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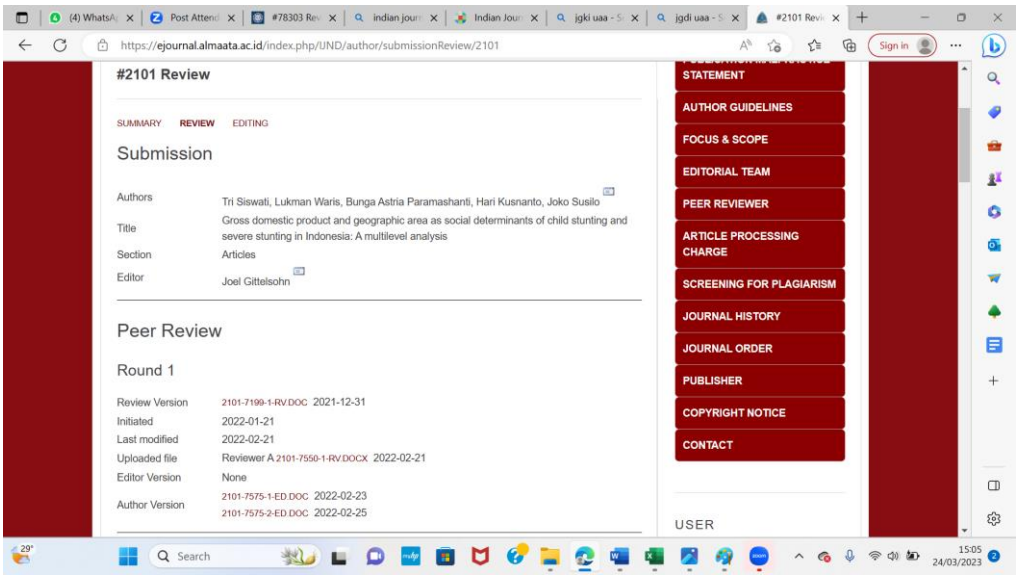

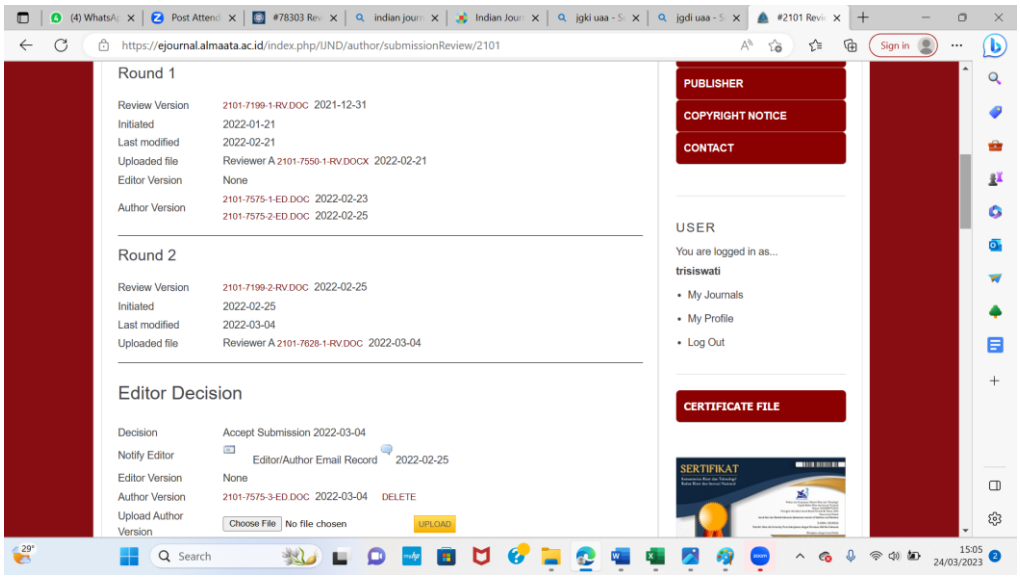

Gross Domestic Product and Geographic Area as Social Determinants of Child Stunting and Severe Stunting in Indonesia: A Multilevel Analysis

ABSTRAK

Latar Belakang: *Stunting masih menjadi masalah kesehatan masyarakat di Indonesia. Kesenjangan sosioekonomi dan geografis termasuk akar masalah stunting pada anak.*
Tujuan: *Penelitian ini bertujuan untuk menganalisis sosial determinan stunting dan severe stunting pada anak-anak di Indonesia.*
Metode: *Penelitian ini menganalisis data dari survei potong lintang Riset Kesehatan Dasar tahun 2013, BPS, dan Kementrian Keuangan. Sampel adalah 3,953 anak usia 6-23 bulan dan 10,215 anak usia 24-59 bulan. Variabel dependen adalah prevalensi stunting dan severe stunting. Variabel independen meliputi faktor-faktor di tingkat sosial dengan mengendalikan faktor-faktor pada tingkat struktural dan biologis. Data dianalisis menggunakan analisis multilevel dengan generalized linear mixed models (GLMM) untuk menguji random effects dan mixed effects pada variabel dependen terhadap stunting dan severe stunting balita.*
Hasil: *Gross Domestic Product (GDP) berkaitan dengan penurunan risiko stunting pada anak usia 6-23 bulan (ARRR= 0.99; 95%CI: 0.98-1.00) dan 24-59 bulan (ARRR= 0.99; 95%CI: 0.97-0.99), serta penurunan risiko severe stunting pada usia 6-23 bulan (ARRR= 0.99; 95%CI: 0.98-1.00) dan 24-59 bulan (ARRR= 0.99; 95%CI: 0.97-0.99). Rasio pajak hanya berkaitan signifikan dengan severe stunting pada usia 24-59 bulan. (ARRR= 0.98; 95%CI: 0.96-0.99). Terdapat pula perbedaan geografis terkait stunting dan severe stunting.*
Kesimpulan: *Pertumbuhan ekonomi yang merata merupakan faktor yang penting untuk meningkatkan kesehatan dan kesejahteraan anak-anak stunting dan severe stunting di seluruh tatanan geografis di Indonesia.*

KATA KUNCI: *Stunting; Produk Domestik Bruto; Area Geografis; Determinan Sosial; Analisis Multilevel*

Comment [u1]: Penulisan latar belakang tidak mencerminkan dari judul penelitian

Comment [BP2]: Sudah kami perbaiki dengan menyoroti masalah stunting di Indonesia dan bahwa stunting dapat dipicu oleh akar masalah sosioekonomi dan geografis.

Comment [u3]: Konsisten mau menggunakan istilah severe stunting dalam B.Inggris atau diterjemahkan dalam bahasa

Comment [BP4]: Kami konsisten menggunakan istilah baku dalam Bahasa Inggris, yaitu stunting dan severe stunting

Comment [u5]: Apa itu GDP? Jika ingin menggunakan akronim lebih baiki dituliskan kepanjangan dari singkatan tersebut terlebih dahulu.

Comment [BP6]: Sudah kami tambahkan

Comment [u7]: Apa arti dari hasil analisis ARRR?

Comment [BP8]: Adjusted relative risk ratio (ARRR) – sudah kami tambahkan di bagian Metode

ABSTRACT

Background: *Stunting remains a public health issue in Indonesia. Socioeconomic and geographical disparities are among the root causes of stunting in children.*
Objectives: *This study aimed to analyze the social determinants of stunting and severe stunting children in Indonesia.*
Methods: *We analyzed data from cross-sectional surveys of Indonesia's National Basic Health Research in 2013, the Central Bureau of Statistics, and the Ministry of Finance. Our samples were 3953 children aged 6-23 months and 10215 children aged 24-59 months. Dependent variables were the prevalence of child stunting and severe stunting. Independent variables covered factors at the social level while controlling structural and biological level-factors. Data were analyzed using a multilevel analysis using generalized linear mixed models (GLMM) for testing random effects and mixed effects of dependent variable on stunting and severe stunting children*
Results: *Gross domestic product (GDP) was associated with the reduced risk of stunting among children aged 6-23 months (ARRR= 0.99; 95%CI: 0.98-1.00) and 24-59 months (ARRR= 0.99; 95%CI: 0.97-0.99) as well as with the decreased risk of severe stunting among 6-23 months (ARRR= 0.99; 95%CI: 0.98-1.00) and 24-59 months (ARRR= 0.99; 95%CI: 0.97-0.99) old children. Tax ratio was a significant factor only for the severe stunting among 24-59 months old children (ARRR= 0.98; 95%CI: 0.96-0.99). There was also a geographical difference related to stunting and severe stunting.*
Conclusions: *Equitable economic growth is an essential factor to improve the health and welfare of stunting and severe stunting children across the geographical setting in Indonesia.*

KEYWORD*:* *Stunting; Gross Domestic Product; Geographic Area; Social Determinants; Multilevel Analysis*

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INTRODUCTION

In Indonesia, stunting has the highest incidence of chronic malnutrition comparing other forms of malnutrition. Stunting among children increased during 2010-2013 to as many as 1.6% (1) or 0.53% per year. Meanwhile, Strategic Development Goals have set a global stunting prevalence reduction of 40% by 2025 (2). Based on these targets, it is necessary to decrease stunting by 1.72% per year, so that stunting in Indonesia becomes 14% .Stunting is a social problem, and the government has a responsibility to alleviate stunting problems in collaboration with many health and welfare programs and sectors (2). Macroeconomic development is related to malnutrition. It may be the only way to alleviate malnutrition problems, especially in poor and developing regions (3, 4). Accordingly, stunting is closely related to social indicators such as education, employment, income, and environment (3-5). The disparity of stunting prevalence in Indonesia is vast and varied based on the

geographical setting. In Java-Bali, the prevalence of stunting children is the lowest while the areas in west Indonesia has the highest reported cases (1).

Stunting can impact all periods of human life, increasing the risk of infection (6, 7), impaired development (8, 9), poor school performance (10, 11), obesity in adults and metabolic syndrome (12, 13), less productivity and income (4, 7, 14), and increased economic burden (15). Social determinants of health involve the circumstances of people's lives that affect health status, especially for vulnerable groups, including young children. Thus, this study aimed to determine the social determinants for stunting and severe stunting among 6-23 and 24-59 months old Indonesian children.

MATERIALS AND METHODS

This research was cross-sectional using secondary data from Indonesia's Basic Health Research (Riskesdas) 2013 (1), Central Bureau of Statistics (16), Anti-corruption Agency (17), and Ministry of Finance (18). The total population was 82,266 children aged 0-59 months across provinces during the Riskesdas survey in 2013. The inclusion criteria of our study samples included: single birth and without chronic disease. Children with any missing data and had height-for-age Z-score below minus six and above six standard deviations (SD) were excluded from the analysis. Thus, we included a total of 14,168 children, consisting of 3,953 children aged below two years and 10,215 aged two years or above. This research was approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, Universitas Gadjah Mada, Yogyakarta, Indonesia with approval number KE/FK/0099/2017 dated January 27, 2017.

Dependent variables were stunting and severe stunting. The height-for-age Z-score (HAZ) of the children was estimated using WHO Anthro 2005. Children were categorized as stunted if they had HAZ between -3 SD and <-2 SD whereas severely stunted children had HAZ <-3 SD (19). Independent variables were social determinant variables such as gross domestic product (GDP), tax ratio, Gini ratio, corruption perception index, poverty gap index, severity gap index, gender development index, women empowerment index, human development index, and geographic area.

Potential covariates that being controlled in this study were structural and biological factors. Structural factors included parental education (low if completed junior high school or below, middle if completed senior high school and high if completed higher education), father's occupation (not working; non-formal if worked as entrepreneurs, farmers, fishermen or labours; and formal if worked as employees at government or private sectors), household economic status (low if 1^{st} and 2^{nd} quintiles, middle if 3^{rd} quintile, high if 4^{th} and 5^{th} quintiles), number of household members (>5 or $\leq$5), water access (sufficient if the source of water

was from tap water or protected spring water with good physical quality and could be accessed in less than ten meters away and less than five minutes, and adequate for 20L per person per day; otherwise, not sufficient), sanitation (good if met the criteria as follows: a drain pipe/sewage and private toilet; otherwise poor if one of the requirements was not met), cooking fuel (traditional if used charcoal, briquettes, coconut shell, or firewood; modern if used electricity, gas, or kerosene), and household iodine status (sufficient if the results of household iodine test was blue colored; otherwise, not sufficient or none).

Descriptive statistics was done to present the characteristics of the study samples. Bivariable analyses were performed by multinomial logistic regression. Adjusted relative risk ratio (ARRR) with 95% confidence interval (CI) were estimated, and those with $p<0.25$ were entered into the multivariate analysis. To obtain the most fitted model of the association between risk factors and stunting and severe stunting, we performed a multivariate multilevel analysis using generalized linear mixed models (GLMM). We also conducted a manual backward elimination to retain factors associated with stunting and severe stunting at the level of significance of $p<0.05$. The ARRR with 95% CI were presented. A likelihood ratio test was used to address the significant differences between the final model and the null model. The collinearity test was applied to analyze the correlation between variables. The analyses were done by STATA version 14.2 (StataCorp, College Station, TX, USA). This study was ethically approved by te Medical and Health Research Ethics Committee (MHREC), Faculty of Medicine, Gadjah Mada University – Dr. Sardjito General Hospital (reference number: KE/FK/0099/EC/2017).

RESULTS AND DISCUSSIONS

Stunting and severe stunting were more prevalent among 24-59 months children (37.32%) compared to 6-23 months (33.97%). Meanwhile, the mean and standard deviation (SD) of social risk factors were described as follows: GDP was 10.10±8.81 billion, Gini ratio was 0.37±0.04, perception corruption index (PCI) was 4.86±0.62, poverty gap index (PGI) was 1.92±1.02, severity gap index (SGI) was 0.49±0.36, gender development index (GDI) was 64.62±3.82, women empowerment index (WEI) 64.85± 7.01, Human development index 73.29±2.52 (HDI), tax ratio 11.9±5.78, and health expenditure 3.1±0.51.

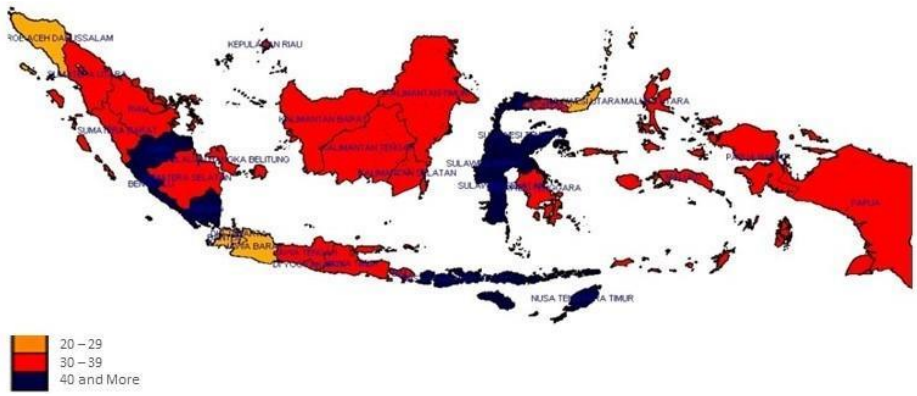

Figure 1. The severity of childhood stunting among children aged 6-23 months in Indonesia

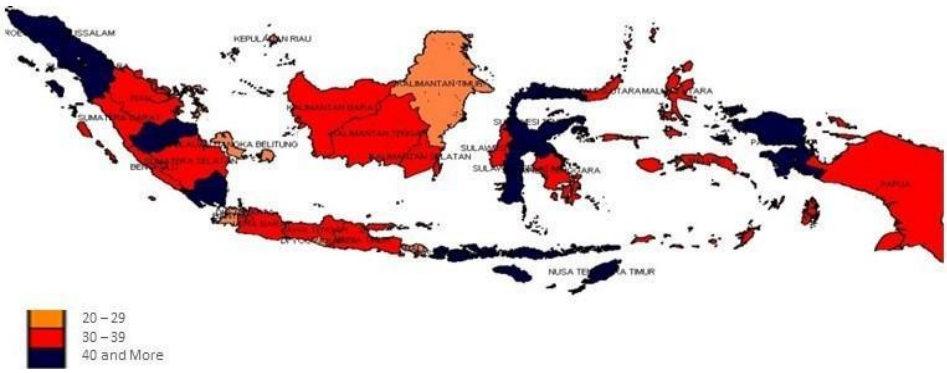

Figure 2. The severity of childhood stunting among children aged 24-59 months in Indonesia

The severity of stunting and severe stunting among children aged 6-23 months and 24-59 months in Indonesia varied across the geographic location. As seen in Figure 1 and Figure 2, the Middle part of Indonesia (Java, Bali, and Kalimantan islands) had lower stunting and severe stunting prevalence than the Western and Eastern regions.

We also presented the children's characteristics in Table 1. The majority of our samples were born with average body weight and length. The breastfeeding proportion was only around 38%. Approximately 33% of mothers and 27% of fathers of children in the two groups were short-statured. More than half of the households had the highest quintile of economic status, whereas around half of the parents had a low educational level.

Table 1. Characteristics of children aged 6-59 months

Characteristic	6-23 months (n= 3,953)		24-59 months (n= 10,215)	
	n	%	n	%

Characteristic	6-23 months (n= 3,953)		24-59 months (n= 10,215)	
	n	%	n	%
Sex				
Male	1979	50.1	5137	50.3
Female	1974	49.9	5078	49.7
Birth weight				
Low	219	5.5	430	4.2
Normal	3734	94.5	9785	96.8
Newborn length				
Short	777	19.7	1909	18.7
Normal	3176	80.3	8306	81.3
Infection				
Yes, ever	150	3.8	372	3.6
Never	3803	96.2	9843	96.4
Exclusive breastfeeding				
No	2463	62.3	-	
Yes	1490	37.7		
Vitamin A Supplementation				
No	697	17.6	1850	18.1
Yes	3256	82.4	8360	81.9
Immunization				
Incompleted	-		3620	35.4
Completed			6595	64.6
Mother's height				
Short	1321	33.4	3412	33.4
Normal	2632	66.6	6803	66.6
Father's height				
Short (≤ 160 cm)	1054	26.7	2809	27.5
Normal (>160 cm)	2899	73.3	7406	72.5
Household iodine status				
None	193	4.9	511	5.0
Insufficient	453	11.5	1125	11.0
Sufficient	3307	83.6	8579	84.0
Number of household members				
>5	660	16.7	1633	16.0
≤ 5	3293	83.3	8582	84.0
Number of children under-fives				
≥2	50	1.3	10039	1.7
<2	3903	98.7	176	98.3
Father's occupation				
Not working	95	2.4	260	2.5
Non-formal	2732	69.2	7059	69.1
Formal	1126	28.4	2896	28.4
Mother's occupation				
Not working	2523	63.8	6007	58.8
Non-formal	913	23.1	2833	27.7
Formal	517	13.1	1375	13.5
Father's education				
Low	1915	48.4	4941	48.4
Middle	1517	38.4	3910	38.3

Characteristic	6-23 months (n= 3,953)		24-59 months (n= 10,215)	
	n	%	n	%
High	521	13.2	1364	13.3
Mother's education				
Low	2031	51.4	5289	51.9
Middle	1364	34.5	3507	34.2
High	558	14.1	1419	13.9
Economic status				
Low	1021	25.9	2465	24.1
Middle	742	18.7	1981	19.4
High	2190	55.4	5769	56.5
Smoke exposure				
Yes	3102	78.5	7742	77.8
No	852	21.5	2273	22.2
Sanitation				
Poor	3583	90.6	9270	90.8
Good	370	9.4	945	9.2
Water access				
Insufficient	3829	96.9	9878	96.7
Sufficient	124	3.1	373	3.3
Cooking fuel				
Yes, traditional	1400	35.4	3437	33.7
No	2553	64.6	6778	66.3

The results of the final model are discussed in Table 2. The likelihood ratio $\chi 2$ statistics were used to ensure each outcome variable's dependence on the selected variables in the model. For instance, among children aged 6-23 months, the model $\chi 2$ statistics amounts to 95.78 and is highly significant ($p<0.001$). This indicates that the log odds of stunting are related to the independent variables. Similarly, this also applied to other outcome variables such as stunting at age 24-59 months and severe stunting at age 6-23 months and 24-59 months.

Table 2. A multilevel analysis of social, structural, and biological risk factors for stunting and severe stunting among children aged 6-23 months and 24-59 months

Variables	6-23 months		24-59 months	
	Stunting ARRR (95%CI)	Severe stunting ARRR (95%CI)	Stunting ARRR (95%CI)	Severe stunting ARRR (95%CI)
Social				
GDP	0.99(0.98-1.00)*	0.99(0.97-1.00)*	0.99(0.98-1.00)*	0.99(0.97-0.99)*
Tax				0.98(0.96-0.99)*
Region				
Java-Bali, urban	1	1	1	1
Java-Bali, rural	0.99(0.98-1.00)*	0.99(0.97-1.00)*	1.12(0.93-1.35)	1.07(0.86-1,34)
Sumatera, urban	1,32(1.00-1.73)*	1.42(1.07-1.89)*	1.16(0.91-1.46)	1.34(1.07-1.68)*

Variables	6-23 months		24-59 months	
	Stunting ARRR (95%CI)	Severe stunting ARRR (95%CI)	Stunting ARRR (95%CI)	Severe stunting ARRR (95%CI)
Sumatera, rural	0.94(0.70-1.27)	1.67(1.26-2.21)*	1.06(0.84-1.34)	1.50(1.20-1.88)*
Eastern Indonesia, urban	1.28(0.82-1.98)	1.20(0.75-1.91)	1.26(0.89-1.79)	1.10(0.77-1.59)
Eastern Indonesia, rural	1.16(0.741.18)	1.65(1.07-2.55)*	1.30(0.93-1.80)	1.60(1.16-2.21)*
Kalimantan, urban	1.05(0.70-1,58)	1.33(0.88-2.00)	0.91(0.66-1.25)	1.28(0.95-1.73)
Kalimantan, rural	1.06(0.70-1.61)	1.42(0.94-2.15)	1.14(0.82-1.57)	1.16(0.84-1.60)
Sulawesi, urban	1.18(0.77-1.82)	1.13(0.71-1.79)	1.30(0.93-1.81)	1.01(0.71-1.45)
Sulawesi, rural	1.28(0.85-1.92)	1.54(1.03-2.32)*	1.18(0.86-1.63)	1.09(0.79-1.52)
Structural				
Mother's education				
Low	1.40 (1.04-1.87)*	1.34(1.01-1.81)*	1.40(1.17-1.68)*	-
Middle	1.04(0.78-1.40)	1.15(0.86-1.54)	1.18(1.00-1.41)*	
High	1	1	1	
Economic status				
Low	1.28(1.01-1.62)*	1.18(1.01-1.50)*	1.52(1.32-1.74)*	1.59(1.37-1.85)*
Middle	1.00(0.78-1.27)	1.11(0.88-1.41)	1.21(1.05-1.39)*	1.41(1.21-1.63)*
High			1	1
Number of household members				
>5				1.2(1.04-1.40)*
≤5				1
Father's occupation				
Not working			0.70(0.49-1.01)	0.98(0.67-1.42)
Yes, non-formal			1.18(1.04-1.35)*	1.35(1.16-1.57)*
Yes, formal			1	1
Mother's occupation				
Not working				1.39(1.13-1.70)*
Yes, non-formal				1.38(1.11-1.72)*
Yes, formal				1
Water access				
Insufficient			1.46(1.07-1.98)*	-
Sufficient			1	
Biological				
Sex				
Male	1.27 (1.07-1.51)*	1.23(1.03-1.46)*		
Female	1	1		
Birth weight				
Low	2.15(1.53-3.04)*	1.90(1.33-2.70)*		
Normal	1	1		
Birth length	-			
Short		1.28(1.03-1.59)*	1.28(1.13-1.45)*	1.23(1.07-1.41)*

Variables	6-23 months		24-59 months	
	Stunting ARRR (95%CI)	Severe stunting ARRR (95%CI)	Stunting ARRR (95%CI)	Severe stunting ARRR (95%CI)
Normal		1	1	1
Mother's height				
Short	1.67(1.40-2.00)*	1.30(1.08-1.56)*	1.63(1.47-1.80)*	1.43(1.27-1.60)*
Normal	1	1	1	1
Father's height				
Short	1.27(1.05-1.54)*	1.36(1.12-1.64)*	1.32(1,18-1.47)*	1.41(1.25-1.60)*
Normal	1	1	1	1
Constant (OR, MOR)	0.097(0.063-0.149)	0.117(0.82-0.17)	0.099(0.067-0.147)	0.117(0.082-0.168)
Standard error	0,021	0.021	0.0137	0.009
Provincial variable (OR)	8.12e-30 – 5.53e-16	6.56e-35 – 5.34e-19	0.027(0.009-0.733)	0.011(0.0019-0.063)
Log likelihood	-1606.058	-1624.863	-4657.678	-3884.064
Model $\chi 2$ statistics for LR test	95.78 (p<0.001)	92.45 (p<0.001)	334.00 (p<0.001)	307.14 (p<0.001)

OR: odds ratio; AOR: adjusted odds ratio; MOR: median odds ratio
CI: confidence interval

Several factors were identified to be significantly associated with stunting and severe stunting. Gross domestic product was associated with the reduced risk of stunting among children aged 6-23 months (ARRR= 0.99; 95%CI: 0.98-1.00) and 24-59 months (ARRR= 0.99; 95%CI: 0.97-0.99) as well as with the decreased risk of severe stunting among 6-23 months (ARRR= 0.99; 95%CI: 0.98-1.00) and 24-59 months (ARRR= 0.99; 95%CI: 0.97-0.99) old children. Tax ratio was a significant factor only for the severe stunting among 24-59 months old children (ARRR= 0.98; 95%CI: 0.96-0.99). There was also a geographical difference related to stunting and severe stunting.

Our results showed that increasing 1 billion IDR in the GDP can reduce 1% of stunting and severe stunting. A macro-economic approach was the prior choice to overcome stunting in development countries, as seen in Brazil (20), 36 poor countries (21), Bangladesh and Nepal (22), Senegal (23), and Indonesia using the 2010 Basic Health Research survey data from 2010 (24). GDP can reduce the prevalence of malnutrition by improving the micro economy (25, 26), increasing capability to pay on goods related to nutritional and health status (21), improving access to health providers, food consumption, environment, housing, and education facilities (23).

Increasing of 1% tax ratio can reduce the prevalence of severe stunting of 24-59 months old children by 2%. Indonesia's tax ratio achievement was below 20% of the target (27). Tax changes involve a fiscal policy to achieve optimal economic growth, improving public health status and facilities such as schools, hospitals, roads, markets, hospitals), reducing income gaps, improving the welfare of the population, sources of government expenditure, while addressing disparities in health in rural and remotes areas (28). Tax

reform includes budgeting, regulation, distribution, and stabilization functions (29), while the implication is for improving health-related impact, health promotion while increasing prevention and curatives (30), and food price subsidies (31).

The geographical setting was an important issue contributing to Indonesia's stunting disparities, consisting of islands, land, water, mountains, urban, rural, and remote areas. Geographical factors affect the environment, social, material resources such as communication systems, transportation, public facilities, including education, health, and recreation (24, 32-34). Children living in Sumatra, Kalimantan, Eastern Indonesia, and rural areas generally have a higher risk of stunting/severe stunting. Rural areas were also a risk factor for stunting, which is consistent with previous studies in Cambodia (35), Nigeria (36), and Ghana (37).

The analysis of structural risk factors showed that parents' education, occupation, water access, and the number of family members influenced stunting and severe stunting (Table 2). Education was a fundamental factor (37) since education affects health through three ways: a) opportunities to gain good health knowledge, problem-solving skills and adapt to problems encountered, b) opportunities for better employment and income, and c) opportunities for an environment with good social support and social status (32). Socio-economic disadvantages influence the genetic and biological system by long-term effects and neurobiological pathway complexity (32). Studies demonstrated the consistency of the mother's education with stunting children (38, 39). Mothers play an important role in giving parenting and maintaining children's health by providing sufficient food intake, caring, and stimulating growth and development. Unfortunately, low to middle-educated adolescent girls tend to get married young and become pregnant, which is a strong predictor for small birth size (40), due to nutrition competition during pregnancy and growth (41). Additionally, the occupation was closely related to income, social status (23, 32), and children's malnutrition (36, 42, 43). Other issues include an increased number of family members, which causes difficulties in distributing the mother's attention and feeding practice to children (44). The results also showed that clean water access was another risk factor for severe stunting children, while this was necessary to prevent infectious disease and lower stunting prevalence (45, 46).

The biology risk factors for stunting and severe stunting showed that low birth weight, length of birth, and parental stature were associated consistently, as seen in Senegal (47) and Nigeria (36), and the results of a previous study in Indonesia (24, 48, 49). Parental stature was found to be an intergeneration malnutrition problem (50, 51). However, environmental factors can manipulate stunting children, including caring, parenting, breastfeeding, adequate nutrition, housing, clean water, sanitation, and economic improvement (4, 50). Interventions for both specific and sensitive programs in the 'first

thousand days' of early life proved to be an effective treatment (52) and was found to provide almost 50% more benefit (53). Results of this study further reinforce the findings that the success of the alleviation efforts for the widespread stunting problem largely depends on the government's political commitment (46), health and welfare program involvement, and community support (54).

This is the first study in Indonesia that examined the social determinants of stunting and severe stunting nationally. Our analysis involved representative data at the national level in Indonesia, which allowed us to determine the relationship across different predictors' levels. Additionally, this study's multilevel mixed modeling enabled us to include the importance of social, structural, and biological variables in our analysis. Nevertheless, our conclusion was restricted by the cross-sectional survey's nature, which did not allow us to draw any causal-effect association. The data was also limited by the unavailability of nutrient intake and parenting data.

CONCLUSIONS AND RECOMMENDATIONS

Gross domestic product and geographical settings were the main risk factors for stunting and severe stunting children 6-23 months and 24-59 months old after controlling the structural and biological risk factors, while tax ratio was the main risk factor for severe stunting children 24-59 months. Improvement is especially needed in the equity of the GDP and tax ratio across the geographical area for the current stunting intervention programs' success.

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