Original Article

Risk factors associated with childhood stunting in Indonesia: A systematic review and meta-analysis

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Background and Objectives: In Indonesia, stunting is one of the most public health concerns. This study aims to systematically review and meta-analyze childhood stunting risk factors in the country. **Methods and Study Design:** We did a systematic review and meta-analysis of observational (cross-sectional and longitudinal) studies on stunting risk factors published between 2010 and 2021 based on available publications in online databases of PubMed, ProQuest, EBSCO, and google scholar. The quality of the publications was evaluated using the Newcastle-Ottawa Quality Assessment Scale and organized according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis. Publication bias was examined using Egger's and Begg's tests. **Results:** A total of 17 studies from the literature search satisfied the inclusion criteria, with 642,596 subjects. The pooled stunting prevalence was 30.9% (95% CI 25.0%-36.8%). Children born with low birth weight (POR 2.39, 2.07–2.76), female (POR 1.05, 1.03-1.08), and did not get the deworming program (1.10, 1.07-1.12) are the primary child characteristics that contributed to stunting. Meanwhile, maternal age ≥ 30 years (POR 2.33, 2.23-2.44), preterm birth (POR 2.12, 2.15-2.19), and antenatal care < 4 times (POR 1.25, 1.11-1.41) were among mother characteristics consistently associated with stunting. The primary household and community risk factors for stunting were food insecurity (POR 2.00, 1.37-2.92), unimproved drinking water (POR 1.42, 1.26-1.60), rural residence (POR 1.31, 1.20-1.42), and unimproved sanitation (POR 1.27, 1.12-1.44). **Conclusions:** A diverse range of risk factors associated with childhood stunting in Indonesia demonstrates the need to emphasize nutrition programs by scaling up to more on these determinants.

Key Words: stunting risk factors, systematic review, meta-analysis, Indonesia

INTRODUCTION

Stunting, physically characterized by low height or length for age, is a form of chronic malnutrition among under-five-age children.[1,2] Childhood stunting results in devastating short- and long-term health, developmental and economic consequences.[3,4] Children affected by stunting have higher morbidity and mortality risk, lower cognitive and language development, and increased health expenditure due to the cost of care. The long-term health impact of stunting can be seen in maternal and paternal low stature, poor reproductive health, suboptimal body composition, and a higher risk of non-communicable chronic disease in adults. In the meantime, lower developmental and economic capacity is reflected in poorer school performance, learning ability, and unachieved potential work capacity and productivity.[1,4] Thus, due to the magnitude of stunting consequences, it is identified as a significant global health priority and the focus of international attention for global reduction targets.[1]

The World Health Organization (WHO) estimated that about 22 %, or equivalent to 149.2 million children under the age of 5, remained stunted in 2020. African and Asian countries are the highest contributors to the stunting rates;

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Manuscript received 27 October 2022. Initial review completed 29 January 2023. Revision accepted 12 April 2023.
doi: 10.6133/apjcn.202306_32(2).0001

about half of all stunted children live in Asia, and over one-third in Africa.[5] The magnitude of the problem is quite similar in Indonesia. Although the stunting prevalence has declined from 30.8 to 24.4 % during the period 2018-2021,[6,7] the country still has more work to achieve the national developmental goals, with the prevalence of stunting expected to reach 14 percent in 2024.[8] Furthermore, there is significant variation in childhood stunting rates within the country's provinces ranging from 10.9 to 37.8 percent, and much more considerable disparity was also found within the districts where the prevalence of stunting ranged from 5.1 to 48.3 percent.[7]

Stunting results from a complex array of causal and contextual factors. The WHO Conceptual Framework on Childhood Stunting explains the complex interaction of household, environmental, socioeconomic, and cultural influences on childhood stunting. Thus, solutions will require multifaceted and transdisciplinary approaches.[9] To achieve the global stunting target, countries are expected to set their targets based on nutrition profiles, risk factor trends, demographic changes, experience with developing and implementing nutrition policies, and degree of health system development.[1]

As part of efforts in the fight against stunting, Indonesia has implemented several targeted programs in accordance with Presidential Regulation No. 72 of 2021, which aims to accelerate stunting reduction. These programs are focused on proximate factors that are strongly linked to stunting at different stages of life, including adolescents, pregnant women, newborns, toddlers, and lactating mothers. Moreover, an inter-sectoral initiative, which adopts a sensitive approach to improving distal determinants such as education, food systems, healthcare, socio-economic factors, and water and sanitation infrastructure and services, is also currently underway.[8]

Along with the increasing attention to stunting in the last few decades, various studies and surveys have been conducted to look at the profile of nutritional status and risk factors of childhood stunting in Indonesia. These studies were conducted in different populations and variable settings, and therefore often contradictory results are found. To be used as a basis for planning and improving intervention programs, the results of existing studies need to be compiled to draw a broad conclusion. A review is required to explore stunting pooled prevalence and risk factors in Indonesia as the key measures in focusing on stunting prevention and acceleration program.

METHODS

Study design and research sample

A meta-analysis reviewed current studies on determinants for stunting among children under five years in Indonesia. This study follows the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines.

Eligibility criteria

Only original publications with observational (cross-sectional and longitudinal) study design, English language, and human participants as study subjects were included. The study's exclusion criteria were the unavailability of a full-text version, inappropriate topics, and data from articles that could not be used for further examination.

Search approach and study collection

A search of PubMed, ProQuest, and EBSCO for related publications published (January 2010 until December 2021) with three main keywords “children OR Child OR under-five” AND “risk factor OR determinants” AND “stunting OR growth disorder AND Indonesia. In this study, stunting among children under five years was the dependent variable. The independent variables were the determinant factors. Two independent investigators conducted the literature search. The duplicates were manually eliminated after the initial examination, and the title/abstracts were screened for relevance. The full texts of potential articles were then assessed using the criteria.

Data extraction

Two different authors used structured extraction forms to obtain data. Extracted data included names of the authors, year of study, study setting, children’s age, sample size, study design, and risk factors associated with childhood stunting. The authors reviewed all included publications; however, to prevent data duplication, we selected one main primary source as the main cited reference from which the data were retrieved for this review. Searching for research articles was depicted using PRISMA flowcharts (Figure 1).

The quality of the publications was evaluated using the Newcastle-Ottawa Quality Assessment Scale (NOS). Articles were categorized into low, medium, and high-quality groups using the numbers 0–3, 4–6, and 7–9.

Data analysis

The pooled stunting prevalence and the Pooled Odds Ratio (POR) from the acquired data were calculated with a 95% confidence interval. I-square (I^2) would indicate heterogeneity between publications if it was greater than 50%. We conducted a random-effects with Restricted maximum likelihood (REML) analysis to estimate the pooled stunting prevalence and POR of factors for stunting. Furthermore, the results were summarized as forest plots, and Egger's and Begg's tests were used to examine study bias. There was no publication bias among the studies, according to the $p > 0.05$ findings of the two tests. STATA 14.2 was used to process and analyze all of the data.

RESULTS

Figure 1 shows that from the identification, screening, and assessment process based on inclusion and exclusion criteria, 17 out of 380 articles identified during the search were included for final analysis. The systematic review of the 17 studies is presented in Table 1.

Table 1 shows that 642,596 participants participated in the studies and the NOS score was 7.89±0.32. This study revealed that risk factors for stunting among children aged under five years in Indonesia were child characteristics (sex, age, low birth weight, acute diarrhoea, and deworming medication), maternal characteristics (age, low level of education, short stature, higher parity, preterm birth, and antenatal care), household and community fac-

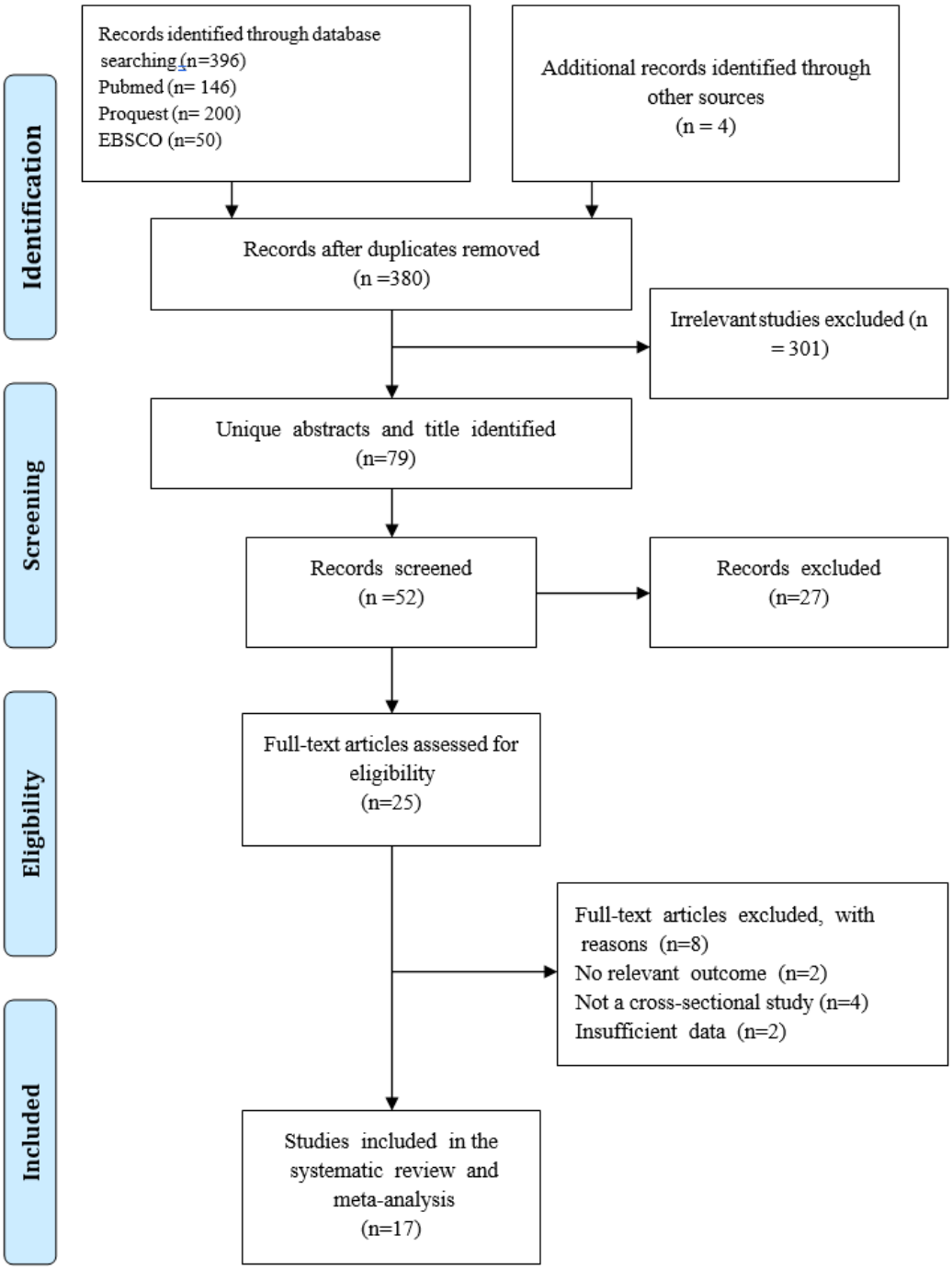

Figure 1. PRISMA flowcharts

tors (low income, > 4 individuals eating meals from the same kitchen, unimproved sanitation, untreated water treatment, severely food insecure and, and rural residence).

Figure 2 shows the pooled stunting prevalence among children under five years in Indonesia (95% CI) was 30.9% (25.0%-36.8%).

Meta-estimate the determinant for stunting among children under five years in Indonesia is depicted in Table 2. It reveals child characteristics that significantly associated with stunting are children aged ≥ 24 months with the highest POR (95% CI) (3.33, 3.16-3.52), followed by low birth weight (2.39, 2.07–2.76), acute diarrhoea in past seven days or past four weeks (1.23, 1.18-1.29), male (1.05, 1.03-1.07), and child received deworming medication in past 6 months (1.10, 1.07-1.12) with stunting among children aged under five years in Indonesia. The heterogeneity analysis revealed homogenous child characteristics in females, low birth weight, and child received deworming medication in the past six months ($I^2 \leq$ 50%). Based on maternal characteristics, it is showed the mother's height and short stature have the highest POR (2.61, 2.53-2.68), followed by maternal age (≥ 30 years) (2.33, 2.23-2.44), preterm birth (2.12, 2.05-2.19), higher parity (1.30, 1.26-1.35), low level of maternal education (1.28, 1.23-1.33), and antenatal care (<4 times) (1.25, 1.11-1.41). The heterogeneity analysis revealed homogeneity of maternal characteristics in maternal age, preterm birth, and antenatal care ($I^2 \leq 50\%$).

Table 1. A systematic review of stunting determinants for stunting among children aged under five years in Indonesia

Author	Year	Study setting	Children's age	Sample size	Study design	Risk factors (OR, 95% CI)	NOS
Semba et al. (a)[10]	2011	Rural population from the provinces of Lampung, Banten, West Java, Central Java, East Java, the island of Lombok (West Nusa Tenggara), and South Sulawesi	Children aged 6 to 59 months	222,250	A survey from the nutritional surveillance system (NSS)	Male (1.03, 1.01-1.05), low level of maternal education (1.57, 1.46-1.68), the child received deworming medication in the past 6 mo (1.09, 1.06-1.12), diarrhea in the past 7 days (1.30, 1.22-1.37), > 4 individuals eating meals from the same kitchen (1.09, 1.06-1.12)	8
Semba et al. (b)[10]	2011	Five major urban poor populations from slum areas in the cities of Jakarta, Surabaya, Makassar, Semarang, and Padang	Children aged 6 to 59 months	79,940	A survey from the nutritional surveillance system (NSS)	Low level of maternal education (1.62, 1.47-1.78), the child received deworming medication in the past 6 mo (1.12, 1.07-1.17), diarrhea in the past 7 days (1.09, 1.01-1.18), HH member > 4 individuals (1.14, 1.09-1.19)	8
Oddo et al.[11]	2012	Rural areas from Lampung, Banten, West Java, Central Java, East Java, Lombok, South Sulawesi, and West Sumatra.	Children under five years	247,126	The NSS of Indonesia	Maternal age (≥ 30 years) (2.22, 2.02-2.44), low level of maternal education (1.07, 1.02-1.13), maternal height (<145 cm) (2.32, 2.25-2.40), female (1.05, 1.02-1.07), Children aged ≥ 24 months (3.46, 3.26-3.65), higher parity (1.20, 1.15-1.24), > 4 individuals eating meals from the same kitchen (1.18, 1.13-1.23), low income (1.11, 1.07-1.16)	8
Rachmi et al.[12]	2016	Five main islands in Indonesia (Sumatra, Java, Kalimantan, and Sulawesi)	Children aged 2-4.9 years	4,101	The Indonesian Family Life Survey (IFLS)	Mother's height, short stature (2.21, 1.76-2.78), rural housing area (1.55, 1.22-1.97)	8
Torlesse et al.[13]	2016	Sikka in East Nusa Tenggara Province, in Papua Province, and Klaten in Central Java	Children aged 0-23 months	1,366	Survey Maternal and Young Child Nutrition Security Initiative (MYCNSIA)	Male (1.45, 1.11-1.90), age of the child (12-23 months) (4.40, 2.97-6.5 low-level income (2.30, 1.43-3.68), unimproved sanitation (1.27, 0.99-1.63), untreated water treatment (1.59, 1.08-2.34), ANC (< 4 times) (1.70, 1.12-2.60)	8
Mahmudiono et al.[14]	2017	Coastal and mountainous regions in East Java Province, Indonesia	Children under five years	736	Cross-sectional	Severely food insecure (1.83, 1.07-3.15)	8
Mahmudiono et al.[15]	2018	Surabaya City area	Children under five years	700	Cross-sectional	Female (1.69, 1.08-2.67), severely food insecure (2.18, 1.28-3.72)	8
Rah et al.[16]	2018	Jayawijaya District in Papua Province, Klaten District in Central Java Province, and Sikka District in Nusa Tenggara Timur (NTT) Province.	Children under 3 years	1,450	Survey Maternal and Young Child Nutrition Security Initiative (MYCNSIA)	Poorer wealth index (1.26, 0.93-1.71), child's age (6-23 months) (2.04, 1.38-3.00)	8

Table 1. A systematic review of stunting determinants for stunting among children aged under five years in Indonesia (cont.)

Author	Year	Study setting	Children's age	Sample size	Study design	Risk factors (OR, 95% CI)	NOS
Sofiatin et al.[17]	2019	Tanjungsari, West Java Province	Children under five years	4,698	Longitudinal study	Child age (24 months) (2.28, 1.90-2.72), low birth weight (1.85, 1.36-2.53), unimproved source of drinking water (1.29, 1.08-1.54),	8
Titaley et al.[18]	2019	33 provinces and 497 districts/cities in Indonesia	Children aged 0-2 years	24,657	Cross-sectional survey	Rural place of residence (1.32, 1.18-1.47), > 4 individuals eating meals from the same kitchen (1.11, 1.03-1.20), poorest household wealth index (1.74, 1.51-2.01), number of ANC visits < 4 times (1.22, 1.08-1.39), male (1.33, 1.22-1.45), child aged 12-23 months (1.89, 1.54-2.32), low birth weight (2.55, 2.05-3.15)	8
Febriana et al.[19]	2019	East Jakarta	Children aged 6-23 months	143	Cross-sectional study	Low birth weight (2.71, 0.88-8.44)	7
Flynn et al.[20]	2020	Musi sub-district, East Nusa Tenggara Province	Children under five years	218	Cross-sectional study	Low birth weight (2.95, 1.03-8.48), no formal education (10.0, 1.09-91.44), maternal height < 150 cm (2.76, 0.99-7.66),	7
Ciptanurani et al.[21]	2021	33 provinces in Indonesia	Children aged 2-5 years	45,050	Cross-sectional	Poor socio-economic status (1.33, 1.05-1.68)	8
Djuardi et al. [22]	2021	Nangapanda subdistrict, Ende, East Nusa Tenggara	Children aged 12-59 months	393	Cross-sectional	Female (0.87, 0.52-1.44)	8
Hadi et al.[23]	2021	Timor Tengah Selatan district of Nusa Tenggara Timur province, Indonesia	Children aged 6-24 months	408	Cross-sectional	Poor monthly household expenditure (2.28, 1.12-4.64), low level of maternal education (1.96, 1.08-3.55)	8
Mulyaningsih et al.[24]	2021	More than 20 provinces	Children under five years	8,045	Indonesian Family and Life Surveys (IFLS)	Male (1.17, 1.04-1.32), low birth weight (2.29, 1.73-3.01), acute diarrhea (3 times/day in the past 4 weeks) (1.27, 1.08-1.49), mother short (<145 cm) (1.19, 1.05-1.34), no access sanitation (1.27, 1.10-1.46), no access water (1.52, 1.28-1.80), rural (1.19, 1.02-1.40)	8
Sari et al.[25]	2021	514 districts/cities and 34 provinces in Indonesia	Children under five years	756	Cross-sectional study	Higher parity (1.70, 1.59-1.82), gestational age (<37 weeks) (2.12, 2.05-2.19), mother's height < 145.0 cm and father's height <161.9 cm (5.93, 5.53-6.36), parent's age < 20 or > 35 years (2.37, 2.25-2.50)	8
Sartika et al.26	2021	Sambas District, West Kalimantan Province	Children aged 0-11 months	559	Cross-sectional study	Low birth weight (5.01, 2.49-10.06), preterm birth (2.13, 1.05-4.33), diarrhea in the last 2 weeks (2.96, 1.69-5.19), maternal stature (2.41, 1.45-4.00), lower income per capita (1.68, 1.07-2.64)	8
Total samples				642,596			
NOS score							7.89±0.32

Table 2. Meta-estimate of determinant factors for stunting among children aged under five years in Indonesia

Determinant factors First author	OR (95% CI)	POR (95% CI)	Weight (%)	Heterogeneity I^2 (%)	 p
Child characteristics					
Male		1.05 (1.03-1.07)		92.7	<0.001
Semba et al(a)[10]	1.03 (1.01-1.05)		32.7		
Torlesse et al[13]	1.45 (1.11-1.90)		11.9		
Mulyaningsih et al[24]	1.17 (1.04-1.32		26.9		
Titaley et al[18]	1.33 (1.22-1.45)		28.6		
Female		1.05 (1.03-1.08)		58.2	0.092
Oddo et al[11]	1.05 (1.02-1.07)		44.6		
Mahmudiono et al[15]	1.69 (1.08-2.67)		20.1		
Djuardi et al[22]	0.87 (0.52-1.44)		35.3		
Children aged < 24 months		2.22 (1.88-2.62)		85.9	0.001
Torlesse et al[13]	4.40 (2.97-6.53)		23.7		
Rah et al[16]	2.04 (1.38-3.00)		36.1		
Titaley et al[18]	1.89 (1.54-2.32)		40.3		
Children aged ≥ 24 months		3.33 (3.16-3.52)		94.7	<0.001
Oddo et al[11]	3.46 (3.26-3.65)		51.2		
Sofiatin et al[17]	2.28 (1.90-2.72)		48.8		
Low birth weight		2.39 (2.07-2.76)		34.0	0.181
Sofiatin et al[17]	1.85 (1.36-2.53)		32.5		
Titaley et al[18]	2.55 (2.05-3.15)		35.3		
Febriana et al[19]	2.71 (0.88-8.44)		1.2		
Flynn et al. [20]	2.95 (1.03-8.48)		1.2		
Mulyaningsih et al[24]	2.29 (1.73-3.01)		28.7		
Sartika et al[26]	5.01 (2.49-10.06)		1.2		
Acute diarrhea		1.23 (1.18-1.29)		86.6	<0.001
Mulyaningsih et al[24]	1.27 (1.08-1.49)		23.3		
Semba et al(a)[10]	1.30 (1.22-1.37)		38.6		
Semba et al(b)[10]	1.09 (1.01-1.18)		27.5		
Sartika et al[26]	2.96 (1.69-5.19)		10.7		
The child has had unreceived deworming medication in the past 6 months		1.10 (1.07-1.12)		2.8	0.311
Semba et al(a)[10]	1.09 (1.06-1.12)		53.1		
Semba et al(b)[10]	1.12 (1.07-1.17)		46.9		
Maternal characteristics					
Maternal age (≥ 30 years)		2.33 (2.23-2.44)		28.8	0.236
Oddo et al[11]	2.22 (2.02-2.44)		43.5		
Sari et al[25]	2.37 (2.25-2.50)		56.5		

CI: confidence interval; OR: odds ratio; POR: Pooled odds ratio

Table 2. Meta-estimate of determinant factors for stunting among children aged under five years in Indonesia (cont.)

Determinant factors First author	OR (95% CI)	POR (95% CI)	Weight (%)	Heterogeneity	
				I^2 (%)	p
Low level of maternal education		1.28 (1.23-1.33)		96.3	<0.001
Semba et al(a)[10]	1.57 (1.46-1.68)		31.4		
Semba et al(b)[10]	1.62 (1.47-1.78)		30.4		
Oddo et al[11]	1.07 (1.02-1.13)		22.3		
Flynn et al. [20]	10.0 (1.09-91.44)		10.0		
Hadi et al[36]	1.96 (1.08-3.55)		5.9		
Mother's height/short stature		2.61 (2.53-2.68)		99.3	<0.001
Oddo et al[11]	2.32 (2.25-2.40)		18.8		
Rachmi et al[12]	2.21 (1.76-2.78)		18.3		
Flynn et al. [20]	2.76 (0.99-7.66)		9.4		
Mulyaningsih et al[24]	1.19 (1.05-1.34)		18.7		
Sari et al[25]	5.93 (5.53-6.36)		18.5		
Sartika et al[26]	2.41 (1.45-4.00)		16.4		
Higher parity		1.30 (1.26-1.35)		98.7	<0.001
Oddo et al[37]	1.20 (1.15-1.24)		50.6		
Sari et al[25]	1.70 (1.59-1.82)		49.4		
Preterm birth		2.12 (2.05-2.19)		0	0.990
Sari et al[25]	2.12 (2.05-2.19)		59.8		
Sartika et al[26]	2.13 (1.05-4.33)		40.2		
Antenatal care (< 4 times)		1.25 (1.11-1.41)		44.3	0.139
Torlesse et al[13]	1.70 (1.12-2.60)		20.4		
Titaley et al[18]	1.22 (1.08-1.39)		79.6		
Household/ community factors					
Low income		1.16 (1.12-1.21)		89.7	<0.001
Oddo et al[11]	1.11 (1.07-1.16)		26.2		
Torlesse et al[13]	2.30 (1.43-3.68)		4.9		
Rah et al[38]	1.26 (0.93-1.71)		17.2		
Titaley et al[18]	1.74 (1.51-2.01)		21.6		
Ciptanurani et al[21]	1.33 (1.05-1.68)		19.6		
Hadi et al[36]	2.28 (1.12-4.64)		2.2		
Sartika et al[26]	1.68 (1.07-2.64)		8.3		
HH member > 4 individuals		1.12 (1.10-1.14)		70.7	0.017
Semba et al(a) [10]	1.09 (1.06-1.12)		33.0		
Semba et al (b) [10]	1.14 (1.09-1.19)		25.7		
Oddo et al[11]	1.18 (1.13-1.23)		25.7		
Titaley et al[18]	1.11 (1.03-1.20)		15.5		
Unimproved sanitation		1.27 (1.12-1.44)		0	1.000
Torlesse et al[13]	1.27 (0.99-1.63)		24.0		
Mulyaningsih et al[24]	1.27 (1.10-1.46)		75.9		

CI: confidence interval; OR: odds ratio; POR: Pooled odds ratio

Table 2. Meta-estimate of determinant factors for stunting among children aged under five years in Indonesia (cont.)

Determinant factors First author	OR (95% CI)	POR (95% CI)	Weight (%)	Heterogeneity	
				I^2 (%)	p
Untreated water treatment		1.42 (1.26-1.60)		3.2	0.356
Torlesse et al[13]	1.59 (1.08-2.34)		9.3		
Sofiatin et al[17]	1.29 (1.08-1.54)		49.2		
Mulyaningsih[24]	1.52 (1.28-1.80)		41.5		
Severely food insecure		2.00 (1.37-2.92)		0	0.651
Mahmudiono et al[14]	1.83 (1.07-3.15)		57.9		
Mahmudiono et al[15]	2.18 (1.28-3.72)		42.1		
Rural residence		1.31 (1.20-1.42)		39.8	0.190
Rachmi et al[12]	1.55 (1.22-1.97)		10.4		
Titaley et al[18]	1.32 (1.18-1.47)		54.1		
Mulyaningsih et al[24]	1.19 (1.02-1.40)		35.4		

CI: confidence interval; OR: odds ratio; POR: Pooled odds ratio

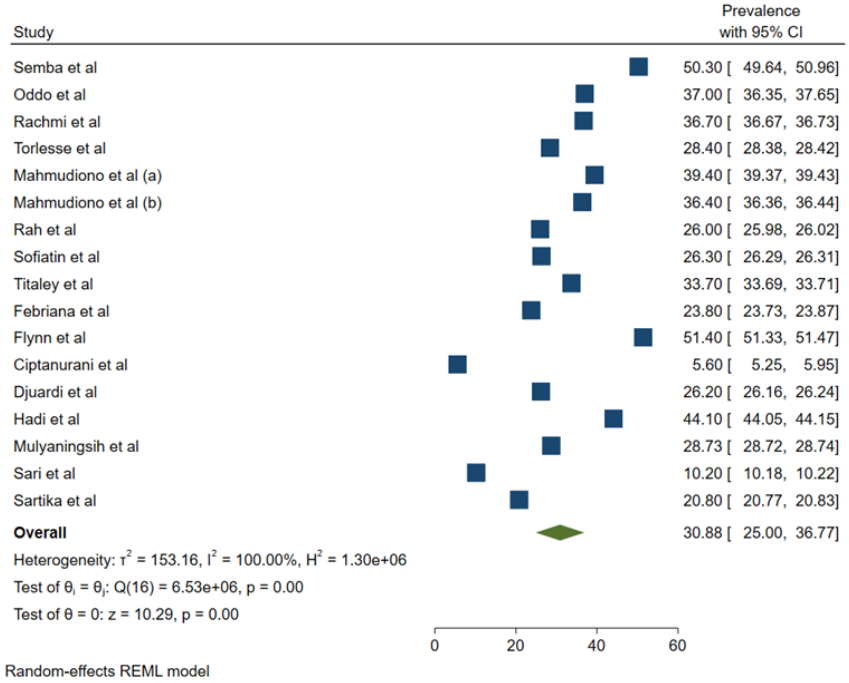

Figure 2. The pooled prevalence of stunting among children aged under five years in Indonesia

Based on household factors, it is found that mother's severely food insecure has the highest POR (2.00, 1.37-2.92), followed by untreated water treatment (1.42, 1.26-1.60), unimproved sanitation (1.27, 1.12-1.44), low income (1.16, 1.12-1.21), Household member > 4 individuals (1.12, 1.10-1.14), rural residence (1.31, 1.20-1.42). The heterogeneity analysis revealed homogenous household factors in unimproved sanitation, untreated water treatment, and severe food insecurity ($I^2 \leq 50\%$).

Egger's and Begg's test results are included to assess bias among studies (Table 3). It revealed that associated factors of child characteristics (male, female, children aged < 24 months, children aged ≥ 24 months, low birth weight, acute diarrhea, and child received deworming medication), maternal characteristics (maternal age, low-level education, short stature, higher parity, preterm birth, and antenatal care), household factors (low income, > 4 individuals eating meals from the same kitchen, unimproved sanitation, untreated water treatment, and severely food insecure, rural residence) had no study bias among publications included (p>0.05)

Table 4 showed no differences in the determinant factors of stunting among children under five years based on ethnic groups in Indonesia (p>0,05, $I^2 \leq 50\%$).

DISCUSSION

This study found that the pooled stunting prevalence from 17 studies published between 2010 and 2021 was 30.9(25.0, 36.8) per cent. The prevalence is comparable with the national stunting prevalence in 2013 and 2018 (37.2 % and 30.8%, respectively),[6,27] but much higher than the latest stunting prevalence in 2021 (24.4%).[7] This is understandable, given that most of the studies analyzed were conducted before 2021.

Of the 17 studies analyzed, seven looked at the relationship between the characteristics of children in terms of age and stunting. The findings were different, in which four studies stated that boys were more at risk of stunting than girls, while three other studies found the opposite result, where girls had a higher risk of stunting. However, from the heterogeneity test, it is known that there is a fairly high variation in the results of studies that examine the relationship between a child's gender and the occurrence of stunting (I^2 >50%). Therefore, it is difficult to draw a conclusion as to whether girls or boys are more at risk of experiencing stunting. In 5 studies that examined age as a risk factor for stunting, similar findings were observed. Specifically, three of the studies revealed that children under 24 months of age were at a higher risk of stunting, with a POR of 2.22 (1.88-2.62), while the other two studies indicated that children above 24 months of

Table 3. The results of Egger's and Begg's test to assess bias among studies included

Related factors	Study bias	
	Egger's test	Begg's test
Child characteristics		
Male	0.133	0.863
Female	0.718	0.417
Children aged < 24 months	0.504	0.892
Children aged ≥ 24 months	0.100	0.211
Low birth weight	0.434	0.160
Acute diarrhea	0.559	0.412
The child received deworming medication	0.900	0.990
Maternal characteristics		
Maternal age (≥ 30 years)	0.110	0.115
Low level of maternal education	0.419	0.499
Maternal short stature	0.945	0.260
Higher parity	0.100	0.210
Preterm birth	0.130	0.751
Antenatal care (< 4 times)	0.204	0.056
Household/Community factors		
Low income	0.080	0.370
HH member > 4 individuals	0.531	0.375
Unimproved sanitation	0.520	0.239
Untreated water treatment	0.761	0.514
Severely food insecure	0.261	0.275
Rural residence	0.720	0.627

p>0.05, no publication bias.

Table 4. Subgroup analysis of determinant factors for stunting among children aged under five years based on Region in Indonesia

Subgroup analysis	Heterogeneity test	
	p-value	I^2
Javanese	0.133	48.72
Minangkabaunese	0.718	41.53
Bataknese	0.504	39.32
Bugis	0.100	41.45
Sundanese	0.434	51.05

age were more likely to experience stunting, with a POR of 3.33 (3.16-3.52). This shows the need for further research on age groups that are more at risk for stunting. The previous theory has explained that the process of stunting already takes place, especially in the first 1000 days of life, but the occurrence of stunting will be visible after the child is over two years old.[1]

Characteristics of children that consistently affect stunting are low birth weight, found in 6 studies with POR 2.39 (2.07-2.76), $I^2 < 50\%$, and *p*-value >0.05. This is in line with previous research, which found that low birth weight was one of the main predictors of stunting.[28-30] Another child characteristic variable that is also consistently associated with stunting is the administration of deworming drugs. The incidence of stunting is more commonly found in children who do not get deworming medicine in urban and rural areas. This finding indicates that deworming programs are still needed to prevent helminth infections which can harm the utilization of nutrients in the child's body and ultimately lead to chronic malnutrition or stunting. Meanwhile, children who experience acute diarrhea are at higher risk of stunting than healthy children, but this finding has high heterogeneity between existing studies (I^2 >50%, *p*-value <0.05).

From 10 studies that looked at the risk factors for stunting from maternal characteristics, it was found that children with maternal age ≥ 30 years, low maternal education, short maternal stature, high parity, preterm birth, and antenatal visits less than four times have a higher risk for stunting. However, from the heterogeneity test, the factors that consistently affect stunting are maternal age ≥30 years, preterm birth, and antenatal care <4 times (I^2 <50%, *p*-value > 0.05), while the findings of other risk factors have significant heterogeneity. This shows that maternal factors are the most critical phase in stunting prevention, especially during pregnancy. Therefore, specific and sensitive intervention programs such as the provision of iron tablets, supplementary food for pregnant women with chronic energy deficiency, antenatal care, nutrition, and health promotion, etc., which have been previously carried out, need to be improved so that there are no more children born with wasting or stunting at birth.

The heterogeneity analysis revealed that homogenous household and community factors associated with stunting were unimproved sanitation, unsafe drinking water, severe food insecurity, and rural residence ($I^2 \leq 50\%$, *p*-value>0.05). These factors have been identified as determinants of stunting in Indonesia from a previous systematic review.[31] The mechanism of the relationship between household and environmental factors and stunting has been described in the WHO framework for stunting prevention.[32]

Despite the specific and sensitive intervention programs have been implemented, this study show that various proximate and distal risk factors for stunting still exist, relating to the characteristics of children, mothers, families, and the community environment. Several specific intervention programs to address stunting such as universal immunization, Iron and Folic acid (IFA) and vitamin A supplementation, supplementary food provision for undernourished pregnant women and children, exclusive breastfeeding for 6 months and the provision of nutritious complementary foods for children aged 6-24 months, as well as various integrated multilateral sensitive interventions involving health, education, sanitation, and food sectors have not had a significant impact on reducing the prevalence of stunting.

Several challenges in addressing stunting, which hinders the rate of stunting reduction include regional disparities, lack of knowledge and awareness among communities, socio-economic factors, and implementation issues such as inter-sector collaboration.[6,33-35] Therefore, efforts can be made by improving inter-sectoral coordination and accessibility to high-quality food in vulnerable areas. Raising awareness about nutrition and health, especially among pregnant and breastfeeding mothers, improving the quality of healthcare services in underserved areas, and monitoring and evaluating stunting reduction programs regularly are also important steps. Strengthening collaboration between the government, private sector, and civil society, conducting research and innovation to find new solutions, are also crucial to achieving Indonesia's goal of stunting reduction.

To the best of our knowledge, this study is the first meta-analysis of the risk factor of stunting in the Indonesian setting. We revealed the pool odds ratio for the child, maternal, and household risk factors identified from a diverse range of studies with large sample sizes and different demographics in the country. Thus, the analysis could provide a basis for concluding risk factors statistically associated with childhood stunting in Indonesia. There was no publication bias detected for studies included in the analysis. Based on the subgroup analysis, the stunting determinants were consistent for all studied ethnic groups in Indonesia, such as Javanese, Minangnese, Bataknese, Sundanese, and Bugis. However, predictor variables were estimated by odds ratio, which may be affected by other confounding variables. The other limitation is that the search strategy restricted articles published in the selected databases only in English. There might be articles published in different databases using another language that was not included.

Conclusion and recommendation

The systematic review revealed numerous child, maternal, household, and community characteristics that are linked to childhood stunting in Indonesia. Stunting is more common in female children with low birth weight who did not receive deworming. Maternal age of 30 years or older, preterm birth, and fewer than 4 antenatal care visits were consistently associated with stunting. Food insecurity, lack of access to improved drinking water and sanitation, and living in rural areas were the main household and community risk factors for stunting. Given the significant connection between child, maternal, and household risk factors and stunting, there is a need to improve comprehensive and integrated nutrition interventions.

ACKNOWLEDGEMENTS

The authors would like to thank the Indonesian National Institute for Health Research and Development (currently converted to the Health Policy Agency Ministry of Health), Asian Devel-

opment Bank, Andalas University, and Health Ministry Polytechnic of Padang for their institutional collaborative support in the study.

AUTHOR DISCLOSURES

The authors declare that there are no conflicts of interest.

This study is funded by ADB JFPR, TA-9558 INO: Impact of Adolescent Nutrition Support on Development Outcome.

REFERENCES

1. Onis M De, Branca F. Review Article Childhood stunting : a global perspective. Matern Child Nutr. 2016;12:12–‒26. doi: 10.1111/mcn.12231
2. Onis M De, Borghi E, Arimond M, Webb P, Croft T, Saha K et al. Prevalence thresholds for wasting, overweight and stunting in children under 5 years. Public Health Nutr. 2019;22:175-9. doi: 10.1017/S1368980018002434
3. Dewey KG, Begum K. Long-term consequences of stunting in early life. Matern Child Nutr. 2011;7:5–18. doi: 10.1111/j.1740-8709.2011.00349.x
4. Soliman A, Sanctis V De, Alaaraj N, Ahmed S, Alyafei F. Early and Long-term Consequences of Nutritional Stunting: From Childhood to Adulthood. Acta Biomed. 2021;92:1-11. doi: 10.23750/abm.v92i1.11346
5. United Nations Childre's Fund (UNICEF), World Health Organization (WHO), The International Bank for Reconstruction and Development/World Bank Group. Levels and trends in child malnutrition. Joint Chil. Geneva; 2021.
6. NIHRD MoH Indonesia. National Basic Health Reserach report 2018. Jakarta, Indonesia: Ministry of Health, Indonesia; 2018. (in Indonesian)
7. Indonesian Ministry of Health. Report of Indonesia Nutritional Status Survey at National, Provincial and District Level. Jakarta, Indonesia: Ministry of Health; 2021. (in Indonesian)
8. Ministry of Law and Human Rights of Indonesia. Presidential Regulation of the Republic of Indonesia Number 72 of 2021 concerning Acceleration of Stunting Reduction. Jakarta, Indonesia: Office of the State Secretariat, Deputy for Legislation and legal registration; 2021. (in Indonesian)
9. United Nations Childre's Fund (UNICEF). Conceptual Framework on Maternal and Child Nutrition [Internet]. New York, USA: UNICEF, Nation and Child Development Section Programme Group; 2021. Available from: www.unicef.org/nutrition
10. Semba RD, Moench-pfanner R, Sun K, de Pee S, Akhter N, Rah JH, Campbell AA, Badham J, Bloem MW, Kraemer K. Consumption of micronutrient-fortified milk and noodles is associated with lower risk of stunting in preschool-aged children in Indonesia. Food Nutr Bull. 2011:32:347–53. doi: 10.1177/156482651103200406
11. Oddo VM, Rah JH, Semba RD, Sun K, Akhter N, Sari M, de Pee S, Moench-Pfanner R, Bloem M, Kraemer K. Predictors of maternal and child double burden of malnutrition in rural Indonesia and Bangladesh. Am J Clin Nutr. 2012;95:951-8. doi: 10.3945/ajcn.111.026070
12. Rachmi CN, Agho KE, Li M, Baur LA. Stunting, Underweight and Overweight in Children Aged 2.0–4.9 Years in Indonesia: Prevalence Trends and Associated Risk Factors. PLoS One. 2016;11:1–17. doi: 10.1371/journal.pone.0154756
13. Torlesse H, Cronin AA, Sebayang SK, Nandy R. Determinants of stunting in Indonesian children: evidence from a cross-sectional survey indicate a prominent role for the water, sanitation and hygiene sector in stunting reduction. BMC Public Health, 2016;16:1–11. doi: 10.1186/s12889-016-3339-8
14. Mahmudiono T, Sumarmi MS, Rosenkranz RR. Household dietary diversity and child stunting in East Java, Indonesia. Asia Pac J Clin Nutr. 2017;26:317–25. doi: 10.6133/apjcn.012016.01
15. Mahmudiono T, Nindya TS, Andrias DR, Megatsari H. Household Food Insecurity as a Predictor of Stunted and Overweight/Obesse Mother (SCOWT) in Urban Indonesia. Nutrients. 2018;10:1–16. doi: 10.3390/nu10050535
16. Rah JH, Badgaiyan N, Cronin AA, Torlesse H. Improved sanitation is associated with reduced child stunting amongst Indonesian children under 3 years of age. Matern Child Nutr. 2020;16:1–8. doi: 10.1111/mcn.12741
17. Sofiatin Y, Pusparani A, Judistiani TD. Maternal and environmental risk for faltered growth in the first 5 years for Tanjungsari children in West Java, Indonesia. Asia Pac J Clin Nutr. 2019;28:32–42. doi: 10.6133/apjcn. 201901_28 (S1).0003
18. Titaley CR, Ariawan I, Hapsari D, Muasyaroh A. Determinants of the Stunting of Children Under Two Years Old in Indonesia: A Multilevel Analysis of the 2013 Indonesia Basic Health Survey. Nutrients. 2019;11:1–13. doi: 10.3390/nu11051106
19. Febriana WR, Nurhaeni N. Comprehensive Child and Adolescent Nursing Is There Any Relationship between Feeding Practices for Children Under Two Years of Age (6–23 Months) and Stunting? Compr Child Adolesc Nurs. 2019;42:65–72. doi:10.1080/24694193.2019.1577927
20. Flynn J, Alkaff FF, Salamah S, Sukmajaya WP. Comparison of WHO growth standard and national Indonesian growth reference in determining prevalence and determinants of stunting and underweight in children under five : a cross-sectional study from Musi sub-district. F1000Res. 2021;9:1–20. doi: 10.12688/f1000research.23156.4
21. Ciptanurani C, Chen H. Household structure and concurrent stunting and overweight among young children in Indonesia. Public Health Nutr. 2021;24:2629–39. doi: 10.1017/S1368980021001385
22. Djuardi Y, Lazarus G, Stefanie D, Fahmida U, Ariawan I, Supali T. Soil-transmitted helminth infection, anemia, and malnutrition among preschool-age children in Nangapanda subdistrict, Indonesia. PLoS Negl Trop Dis. 2021;15: e0009506. doi: 10.1371/journal.pntd.0009506
23. Hadi H, Fatimatasari F, Irwanti W, Kusuma C, Alfiana RD, Asshiddiqi MIN, Nugroho S, Lewis EC, Gittelsohn J. Exclusive Breastfeeding Protects Young Children from Stunting in a Low-Income Population: A Study from Eastern Indonesia. Nutrients. 2021;13:4264. doi: 10.3390/ nu13124264
24. Mulyaningsih T, Mohanty I, Widyaningsih V, Gebremedhin TA, Miranti R, Wiyono VH. Beyond personal factors : Multilevel determinants of childhood stunting in Indonesia. PLoS One [Internet]. 2021;16:1–19. doi: 10.1371/ journal.pone.0260265
25. Sari K, Ayu R, Sartika D. The Effect of the Physical Factors of Parents and Children on Stunting at Birth Among Newborns in Indonesia. J Prev Med. 2021;54:309–16. doi: 10.3961/jpmph.21.120
26. Sartika AN, Khoirunnisa M, Meiyetriani E, Ermayani E, Pramesthi IL, Ananda AJN. Prenatal and postnatal determinants of stunting at age 0–11 months : A cross-sectional study in Indonesia. PLoS One. 2021;16:1–14. doi: 10.1371/journal.pone.0254662
27. NIHRD MoH Indonesia. Indonesian Basic Health Research Report. Jakarta; 2013:1–384. (in Indonesian)

28. Aboagye RG, Ahinkorah BO, Seidu AA, Frimpong JB, Archer AG, Adu C, Hagan Jr JE, Amu H, Yaya S. Birth weight and nutritional status of children under five in sub-Saharan Africa. PLoS One. 2022;17:1–19. doi: 10.1371/journal.pone.0269279
29. Abbas F, Kumar R, Mahmood T, Somrongthong R. Impact of children born with low birth weight on stunting and wasting in Sindh province of Pakistan: a propensity score matching approach. Sci Rep. 2021;11:1–10. doi: /10.1038/s41598-021-98924-7
30. Tampy ST, Nugroho HW, Syuadzah R, Kartikawati D. The Associations between Anemia, Stunting, Low Birthweight, and Cognitive Ability in Indonesian Children : An Analysis from Indonesian Family Life Survey. J Matern Child Heal. 2020;5:402–12. doi: 10.1371/journal.pone.0269279
31. Beal T, Tumilowicz A, Sutrisna A, Izwardy D, Neufeld LM. A review of child stunting determinants in Indonesia. Matern Child Nutr. 2018;14:1–10. doi: 10.1111/mcn.12617
32. Stewart CP, Iannotti L, Dewey KG, Michaelsen KF, Onyango AW. Contextualising complementary feeding in a broader framework for stunting prevention. Matern Child Nutr. 2013;9:27–45. doi: 10.1111/mcn.12088
33. UNICEF Indonesia. Stunting in Indonesia: A Challenge that Matters. 2020. Available at: https://www.unicef.org/indonesia/sites/unicef.org.indonesia/files/2020-06/The-State-of-Children-in-Indonesia-2020.pdf
34. Laksono AD, Wulandari RD, Amaliah N, Wisnuwardani RW. Stunting among children under two years in Indonesia: Does maternal education matter? PLoS ONE. 2022;17: e0271509. doi: 10.1371/journal.pone.0271509
35. World Bank Group. Indonesia's Rising Divide: Poverty, Inequality, and the New Middle Class. 2016 [cited: 2022/01/17]. Available at: https://documents1.worldbank.org/curated/en/267671467991932516/pdf/106070-WP-PUBLIC-Indonesias-Rising-Divide-English.pdf