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Modeling determinants of stunting among children under five years in Urban Areas

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ABSTRACT

Child stunting remains a global public health problem. Compared to other middle-income countries, Indonesia is one of the countries with a high prevalence of stunting. This study aims to identify predictive indices and analyse the determinants of stunting in children under five in urban areas. Case control design was conducted on 420 (210 cases and 210 controls). Simple random sampling and side proportional techniques were used for sampling. Structured questionnaires were used to collect data through interviews and anthropometric measurements. Multivariable binary logistic regression analysis and statistical significance expressed at 95% CI, as well as receiver operating characteristic analysis were used. Mothers with low education (OR=1.6, 95% CI=1.0-2.6), fathers with no permanent job (OR=1.5, 95% CI=1.0-2.4), pregnancy interval less than 24 months (OR=1.6, 95% CI=1.0-2.6), family size of five or more (OR=2.1, 95% CI=1.3-3.3), income below minimum household income (OR=1. 7, 95% CI=1.0-2.8), not exclusively breastfed (OR=2.1, 95% CI=1.1-3.7), not fully immunised (OR=2.1, 95% CI=1.0-4.4), low birth weight (OR=2.3, 95% CI=1.2-4.5), and a history of disease (OR=2.0, 95% CI=1.0-3.8) were determinants of stunting. The most dominant determinant of stunting in children under five years old is low birth weight. Therefore, strategies and programmes are aimed at early prevention efforts, by increasing awareness to change community behaviour regarding improving maternal nutrition since pregnancy.

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1. INTRODUCTION

Child stunting remains a global public health problem [1], [2]. It is an indicator of malnutrition in early childhood and has important associations with a variety of diseases [3]. Stunting is irreversible, causing adverse health consequences in childhood [4]. Therefore, the first 1000 days from conception to two years of age are critical for children [5]. In addition to disease and disability, stunting is a leading cause of child mortality and disease burden, causing an estimated 3.1 million or 45% of child deaths worldwide per year [6]. Compared to other middle-income countries, Indonesia is one of the countries with a high prevalence of stunting [7]. Compared to ASEAN countries, Indonesia still has a lower frequency of stunting than Myanmar (35%), but still higher than Vietnam (23%), Malaysia (17%), Thailand (16%), and Singapore (4%) [8].

Stunting is the most commonly used index defining undernutrition [9]. Stunted children under five have an age ranging from 0 to 59 months and have a nutritional status category with a Z-score <¬2 standard deviations according to the height-for-age index [10]. Stunting has short-term and long-term impacts. The short-term impacts of stunting include increased morbidity and mortality rates, impaired development (cognitive, motor, language), and an increased economic burden for the care and treatment of sick children [11]. Furthermore, stunted children who experience rapid weight gain after two years of age have an increased risk of becoming overweight or obese later in life. Such weight gain is also associated with a higher risk of coronary heart disease, stroke, hypertension, and type-2 diabetes [12]. In the long run, it leads to poor reproductive health, learning concentration, and low work productivity [13].

Proportion of stunted children under five years in Indonesia to fall from 24.4% to 21.6% by 2022 [14]. The proportion of stunted children under five is highest in West Sulawesi at 35%. West Java is a province that has a proportion of stunted toddlers below the national proportion of 20.2% [15]. The prevalence of stunting in Bandung City in 2022 decreased compared to 2021, from 7.59% to 6.43% with an absolute number of 7,568 toddlers in 2021 to 6,518 children in 2022. Although the percentage of stunted toddlers indicates a downward trend, when observed from 2017, it still shows an increasing pattern of 6.50% [16]. The accelerated stunting prevention programme is a government priority. The Indonesian government has launched many corrective measures to reduce the burden of malnutrition and the incidence of stunting. Government policies to reduce the prevalence of stunting include the sustainable development goals (SDGs) of ending hunger, achieving food security and improved nutrition, and launching sustainable agriculture, as well as addressing stunting in children. In addition, the programme accelerates stunting reduction by increasing the effectiveness of specific and sensitive nutrition interventions [10].

Stunting is a complex problem as described by various conceptual frameworks, focusing on child undernutrition, maternal undernutrition, and food and nutrition security. The causes of stunting are multiple interrelated factors such as biological, social and environmental (sanitation). Contaminated environment, overcrowding, unclean water and sanitation will affect the growth of children [17]. In addition, there are several determinants of stunting, including child sex, age, birth weight, birth order, number of siblings, wealth index, maternal education, maternal body mass index and access to health services [18]. In order to reduce the prevalence of stunting, appropriate prevention efforts are required, appropriate prevention efforts are based on appropriate needs, and the most vulnerable communities should be the focus of interventions. Therefore, the first step in creating effective interventions is to identify predictor indices of the determinants of stunting in children under five years, so that prevention efforts can be relevant in reducing the prevalence of stunting in children under five. This study aims to identify predictive indices and analyse the determinants of stunting in children under five years of age in an urban area in Indonesia

2. METHOD

2.1. Study design and location

A community-based case-control study was conducted in Bandung City in January-February 2024. Bandung City as the capital of West Java Province makes it the centre of government as well as the economy. Bandung City is the third largest city in Indonesia and has an area of 167.31 KM2 divided into 30 sub-districts. Based on population projections from the Central Bureau of Statistics of Bandung City in 2022, the total population of children aged less than five years is 129,609. Health service coverage for children under five years old is 83.53%, there are 38 hospitals and 80 health centres.

2.2. Population and study sample

The source population was all mothers and children under the age of 6-59 months who lived for at least six months in the study area. The study population was all children aged 6-59 months in Bandung City. Cases are hildren between 6-59 months of age with (Z-score<-2.0 SD); and control as control are children aged between 6-59 months with Z-score≥2.0 SD).

2.3. Eligibility

- Inclusion criteria: i) All children aged between 6-59 months and their mothers living in the study area for the past six months, ii) able to communicate using Bahasa Indonesia.
- Exclusion criteria: All children aged between 6-59 months and their mothers who were critically ill and unable to communicate at the time of data collection.

2.4. Sample size

The sample size was calculated using the sample size formula for the hypothesis test of differences in 2 proportions. Determination of the size of the research sample by considering the odds ratio (OR) in previous

studies on the determinants of the incidence of stunting in children under five years of age. The sample size calculation uses a significance level (α) of 5% (Zα=1,960), power of test (β) of 80% (Zβ=0,842). Thus, the number of samples is 210, using a ratio of 1:1 so that the total sample is 420, consisting of 210 cases and 210 control. The minimum sample size was calculated based on data from previous literature. A minimum sample size of 107 was obtained for each group [19], [20].

2.5. Sampling procedure

From a total of 30 sub-districts, 10 sub-districts were selected using a random sampling technique. A census of the 10 sub-districts was conducted to determine a list of randomly selected households to count all children aged 6-59 months. All children aged 6-59 months living for more than six months in Bandung City and meeting the eligibility criteria were strictly sampled after random selection. Only homes that met the inclusion criteria were considered for the sample.

To determine the number of samples from each sub-district, a side-proportional allocation of samples was made in relation to the total sample size allocated for the study. All children aged 6-59 months who were selected as samples were anthropometrically measured and the height Z score was calculated according to their age. Categorised as a case group (stunted toddlers), if the anthropometric measurement results with a Z score <-2 SD. Categorised as a control group (toddlers not stunted), if the results of anthropometric measurements with a Z score of ≥-2 SD. Eventually, mothers and children from each sub-district were selected and enrolled using the simple random sampling method. Households were selected using the lottery method. If there was more than one eligible child in a household, only one child was selected using the lottery method.

2.6. Research variables

Dependent variable in this study is stunting. The stunting variable is classified into stunting (case) and non-stunting (control). The independent variables are socio-economic and demographic (maternal age, maternal education, paternal education, maternal occupation, paternal occupation, parity, previous birth spacing, number of family members in the household, household income). Characteristics of children less than five years old (sex, age, exclusive breastfeeding history, basic immunisation history, birth weight, and history of infectious disease). Environmental factors (drinking water source, family toilet facilities, garbage disposal facilities, waste water disposal facilities).

Mother's age variable was classified into <20 and >35 years and 20-35 years. The mother's education and father's education variables were classified into low, if the education level was <senior high school and high, if the mother's education level was ≥senior high school. The variables of mother's employment and father's employment are classified into not employed if the mother or father does not have a permanent job, and permanent employment, if the father or mother has a permanent job. The Pregnancy Interval variable was classified into <24 months and ≥24 months. Number of family members is classified into ≥5 and 2-4. The income variable is classified into below minimum wage, if the family income is <Rp.4,200,000 and above minimum wage, if the family income is ≥Rp.4,200,000.

The child's gender variable was classified into male and female. Child age variables were classified into ≥24 months and <24 months. Exclusive breastfeeding history was categorized into No, if the child was not exclusively breastfed for six months since birth and yes, if the child was exclusively breastfed for 6 months since birth. The basic immunization history variable was classified into Incomplete, if the child did not receive complete basic immunization and Complete, if the child received complete basic immunization. The variable birth weight was classified into low birth weight, if the child's weight at birth was <2.5 kg and normal, if the child's weight at birth was ≥2.5 kg. The history of infectious disease variable was classified as yes, if the child had recurrent infectious diseases, such as diarrhea and upper respiratory tract infection. It was classified as no if the child did not have recurrent infectious diseases.

Drinking water source variables are classified into Not qualified, if the drinking water consumed contains one of (taste, smell, color, and contains harmful microorganisms). And qualified, if the drinking water consumed is tasteless, odorless, colorless, and does not contain harmful microorganisms. The variable Family toilet facilities is classified into Not qualified, if they dispose of their waste in the river or sea. And qualified, if they dispose of their waste in a special feces' storage or septic tank. Garbage disposal facilities variable is classified into Not qualified, if there is no temporary garbage disposal at home. And qualified, if there is a temporary garbage disposal at home. The variable waste water disposal facilities are classified into Not qualified, if the household wastewater management system is not centralized (e.g. clogged, not flowing, final disposal to the river). Qualified, if the household wastewater management system is centralized, flowing, not stagnant, has final disposal.

2.7. Data collection

Data were collected by five trained midwives. Training was provided for one and a half days before starting data collection on anthropometric measurements, interviews, household selection criteria, and approaches to respondents. Data were collected through house-to-house visits. Questionnaires were adapted from various types of literature and guidelines and prepared in Bahasa Indonesia. Data were collected by anthropometric measurements (child height) and face-to-face interviews with eligible subjects using pre-tested structured questionnaires. The questionnaire included questions on Socio-Demographics, Characteristics of children less than five years old, and environmental factors. Mothers were interviewed about their children using the questionnaire.

2.8. Anthropometric measurements

The body length of children aged 6 to 23 months was measured in the supine position with an accuracy of 0.1 cm using a standard-length measuring board without shoes. Height of children aged 24 to 59 months was measured by placing the child in an upright position in the centre of the board wearing light clothing without shoes. The child's head, shoulders, buttocks, knees, and heels were adjusted to touch the board and each measurement was taken twice to ensure the reliability of the study to an accuracy of 0.1 cm. For mothers who did not know the exact age of their child, their immunisation card was used, or the age was kept accurate to the nearest month. Mothers' weight was measured using a portable weight scale to the nearest 0.1 kg and mothers were not allowed to carry anything that added to the recorded weight. The weighting scale was checked and reset at zero point for each consecutive study subject. Maternal height was measured in a standing position and measurements were taken by two data collectors holding a tape measure from the heel to the back of the head and measured to the nearest 0.1 cm.

2.9. Statistical analysis

Anthropometric data were calculated using WHO Anthro software version 3.1.0, and height-for-age Z scores were also generated based on the 2006 WHO reference population median (child growth standards). Univariate analysis was conducted to determine the socio-demographic characteristics and distribution of respondents displayed using frequency distribution data. Bivariate analysis used the chi square (X2) test, to determine the relationship between the study variables.

Simple logistic regression aims to select candidate risk factors for DHF incidence that will be continued to the multiple logistic regression test analysis. In selecting candidates, if the results of simple logistic regression showed p value <0.25, then the variable could be continued to be analysed simultaneously. Multiple logistic regression aims to model the predictive index of DHF incidence that analyses variables together or simultaneously. This will result in the OR value and also the best index (fit). Receiver operating characteristic (ROC) analysis aims to test the performance (sensitivity and specificity) of a test within a certain range of values. The results of the ROC analysis will also produce an ROC curve which can determine the cut of point value based on the ROC curve that has been obtained.

2.10. Ethical clearance

Is study has been approved by the Health Research Ethics Commission, Bhakti Kencana University, decisions number No.083/09.KEPK/UBK/VII/2023.

3. RESULTS AND DISCUSSION

Table 1 shows the socio-economic, demographic and incidence of stunting among research participants. A total of 420 (210 cases and 210 controls) mothers and children were included in this study, with a 100% response rate. The majority of mothers (57.6%) in the case group and 60.5% in the control group were in the age range of 20-35 years. The education of mothers was higher in the control group (62.4%) than in the case group (47.6), while the education of fathers was higher in 65.2% and 70.5%, respectively. The majority of mothers were unemployed in the case group (56.7%) and control group (60.5%), pregnancy range was more than 24 months (55.7% and 74.3%), and income was below the minimum wage (72.4% and 58.1%). Socio-economic and demographic factors that significantly influenced stunting in children under five years old were mother's education (OR=1.824, 95% CI=1.236-2.691, p=0.003), father's occupation (OR=1.710, 95% CI=1.162-2.516, p=0.008), pregnancy interval (OR=2.296, 95% CI=1.521-3.468, p=0.0001), family size (OR=1.897, 95% CI=1.285-2.801, p=0.002), and income (OR=1.890, 95% CI=1.257-2843, p=0.003).

Table 2 shows the characteristics of children less than five years old and incidence of stunting among research participants. Children under five years of age involved in this study were mostly aged <24 months (58.1%) in the case group and (63.8%) in the control group. The majority of children were not exclusively breastfed (81.0%) in the case group and control group (56.2%), fully immunised with 61.0% in the case group

and 84.3% in the control group. Half (50.5%) were found to have low birth weight in the case group, and (22.9%) in the control group. The majority of children had infectious diseases (86.2%) in the case group and (63.3%) in the control group. Child characteristics associated with stunting were exclusive breastfeeding history (OR=3.314, 95% CI=2.136-5.141, p=0.0001), immunisation history (OR=3.436, 95% CI=2.161-5.463, p=0.0001), birth weight (OR=3.440, 95% CI=2.259-5.239, p=0.0001), and history of infectious disease (OR=3.613, 95% CI=2.231-5.852, p=0.0001).

Table 1. Socio-economics, demographics and the incidence of stunting

Variable	Univariate	Bivariate				
	n (%)	Cases (%)	Controls (%)	p-value	OR	95% CI
Mother's age						
<20 and >35years	172 (41.0)	89 (42.4)	83 (39.5)	0.620	1.125	0.763-1.661
20-35 years	248 (59.0)	121 (57.6)	127 (60.5)			
Mother's education						
Low (<Senior high school)	189 (45.0)	110 (52.4)	79 (37.6)	0.003	1.824	1.236-2.691
High (≥senior high school)	231 (55.0)	100 (47.6)	131 (62.4)			
Father's education						
Low	135 (32.1)	73 (34.8)	62 (29.5)	0.296	1.272	0.844-1.918
High	285 (67.9)	137 (65.2)	148 (70.5)			
Mother' occupation						
Not employed	246 (58.6)	119 (56.7)	127 (60.5)	0.488	0.855	0.579-1.261
Permanent employment	174 (41.4)	91 (43.3)	83 (39.5)			
Father's occupation						
Not employed	208 (49.5)	118 (56.2)	90 (42.9)	0.008	1.710	1.162-2.516
Permanent employment	212 (50.5)	92 (43.8)	120 (57.1)			
Pregnancy interval						
<24 months	147 (35.0)	93 (44.3)	54 (25.7)	0.0001	2.296	1.521-3.468
≥24 months	273 (65.0)	117 (55.7)	156 (74.3)			
Number of family members						
≥5	189 (45.0)	111 (52.9)	78 (37.1)	0.002	1.897	1.285-2.801
2–4	231 (55.0)	99 (47.1)	132 (62.9)			
Income						
Below the minimum wage	274 (65.2)	152 (72.4)	122 (58.1)	0.003	1.890	1.257-2843
Above minimum wage	146 (34.8)	58 (27.6)	88 (41.9)			

Table 2. Characteristics of children less than five years old and incidence of stunting

Variable	Univariate	Bivariate				
	n (%)	Cases (%)	Controls (%)	p-value	OR	95% CI
Child's gender						
Male	208 (49.5)	111 (52.9)	97 (46.2)	0.205	1.306	0.890-1.917
Female	212 (50.5)	99 (47.1)	113 (53.8)			
Child's age						
≥24 months	164 (39.0)	88 (41.9)	76 (36.2)	0.271	1.272	0.859-1.884
<24 months	256 (61.0)	122 (58.1)	134 (63.8)			
Exclusive breastfeeding history						
No	288 (68.6)	170 (81.0)	118 (56.2)	0.0001	3.314	2.136-5.141
Yes	132 (31.4)	40 (19.0)	92 (43.8)			
Immunisation history						
Incomplete	115 (27.4)	82 (39.0)	33 (15.7)	0.0001	3.436	2.161-5.463
Complete	305 (72.6)	128 (61.0)	177 (84.3)			
Birth weight						
Low birth weight	154 (36.7)	106 (50.5)	48 (22.9)	0.0001	3.440	2.259-5.239
Normal	266 (63.3)	104 (49.5)	162 (77.1)			
History of infectious disease						
Yes	314 (74.8)	181 (86.2)	133 (63.3)	0.0001	3.613	2.231-5.852
No	106 (25.2)	29 (13.8)	77 (36.7)			

Environmental factors were also observed in this study, it is shown in Table 3. The majority of mothers and children used eligible drinking water sources (70.0%) and (81.4%) in the control group. The majority of eligible mothers (61.0%) in the case group and (81.4%) in the control group had family latrines. The majority were ineligible for garbage disposal facilities and wastewater disposal facilities (57.6% of cases and 58.6% of controls) and (62.4% of cases and 58.6% of controls) respectively. Environmental factors associated with stunting in children under five years of age were clean water or drinking water sources (OR=1.879, 95% CI=1.191-2.965, p=0.009) and family toilet facilities (OR=1.640, 95% CI=1.089-2.468, p=0.023).

Table 3. Environmental factors and the incidence of stunting

Variables	Univariate	Bivariate				
	n (%)	Cases (%)	Controls (%)	p-value	OR	95% CI
Drinking water source						
Not qualified	102 (24.3)	63 (30.0)	39 (18.6)	0.009	1.879	1.191-2.965
Qualified	318 (75.7)	147 (70.0)	171 (81.4)			
Family toilet facilities						
Not qualified	141 (33.6)	82 (39.0)	59 (28.1)	0.023	1.640	1.089-2.468
Qualified	279 (66.4)	128 (61.0)	151 (71.9)			
Garbage disposal facilities						
Not qualified	244 (58.1)	121 (57.6)	123 (58.6)	0.921	0.962	0.653-1.417
Qualified	176 (41.9)	89 (42.4)	87 (41.4)			
Waste water disposal facilities						
Not qualified	254 (60.5)	131 (62.4)	123 (58.6)	0.485	1.173	0.793-1.735
Qualified	166 (39.5)	79 (37.6)	87 (41.4)			

Table 4 is the final model of the determinants of stunting in this study. The factors that have impact on causing stunting are mother's education, father's occupation, pregnancy interval, number of family members, income, exclusive breastfeeding history, immunisation history, low birth weight, and history of infectious diseases. The dominant factor causing stunting in children under five years old was low birth weight (OR=2.360, 95% CI=1.232-4.518, p=0.010) after controlling for other variables.

Table 4. Modeling determinants of stunting among children under five years in urban areas

Variable		B	SE	p-value	OR	95% CI
Mother's education	Low (<senior high school) High (≥senior high school)	0.523	0.225	0.020	1.688	1.086-2.623
Father's occupation	Not employed Permanent employment	0.458	0.227	0.044	1.580	1.013-2.466
Pregnancy interval	<24 months ≥24 months	0.517	0.236	0.028	1.677	1.056-2.664
Number of family members	≥5 2–4	0.768	0.229	0.0001	2.155	1.377-3.374
Income	Below minimum wage Above minimum wage	0.540	0.251	0.031	1.716	1.049-2.807
Exclusive breasfeeding history	No Yes	0.755	0.294	0.010	2.127	1.196-3.781
Immunisation history	Incomplete Complete	0.768	0.367	0.037	2.155	1.049-4.428
Birth weight	low birth weight Normal	0.859	0.331	0.010	2.360	1.232-4.518
History of infectious disease	Yes No	0.699	0.330	0.034	2.012	1.054-3.840
Constant		-8.843	1.054	0.0001		

The Figure 1 shows the ROC analysis of stunted children in this study. At the middle of the cut-off point on the curve, it indicates that the stunting toddler index formula in this study has a sensitivity value of 47.6%, meaning that the stunting predictive index has the ability to predict toddlers who are really stunted among the population who suffer from stunting is 47.6%. Specificity is 37.6%, meaning that the predictive index of stunting toddlers has the ability to predict people who are really not stunted among the population who are not stunted is 37.6%.

In this study, mothers with low education, fathers who were not permanently employed, pregnancy interval of less than 24 months, family size of five or more, income below the minimum household income, children who were not exclusively breastfed, did not receive complete basic immunisation, low birth weight, and a history of infectious diseases were determinants of stunting at the 95% CI. Children born to mothers with low education are 1.6 times more likely to experience stunting compared to children born to mothers with high education. This is in line with research conducted in Pakistan, Vietnam, Indonesia [21]–[23]. This is because highly educated mothers have better treatment-seeking behaviour for childhood illnesses compared to mothers with low education, which can help prevent stunting [24]–[26]. Parental education is a strong determinant of stunting in Indonesia. An increase in parental formal education will lead to a 3-5% reduction in the risk of children becoming stunted [27].

Children born to fathers who are not in regular employment are 1.5 times more likely to be stunted than children born to fathers who are in regular employment. This is consistent with other studies in

Bangladesh. This is because unemployed fathers will find it difficult to fulfil their children's nutritional needs, so children can become stunted [28]. Pregnancy interval of less than 24 months is one of the causes of stunting in children [29], [30]. This is consistent with a study in Philippines, where the increase in stunting between intervals below 24 months [31]. Family size is also associated with stunting. Children who have large families have a significant association with stunting. This is in line with research conducted in China and Northeast Ethiopia [32], [33]. Family size is also associated with stunting. Children who have large families have a significant association with stunting. This is in line with research conducted in Armenia and Northern Sudan [34].

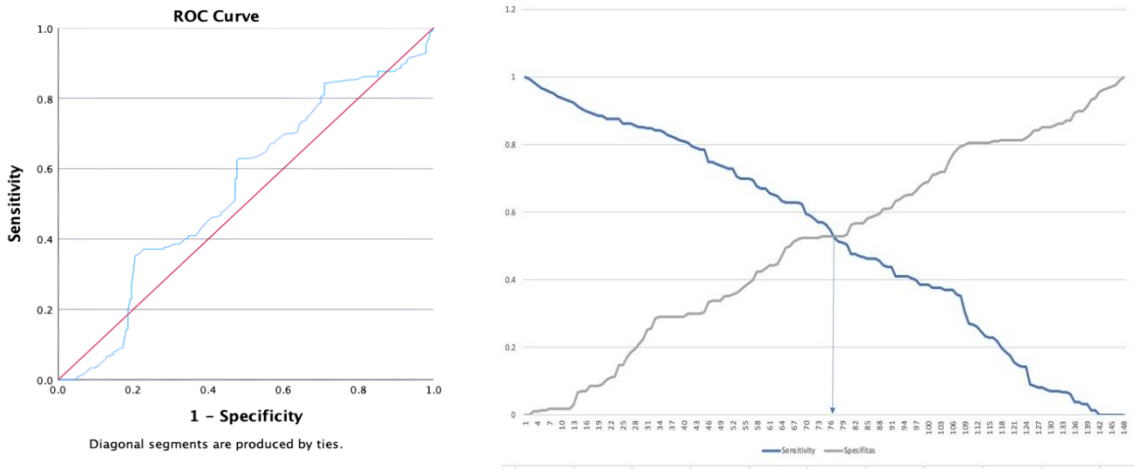

Figure 1. ROC curve of stunted children and cut-off points of sensitivity and specificity

Children born to families whose monthly income is below the minimum wage are 1.7 times more likely to be stunted. This is consistent with other findings showing a higher prevalence of stunting among children in low and middle-income countries [34]–[36]. Another study stated that household socioeconomic factors, including household income per capita, are significant predictors of stunting in children under five years of age [13]. Additionally, children who were not exclusively breastfed, did not receive basic immunisations, had low birth weight at birth, and had previous infectious diseases were more likely to be stunted. This is consistent with several other studies around the world such as Indonesia, Zimbabwe, and Ethiopia [37]–[39]. Children are more susceptible to infectious diseases such as diarrhoea and respiratory diseases if they are not exclusively breastfed, immunised, and born with low birth weight. Repeated bouts of (infectious) diseases have a negative impact on child growth [27], [40].

This study has several strengths and limitations. The first strength is that this study used a case control design, so the results of this study can establish a causal relationship. Second, this study uses receiver operating characteristic, so it can predict toddlers who are really stunted and not stunted. Meanwhile, the weaknesses of this study are firstly that recall bias may occur, because the expected period of recall is relatively long, but this condition is not differential. Secondly, although this study was conducted in a Metropolitan City, the results of this study may not be representative of urban areas throughout Indonesia, given that the sample used in this study was quite small, but this study can provide an overview of the determinants of stunting in toddlers because the research was carried out in accordance with procedures, including the training process, standardisation of anthropometric measurements and close supervision during field activities. Third, socioeconomic differences and education levels in each region are limitations of this study.

4. CONCLUSION

The determinants of stunting in children under five years old are mothers with low education, fathers who are not permanently employed, pregnancy interval of less than 24 months, family size of five or more, income below the minimum household income, children who are not exclusively breastfed, not fully immunised, low birth weight, and a history of disease. Therefore, strategies and programmes are aimed at early prevention, by increasing the awareness of community behaviour change on improving maternal nutrition during pregnancy, exclusive breastfeeding, and basic immunisation.

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