, the study had limitations. Assessing children's food intake through a single 24-hour recall only reflects their status at that moment, while stunting is a result of chronic malnutrition that requires multiple recalls or a Semi-Quantitative Food Frequency Questionnaire (SQFFQ) for accurate evaluation. Additionally, matching between case and control groups was based solely on location, not other variables. Despite this, the study performed a multivariate analysis to consider the influence of confounding factors.

Conclusions

Children born to mothers with anemia during the third trimester of pregnancy in Dili, Timor-Leste had a higher risk of experiencing stunting compared to children born to mothers without anemia. Children with a history of low birth weight in Dili, Timor-Leste also had a higher risk of stunting compared to those with normal birth weight. Other factors, such as birth length, maternal mid-upper arm circumference (MUAC), children's protein intake, history of infections, and maternal education levels, needed to be considered as contributing factors to the incidence of stunting in Timor-Leste.

Conflict of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article.

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Some of the maternal characteristic data from this study were presented at the NUTRI 2024 Scientific Meeting in the form of an abstract titled "Association of Maternal Factors with Stunting in 12-23 Months Old Children in Dili"

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