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Short birth length, low birth weight and maternal short stature are dominant risks of stunting among children aged 0-23 months: Evidence from Bogor longitudinal study on child growth and development, Indonesia

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ABSTRACT

Introduction: Stunting remains a predominant global health problem and Indonesia is no exception. This analysis aims to determine the major factors of stunting among children aged 0-23 months, using data from the Bogor Longitudinal Study on Child Growth and Development (BLSCGD). **Methods**: The BLSCGD was conducted by the Center for Public Health Research and Development, Ministry of Health, Indonesia. This analysis used part of the BLSCGD data. A total of 320 children aged above 23 months were included. Anthropometric measurements were performed by trained enumerators each month from the first month of birth until 23 months of age. The analyses of survival resilience was conducted using survival statistics test using life table and Kaplan Meier, whereby the case for this survival analysis was the occurrence of stunting. Factors affecting stunting (including children and maternal characteristics) were tested using cox proportional hazards regression. **Results**: Determinants of stunting were birth weight with hazards regressions (HR) score=1.847; 95% CI: 1.282-2.662), birth length (HR=1.567; 1.034-2.375), and maternal height (HR=1.436; 1.014–2.030). The probability of children not being stunted decreased with increase in age. **Conclusion**: Birth weight and length at birth, and maternal short stature were the dominant risks factors of stunting among the study children aged 0-23 months.

Keywords: stunting, survival resilience, children under two years of age, Indonesia

INTRODUCTION

It was estimated that 23% of children below five years of age were stunting globally in 2015 (WHO, 2016). The highest prevalence of stunting in children was in Africa (38%) followed by Southeast Asia (33%). Stunting in children remains one of the major nutritional problems in Indonesia. It was reported that 20.2% of under-give stunted children in Indonesia were born with short birth length of less than 48 cm (Trihono *et al.*, 2015). This condition remains up to two years old (23 months), leading to the national stunting prevalence of 32.9%, or more than two million children, in 2013.

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Studies have shown that stunting in childhood is associated with high body mass index (BMI) in adulthood, associated with low academic achievement in adolescence, as well as facing a higher risk for non-communicable diseases in adulthood (Andersen *et al.*, 2016). A review suggests that height by age at two years is a good predictor of the quality of human resource, chronic diseases tend to occur more in children who had malnutrition and sharp weight gain after their infancy (Victora *et al.*, 2008). Several studies also mentioned that stunting in children continues into the next generation (intergeneration effect). Children from stunted parents have a lower rate of development compared to children with non-stunted parents (Walker *et al.*, 2015). Stunting is caused by multiple factors including prenatal environment (Schmidt *et al.*, 2002).

MATERIALS AND METHODS

The Bogor Longitudinal Study on Child Growth and Development (BLSCGD) was conducted in Bogor Tengah sub-district, Bogor city, Indonesia. The overall objective of this study was to identify the determinants of growth and development of children from birth until aged 18 years. Data collection began in 2012 and is on-going, as the BLSCGD aims to cover a sample of 2170 pregnant women by 2030.

The BLSCGD recruited all pregnant women aged 18-35 years based on information provided by the community health volunteers' (*kader)* for each area. The *kaders* are part of the community health center system in Indonesia (National Research Council of the National Academies and AIPI, 2013). An inclusion criteria is willing to take part in the study until the child is 18 years of age. Written consent was obtained before they took part in the study. Subjects were interviewed using a questionnaire for household characteristics, age, education and occupation. Anthropometric measurements (weight, height and upper arm circumference) were taken. Clinical examination by a medical doctor was undertaken each month of pregnancy.

For our study, we considered all 650 deliveries out of 798 pregnant women, recorded from 2012 till 2016. We also included all children aged above 23 months (n=320), based on the objective of this analysis to observe the survival resilience among non-stunting children and its determinants. Anthropometric measurements of the children were obtained from the records of midwives or health workers who assisted in childbirth. Birth weight and length were measured within 24 hours of birth. Birth weight was categorized as 'low' if <3,000 g (Barker, 1995) while the birth length was categorised as 'short' if <48 cm (NIHRD, 2013).

Maternal height was categorised as 'at risk' if it was less than 150 cm (NIHRD, 2013). Mother's education achievement level was categorised as 'low education' (never attended school or graduated from elementary school), 'secondary education' (graduated from junior and senior high school), and 'higher education' (graduated from diploma or college). Maternal pre-pregnancy body mass index (BMI) was calculated from maternal pre-pregnancy weight and height, and categorised into 'obese' (BMI ≥27 kg/m^2), 'overweight' (25 kg/m^2≤ BMI <27 kg/m^2), 'normal' (18.5 kg/m^2< BMI <25 kg/m^2) and 'underweight' (BMI ≤18 kg/m^2) (NIHRD, 2013).

Each month, there is an interview with the mothers regarding the child's anthropometric, food consumption, immunisation status, health seeking behaviour, child growth monitoring, and exclusive breastfeeding practice. The anthropometric measurements are done every month until the child was 23 months of age (i.e. for a total of 23 measurements). Every month on the same date, the respondent comes to the basecamp for measurement. If the sample is unable to attend on that date then there is an allowance to go three days before or three days after the specified date. The body length was measured using length-board with 0.1 cm accuracy. Each child is measured lying down. The children were categorised as 'stunted' if they had *z*-score less than -2 SD based on length for age index (WHO, 2007).

Dietary diversity was assessed based on 24-hour recall method in between the ages of 12–23 months. It was assessed based on food consumption on seven food groups, namely cereals/tubers, beans, milk and processed products, meat/fish/processed, eggs, vegetables and fruit-sources of vitamin A and other vegetables and fruits. Children were categorised as consuming 'diverse foods' if he/she consumed more than or equal to four food groups (WHO, 2008).

The immunisation status of children was based on the compulsory immunisation of children up to the age of one year. The children were considered to be fully immunised if he/she obtain all mandatory immunisations aged 0-1 years established by the government. Health-seeking behaviour was assessed based on the practice of mothers who seek health services when the child was sick, in the period of 0-5 months. The variable of child growth monitoring was based on the regularity of the mother weighing the child each month. Samples were considered to have 'regular growth monitoring' if from the age of 0-23 months the sample is weighed monthly in the integrated health post.

Exclusive breastfeeding practices were asked through questions related to child's breastfeeding patterns, such as consumption of pre-lacteal foods, current breastfeeding and consumption of complementary foods. Assessment of exclusive breastfeeding is derived from 24-hour recall data. Children are categorised as 'exclusively breastfed' if he/she exclusively fed by breast milk from 0-5 months old (WHO, 2008). Child morbidity was assessed according to the frequency of illness experienced by the children during six months period (0-5 months, 6-11 months, 12-17 months and 18-23 months).

Data on length status according to the age (HAZ) of children was processed by using WHO-Antro software. Child survival resilience toward not stunting was analysed by using survival statistic test using life table and Kaplan Meier. In this analysis, 'case' was the occurrence of stunting. The time variable in this analysis was the time (in months) when the children became stunted. Factors affecting stunting were tested using Cox Proportional Hazards Regression. We did multicollinearity assessment between the independent variables before running the regression analysis.

All respondents received an explanation before becoming a research respondent. The study has received ethical approval from the Research Ethics Committee of the Health Research and Development Agency of the Ministry of Health. There is no conflict of interest in the creation of this article.

RESULTS

Based on analysis of sample characteristics (Table 1), the proportion of male infants was 49.7% that was not much different with the proportion of female infants at 50.3%. The percentage of infants with low birth weight (<3,000 g) was 28.4%, while 17.2% infants had short birth length (<48 cm). As much as 17.4% infants were exclusively breastfed, 80.1% were completely immunised, 72.5% were also routinely weighed in growth monitoring programmes at

Table 1. Characteristics of children (0-23 months) (*n*=320)

Factors	*n (%)*
Sex	
Boys	159 (49.7)
Girls	161 (50.3)
Birth weight	
Normal (≥3000 gram)	229 (71.6)
Low (<3000 gram)	91 (28.4)
Birth length	
Normal (≥48 cm)	265 (82.8)
Short (<48 cm)	55 (17.2)
Exclusive breastfeeding practice	
Yes	55 (17.4)
No	261 (81.6)
Complete immunisation	
Yes	249 (80.1)
No	62 (19.9)
Regular growth monitoring	
Yes	229 (72.5)
No	87 (27.5)
Seeking for health services	
Yes	224 (71.6)
No	89 (28.4)
Dietary diversity	
Diverse	183 (57.2)
Non Diverse	137 (42.8)
Experience of illness in 0-5 month	
Never	38 (12.9)
1-3 times	232 (78.9)
>3 times	24 (8.2)
Experience of illness in 6-11 month	
Never	15 (4.9)
1-3 times	170 (55)
>3 times	124 (40.1)
Experience of illness in 12-17 month	
Never	18 (5.8)
1-3 times	166 (53)
>3 times	129 (41.2)
Experience of illness in 18-23 month	
Never	21 (6.7)
1-3 times	205 (65.7)
>3 times	86 (27.6)
Maternal age	
21-35 years	220 (68.8)
Less than 21 years and more than 35 years	100 (31.3)
Maternal height	
Normal (≥150 cm)	211 (65.9)
Short (<150 cm)	109 (34.1)
Maternal pre pregnancy body mass index (BMI)	
Obese	60 (18.9)
Overweight	46(14.5)
Normal	176 (55.3)
Underweight	36 (11.3)
Maternal education	
High	14 (4.4)
Middle	254 (79.4)
Low	52 (16.3)
Maternal occupation	
Housewife	272 (85.0)
Work	48 (15.0)

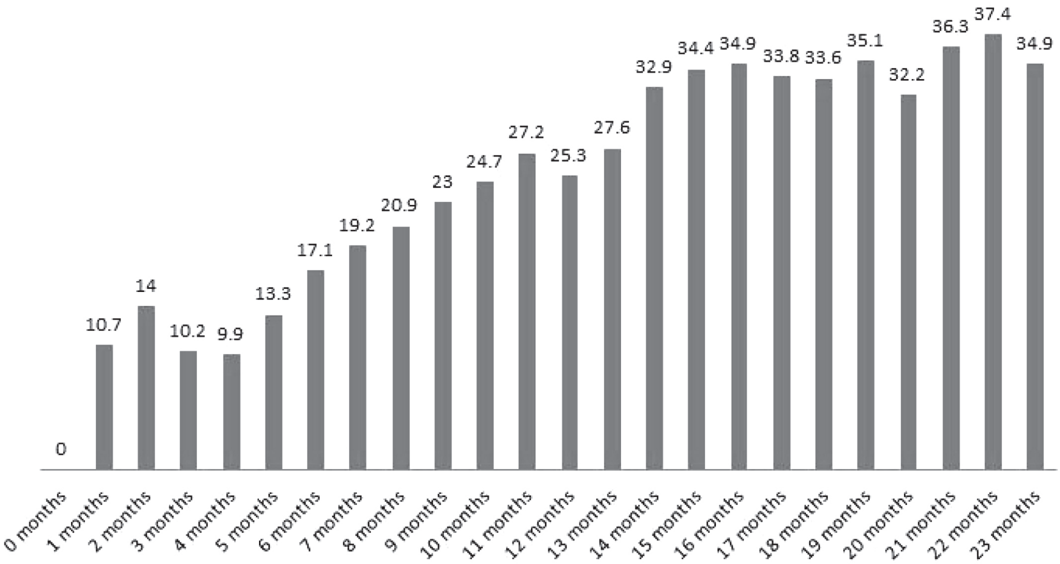

Figure 1. Prevalence of stunting from 0-23 months

Integrated Health Care, and 71.6% respondents sought for healthcare services in the period of 0-5 months of age. There were no differences on child dietary diversity consumption. Results showed that children experienced illness mostly at the age of 0-23 months. Table 1 also showed that approximately 30% of mothers were at the risky age (<21 years and >35 years). Almost one third of the mothers were short (the height less than 150 cm) and more than 10% of mothers were underweight.

Figure 1 shows the prevalence of stunting in children aged 0-23 months. The prevalence of stunting at 0 month was 0%, since only children who were not stunted, or having normal status at birth were included. In the first month of age, the stunting prevalence became 10.7%. This result suggests that the failure of linear growth has begun in the first month of life. The data shows that the prevalence of stunting increases, as the children get older. At the age of 23 months, the approximate ratio is 3:10 for stunted children.

Determinant factors of stunting in children aged 0-23 months

The Cox Proportional Hazards Regression analysis showed that the determinant factors of stunting in children aged 0-23 months old were birth weight with HR (Hazards Regression) score=1.847(1.282-2.662), birth length with HR value=1.567(1.034-2.375), and maternal height with HR value=1.436(1.014–2.030) (Table 2). These results mean that infants with birth weight less than 3,000 g had 1.8 times higher risk to be stunted compared to those with greater than or equal to 3,000 g birth weight. Figure 2 shows that the median survival age to survive toward not stunting in infants with birth weight less than 3,000 g was nine months, and it was lower than those with birth weight greater than or equal to 3,000 g which had median survival age to survive toward not stunting at 18 months. Thus, the infants with normal birth weight can survive from not being stunted twice than those with have low birth weight.

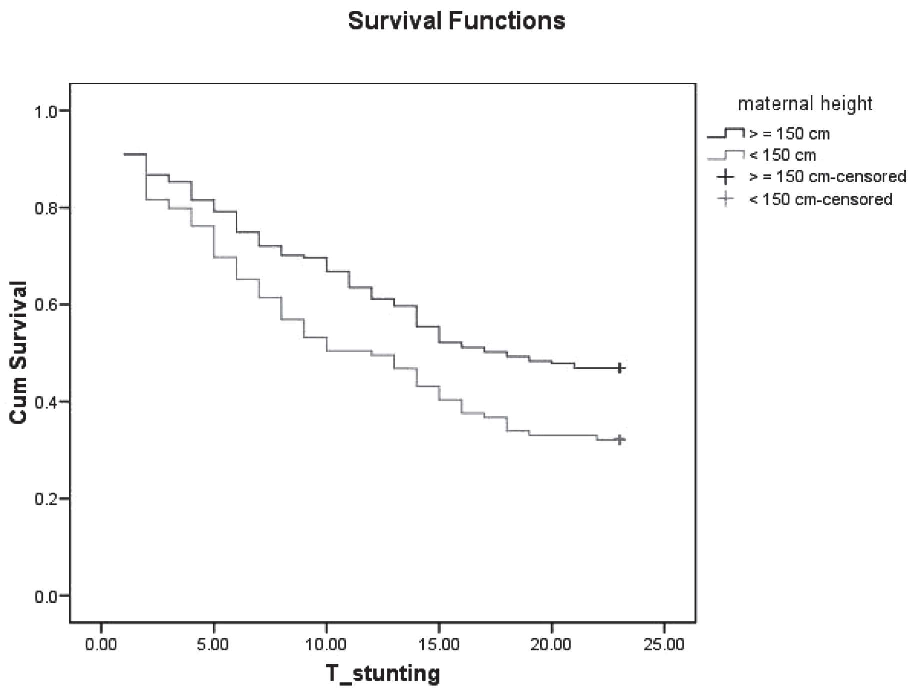

Figure 2. Survival rate in normal nutritional status of children 0-23 month based on birth weight (n=320)

The results also found that infants with short birth length had 1.6 times higher risk to be stunted compared to infants with normal birth length. The survival analysis also indicated that infants with normal birth length could survive toward not stunting for 17 months, which was longer than those with short birth length that could survive toward not stunting for six months.

Table 2 also shows that infants having mothers whose height was less than 150 cm had 1.4 times higher risk to be stunted compared to infants having mothers with the height of at least 150 cm. In addition, the median survival age to survive toward not stunting among infants having mother with the height of less than 150 cm was 12 months, while infants having mother with the height of at least 150 cm can survive from not being stunted for 18 months.

This study also shows that children aged 0-23 months with the birth weight of at least 3,000 g had higher survival rate toward not stunting for each month compared to children with the birth weight of less than 3,000 g (Figure 2). Meanwhile, infants born with normal birth length had a higher survival rate than infants with short birth length toward not stunting (Figure 3). The survival rate toward not stunting among infants with short birth length decreased dramatically in early life. This decreasing rate continues until the age of 23 months and always below the normal birth length children.

In addition, the survival rate of the children having mother with ≥150 cm of height (normal) was higher than children having mother with the height of less than 150 cm (Figure 4). This was consistent from the beginning of observation (0-2 months) to the end of observation (21-23 months).

Table 2. The final model of determinant factors of stunting results in children 0-23 months (*n*=320)

Covariate	*Median survival (month)*	*Analysis multivariate*		
		Hazard ratio	*95% CI*	*p-value*
Sex				
Boys	14	1.418	(0.809 – 2.484)	0.222
Girls	16			
Birth weight				
Low (<3000 g)	9	1.847	(1.282 – 2.662)	0.001*
Normal (≥3000 g)	18			
Birth length				
Short (<48 cm)	6	1.567	(1.034 – 2.375)	0.034*
Normal (≥48 cm)	17			
Exclusive breastfeeding practice (0-6 month)				
No	15	1.451	(0.917 – 2.297)	0.112
Yes	18			
Complete immunisation				
No	21	0.707	(0.461 – 1.084)	0.112
Yes	14			
Regular growth monitoring				
No	14	1.240	(0.656 – 2.346)	0.508
Yes	15			
Seeking for health services				
No	15	1.036	(0. 551 – 1.948)	0.912
Yes	14			
Dietary diversity				
Non Diverse	15	0.911	(0.512 – 1.620)	0.750
Diverse	15			
Experience illness in 0-5 month				
>3 times	13	0.748	(0.225 – 2.488)	0.636
1-3 times	15	0.994	(0.450 – 2.195)	0.988
Never	12			
Experience illness in 6-11 month				
>3 times	14	1.547	(0.279 – 8.502)	0.617
1-3 times	15	0.928	(0.173 – 4.990)	0.931
Never	16			
Experience illness in 12-17 month				
>3 times	15	0.786	(0.184 – 3.36)	0.746
1-3 times	15	0.971	(0.238 – 3.964)	0.967
Never	12			
Experience illness in 18-23 month				
>3 times	14	0.681	(0.222 – 2.089)	0.502
1-3 times	15	0.626	(0.213 – 1.843)	0.395
Never	11			
Maternal age				
Less than 21 years and more than 35 years	15	0.684	(0.378 – 1.240)	0.211
21-35 years	15			
Maternal height				
Short (<150 cm)	12	1.436	(1.014 – 2.030)	0.041*
Normal (≥150 cm)	18			
Maternal pre-pregnancy BMI				
Underweight	15	0.334	(0.099 – 1.126)	0.077
Normal	14	1.006	(0.470 – 2.153)	0.989
Overweight	14	1.318	(0.523 – 3.323)	0.558
Obese	21			
Maternal education				
Low	11	0.926	(0.271 – 3.166)	0.902
Middle	16	0.421	(0.137 – 1.298)	0.132
High	6			
Maternal occupation				
Work	16	1.016	(0.490 – 2.105)	0.996
Housewife	15			

*significant *p<0.05*

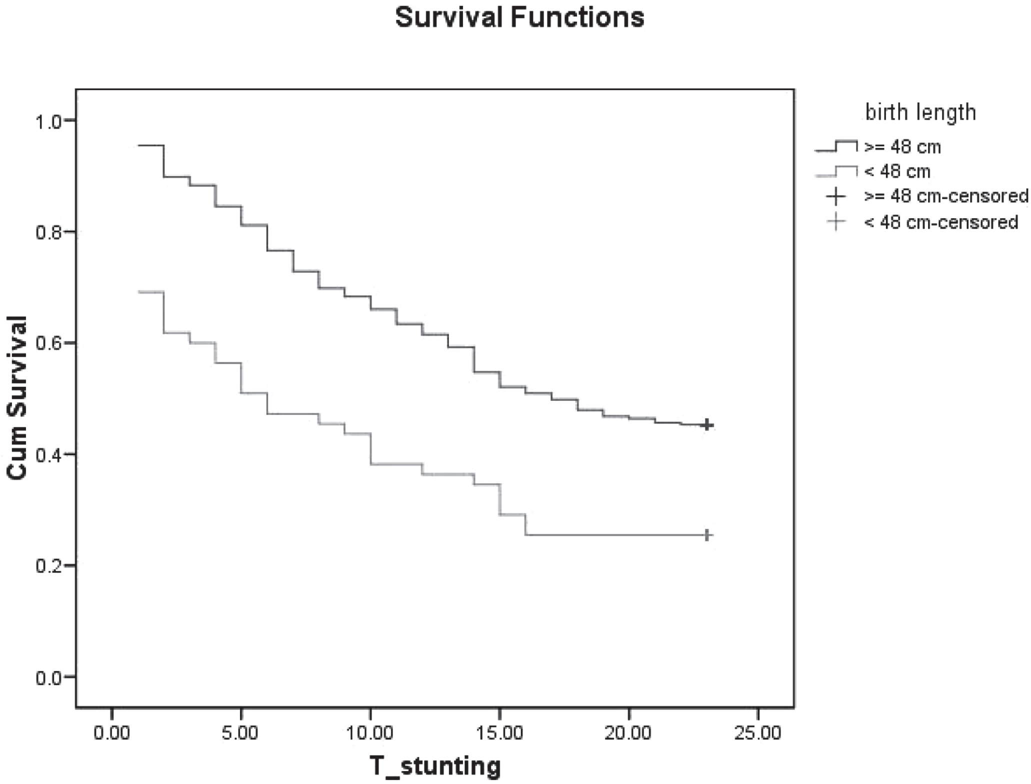

Figure 3. Survival rate in normal nutritional status of children 0-23 month based on birth length (n=320)

DISCUSSION

This study examined the factors affecting stunting among children aged 0-23 months. The main findings were birth weight, birth length and maternal height as dominant risk factors of stunting among children in this age group. This result confirmed previous studies in several Asian countries. This study result is in line with prior longitudinal study in West Java, Indonesia that found the birth weight and length as most important determinants of infant nutritional status (Schmidt *et al.,* 2002). Another analysis on national data conducted in Indonesia also showed that low birth weight was the most dominant predictor for stunting among children aged 12-23 months (Aryastami *et al.,* 2017).

Another study in the Philippines reported that newborn weight and length were the risk factors associated with stunting (Ricci, 2006). Furthermore, a study in Pakistan also suggested that low birth weight was consistently as a dominant factor of growth failure in the first three years of life (Avan *et al.*, 2015). In line with this analysis result, a nation-wide study in India found that growth faltering has occurred even since the child was born which result on the incidence of stunting at the age under five years (Mamidi *et al.,* 2010).

Birth weight is one of predisposing factors to growth attainment after birth. Infants with low birth weight (<2,500 g) are likely to have intrauterine growth restriction even if the infants born at term (Black *et al.,* 2008).

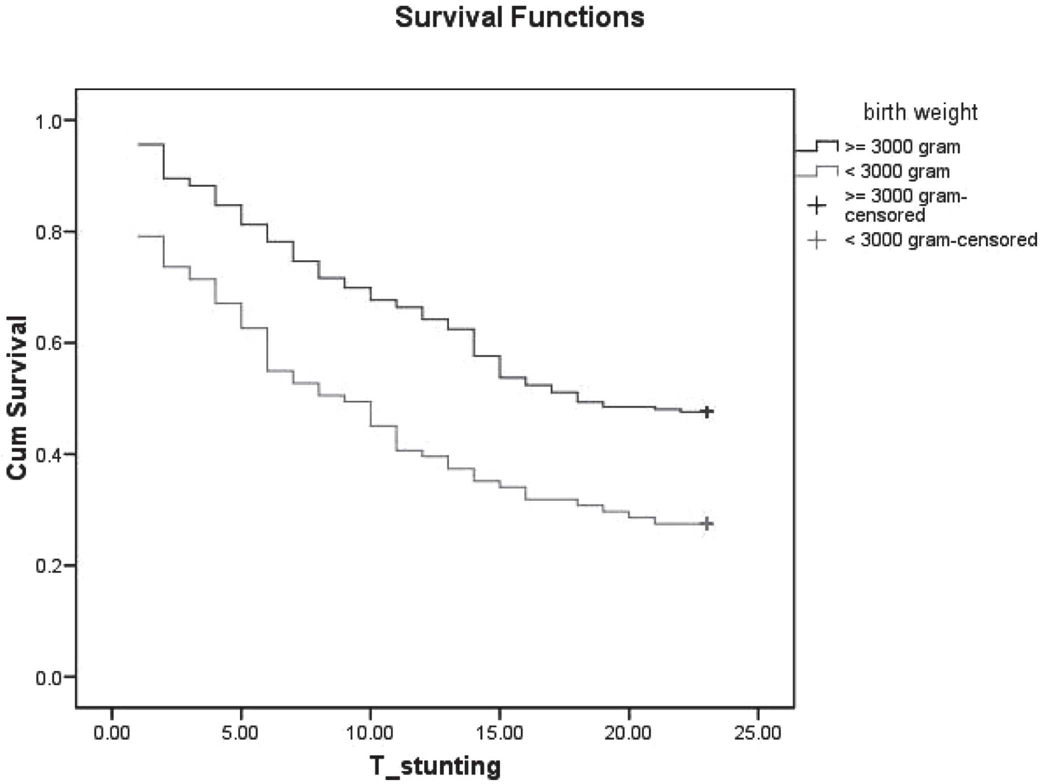

Figure 4. Survival rate in normal nutritional status on children aged 0-23 months based on maternal height (n=320)

Therefore, low birth weight may cause growth faltering in infancy and lead to stunting in childhood. As summarised in Lancet Series of maternal and child undernutrition, adult height is positively associated with birth weight and length in low-middle income countries. It showed that a 0.7-1 cm increase in adults' height is associated with one cm increase in birth length. (Victora *et al.,* 2008).

Important evidences supporting the main findings of this study showed that children with birth weight at least 3,000 g had better resilience towards not stunting. They had longer survival time compared to the ones with birth weight less than 3,000 g. Children with birth length at least 48 cm also could survive longer than children with birth length less than 48 cm. These results emphasised more the importance of adequate nutrition for foetus during the pregnancy for a good healthy pregnancy outcome.

Maternal nutritional status has important contribution to the pregnancy outcome. According to the study findings, having short mother was one of the risk factors of stunting among children. Children who were born by short mother (<150 cm) had higher risk of being stunted. Maternal height is closely related to birth weight and length. A cohort study using the phenotype and genome-wide SNP data from three Nordic countries revealed the causal and strong association between maternal height and birth weight and length (Zhang *et al.,* 2015). These evidences showed that maternal malnutrition will risk the survival, health, and development among offspring. Thus, there might be an intergenerational cycle of malnutrition in the future where a stunted child would be a stunted mother who would deliver a stunted child (Felisbino-Mendes, Villamor, Velasquez-Melendez, Vikbladh, & Saxtrup, 2014).

Low birth weight and short birth length indicated poor nutritional status during pregnancy. It is including chronic energy deficiency and micronutrient deficiencies that will increase the risk of having baby with low birth weight (Kusharisupeni, 2006 and Svefors *et al.,* 2016). Mother with this condition may have reduced protein and energy stores, smaller reproductive organ system and limited room for foetal development (Addo *et al.,* 2013). Moreover, during lactation, they may not provide sufficient breast milk to their baby which may further affect the child growth (Kusharisupeni, 2006).

Genetic factors play an important role to a child's growth. Maternal height as the result of complex interaction between genetic and environment factors prior to pregnancy has major contributions to the child's height. These results emphasised the importance of having optimal health and nutritional status before and during pregnancy for a healthy pregnancy outcome.

As shown in previous studies in developing countries, this study also confirmed an inverse association between maternal height and stunting child (Özaltin, Hill, & Subramanian, 2010; Subramanian, Ackerson, Davey Smith, & John, 2009). Consistent evidence exist for the association between short maternal height and intrauterine growth retardation and also low birth weight, in which short maternal height plays a role as a predictor of infant death and impaired child growth (Murray *et al.,* 2012). Maternal short height can restrict uterine blood flow and growth of the uterus, placenta, and foetus which later delay the development and height either during childhood or adulthood (Black *et al.,* 2008).

An analysis by Mendes MSF, Villamor E, and Melendez GV using the 2006 Brazilian Demographic Health Survey data also showed that maternal height was positively associated to children's HAZ values. Children having mothers <145 cm tall have 1.2 times lower HAZ than those having ≥160 cm height mother. In addition, the results of those analysis also indicated the risk of child stunting by maternal height categories (<145, 145-149, 150-154, 155-159 and ≥160 cm) were 2.95 (1.51; 5.77), 2.29 (1.33; 3.93), 1.09 (0.63; 1.87), and 0.89 (0.45; 1.77), respectively. This suggests that mothers with the height of <145 cm were at greater risk of having stunted children (2.95 times) than other maternal height categories (Mendes *et al.,* 2014).

This study suggested that low birth weight, short birth length, and maternal stunting have serious implications to child growth and development. In the future, it may lead to irreversible damages, such as shorter adult height, reduced lean body mass, less schooling, reduced earnings, and lower birth weight of their descendant (Victora *et al.,* 2008).

The strength of this analysis includes the use of longitudinal data with growth measure from birth into the age of 23 months. Moreover, this study also gives contribution for the dominant factors of stunting and survival resilience of children aged 0-23 months toward not stunting. However, there were still limitations in this study. First, the length of birth was measured by health personnel at the place of birth in which the methods of measurement may vary between children. Second, methods of the birth length measurement may be different with the measurement of body length method applied in this study.

The third limitation of this study was incomplete records each month due to absenteeism of the respondents, neither body length data nor several variables collected monthly. Thus, this may cause the unexpected results found in this analysis, such as less experience of illness, non-diverse diet, and low-educated mother as the protective factors against the incidence of stunting, although the *p*-value is above 0.05. In case of dietary diversity, it needs to consider more appropriate method of measuring dietary diversity, not just one point of measurement. In term of maternal education, the unexpected results may be due to a less variety of maternal education, especially there are fewer mothers with high education level and low education level.

Many interventions were done on pregnant woman for better pregnancy outcomes, especially to fix stunting, such as micronutrients supplementation which reduced the risk of low birth weight at term by 16% (relative risk 0.84, 0.74-0.95) (Bhutta, 2008), nutrition education and counselling, growth monitoring and promotion, immunisation, water sanitation and hygiene, and social safety nets, usually called nutrition-specific interventions (Ruel, 2013). Yet, to eliminate stunting in the longer term, the interventions should be supplemented by improvements in the underlying determinants, such as poverty and poor education (Bhutta, 2008) which likely influence maternal birth weight and adult height. A systematic review showed that successful interventions which can greatly accelerate on reducing stunting were characterised by a combination of political commitment, multi-sectorial collaboration, community engagement, community-based service delivery platform (Hossain, 2017), women's empowerment, agriculture, food systems, education, employment, social protection, and safety nets, called nutrition-sensitive interventions (Ruel, 2013).

CONCLUSION

Nutritional status at birth (weight and length of birth) as well as maternal short height, are the dominant risk factors that affect stunting among children aged 0-23 months. Thus, this finding supports the previous studies that the incidence of stunting is intergenerational. Furthermore, this study has found that resilience of children to survive toward not stunting is decreasing as the age is increasing.

RECOMMENDATIONS

The importance of having optimal health and nutritional status before and during pregnancy for a healthy pregnancy outcome, normal weight and length of birth is indisputable. This implies that the incidence of stunting is intergenerational, even at the beginning of life, so the nutrition-specific interventions supplemented by nutrition-sensitive intervention must be ensured prior to pregnancy.

Authors' contributions

Nur HU, conducted the study, design the analysis, prepared the draft of the manuscript and reviewed the manuscript; Kencana S, conducted the study, assisted in the data analysis and interpretation and reviewed the manuscript; Rika R, conducted the study, assisted in the data analysis and interpretation and reviewed the manuscript; Bunga CH, conducted the study, assisted in drafting of the manuscript and reviewed the manuscript; Anies I, conceptualized the study, reviewed the manuscript; Besral, led the data analysis and interpretations; Nurillah A, conducted the study, assisted in drafting of the manuscript.

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