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Determinants of Stunting in Children Under Five

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ABSTRACT

Introduction: Stunting in children under five years old remains a major global health concern, affecting approximately 22.3% of children worldwide. It contributes to impairments in physical and cognitive development, reduced academic performance, lower economic productivity, and increased susceptibility to non-communicable diseases. This study aims to synthesize comprehensive evidence regarding the determinants associated with stunting in children under five.

Methods: A systematic review and meta-analysis were conducted using data from 22 eligible studies retrieved from international databases (Scopus, PubMed, ScienceDirect, and Springer). Heterogeneity was assessed using the I^2 statistic, and a random-effects model was applied to estimate the odds ratio (OR) and 95% confidence interval (CI). Publication bias was evaluated using funnel plot visualization and Egger's test.

Results: Meta-analysis findings demonstrate that several determinants significantly increase the risk of stunting, including low maternal education (OR = 1.63; 95% CI: 1.11–2.41; I^2 = 84.64%), low paternal education (OR = 1.66; 95% CI: 1.05-2.61; I^2 = 55.64%), maternal occupation (OR = 1.59; 95% CI: 1.09-2.32; I^2 = 71.16%), low household income (OR = 1.83; 95% CI: 1.30-2.58; I^2 = 73.72%), and households with two or more young children (OR = 2.34; 95% CI: 1.65-3.30; I^2 = 23.89%). Additional factors such as inadequate antenatal care (OR = 1.62; 95% CI: 1.07-2.47; I^2 = 41.71%), non-exclusive breastfeeding (OR = 1.21; 95% CI: 1.60-3.03; I^2 = 80.25%), incomplete immunization (OR = 2.77; 95% CI: 1.48-5.19; I^2 = 63.58%), low birth weight (OR = 2.72; 95% CI: 1.61-4.66; I^2 = 65.71%), and a history of infectious diseases (OR = 1.96; 95% CI: 1.36-2.82; I^2 = 64.06%) were also strongly associated with stunting. No substantial publication bias was indicated by Egger's test ($p > 0.05$).

Conclusion: Stunting is influenced by a combination of sociodemographic factors and maternal-child health services, such as parental education, household income, and exclusive breastfeeding. Reducing the prevalence of stunting requires integrated policies that encompass education, health, and family economic empowerment.

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INTRODUCTION

Stunting in children under five is a complex global public health issue. According to WHO data for 2022, approximately 22.3% of children under five experience stunting, reflecting chronic undernutrition and prolonged exposure to multiple risk factors during the critical first 1,000 days of life (1). This condition not only impairs physical growth but also disrupts cognitive development, contributes to lower academic achievement and economic productivity, and increases susceptibility to long-term non-communicable diseases. Collectively, these consequences place a substantial burden on individuals, communities, and countries with high stunting prevalence (2,3). The incidence of stunting arises from an intricate interplay of social, economic, environmental, and biological determinants. Numerous studies have consistently identified key contributing factors, including maternal education, socioeconomic status, exclusive breastfeeding practices, immunisation coverage, and recurrent childhood infections (4,5). Furthermore, environmental health aspects such as access to clean water and adequate sanitation have been shown to significantly influence stunting rates, particularly in developing countries (5–7). Despite this growing body of evidence, findings across studies often show substantial variability, likely due to differences in research methodologies, geographical contexts, and the range of variables assessed.

There have been many systematic reviews to explore the determinants of stunting incidence, such as in Bangladesh (8), Ethiopia (9,10), Southeast Asia (11), including Indonesia (4). A number of previous systematic reviews have sought to map these factors with greater precision. For instance, Aminin et al. (2022) identified that the most dominant determinants of stunting were family socioeconomic status, maternal education, nutritional status, and poor environmental sanitation, based on a synthesis of 14 articles from various developing countries (5). Furthermore, a study by Dessie et al. (2024) involving 69 articles from less developed countries found that stunting often co-occurs with vitamin A deficiency and anaemia, with vitamin A-deficient children having a 1.54 times higher risk of stunting than non-deficient children (12). Concurrently, a meta-analysis review by Maulina et al. (2024) underscored the significance of a multilevel approach, given that the determinants of stunting encompass individual (e.g. low birth weight), household (e.g. family size) and community (e.g. access to sanitation) factors, which are structurally interrelated and serve to amplify the risk of stunting (13).

While the literature on stunting has grown significantly, there are still gaps in a comprehensive synthesis of evidence on its causal factors. Most of the available research is individual observational studies with a local focus and cross-sectional design, which limits generalisation of findings and evidence-based mapping of policy priorities. In this context, systematic reviews and meta-analyses have an important value to quantitatively collate, assess the quality and integrate the available studies to produce more robust and reliable conclusions.

This systematic review and meta-analysis aim to present comprehensive evidence on the relationship between the determinants of stunting in children under five years of age. By synthesising data from multiple countries and contexts, this study is expected to provide a strong scientific foundation for the formulation of more targeted, effective and contextualised intervention policies and practices. The implications are not only important in accelerating the reduction of stunting prevalence globally, but also in supporting the achievement of Sustainable Development Goals (SDG) 2, 3 and 4 targets, particularly those related to the elimination of malnutrition, good health, and quality education.

METHOD

Study Design

This review followed the PRISMA framework, outlining methods for identifying sources, establishing eligibility, and defining inclusion/exclusion criteria, as well as the review process, data extraction, and analysis (14). The 2020 PRISMA version replaces the 2009 guidelines, offering updated and more comprehensive reporting methods for study identification, selection, assessment, and synthesis (15). This study is not registered with PROSPERO.

Identification

In the identification stage, synonyms and keyword variations were used to expand the search with Boolean operators. Keywords included "Stunting," "Child stunting," "Determinants of stunting," "Sociodemographic factors," "Socioeconomic status," "Maternal health," "Prenatal care," and "Nutrition status" (Table S1). The search was conducted on Scopus, PubMed, ScienceDirect, and Springer, yielding 4,384 records. After removing 643 duplicates, 3,741 records remained for title screening, which were exported to Excel for further review.

Screening

Two authors screened titles and abstracts based on predefined criteria, including primary research published in peer-reviewed journals and written in English. Systematic reviews, books, conference proceedings, and non-peer-reviewed articles (e.g., editorials, commentaries) were excluded. This process removed 2,952 irrelevant articles, leaving 789 for further abstracting, full-text extraction, and eligibility screening.

Eligibility

A total of 221 full-text articles were retrieved for eligibility screening. Two authors independently reviewed the articles, excluding 185 based on the following reasons: (1) no primary data (85), (2) not focusing on children aged 0-59 months (43), (3) no epidemiologic measures like Odds Ratio (38), and (4) conducted in school children (19). The remaining 22 articles met the eligibility criteria and proceeded to quality assessment. The PRISMA flowchart (**Figure 1**) shows the screening process from identification to eligibility evaluation.

Quality Assessment

Article quality was assessed using the Joanna Briggs Institute (JBI) checklist for observational studies (16). Two independent reviewers conducted the assessment, resolving disagreements through discussion. Of the 22 articles evaluated, most demonstrated strong methodological quality with low bias risk, and 13 articles met all criteria with a score of 8/8, indicating very low bias risk.

Data Extraction and Synthesis

The authors extracted the data independently using a standardised data extraction form and organised it in a Microsoft Excel spreadsheet. The information collected includes: (1) Author/year. Country, (2) Study Design, (3) Sample size, (4) Children's age, (5) (OR/AOR, 95% CI each variables (OR, 95% CI), (6) NOS (**Table 1**).

Statistical Analysis

The extracted data were analyzed using STATA version 16. The prevalence of stunting in children under five and environmental factors were estimated with the DerSimonian-Laird random effects model (17). Heterogeneity was tested using the Cochrane Q test and I^2 statistic (18), revealing significant heterogeneity ($I^2 = 99.50$, $p < 0.001$). Subgroup analyses based on study area, sample size, and residence were performed, along with sensitivity analyses to assess each study's influence. The effect of small studies was examined using funnel plots and Egger's test (19).

RESULTS

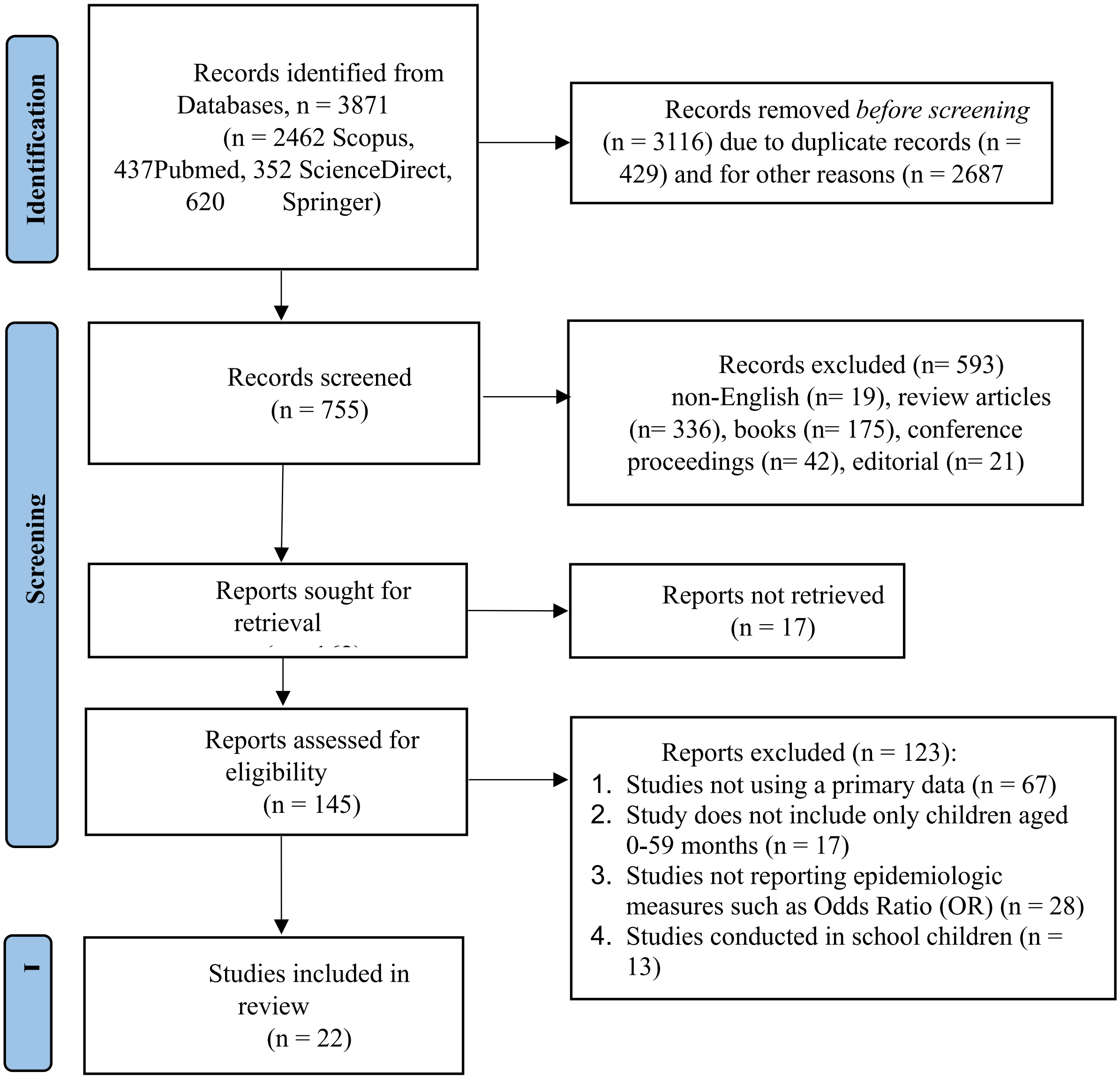

Fig 1. PRISMA flow diagram of article selection for systematic review and meta-analysis

Table 1. Characteristics of included studies

Author/year	Study Design	Sample size	(OR/AOR, 95% CI each variable)	NOS
Mutiarasari et al., 2021 (20) Indonesia	Case-Control Study	520 toddlers	Knowledge (1.58, 1.05-2.36), Child sickness history (9.16, 3.56-23.56), Mother's height (1.38, 0.96-1.97), Mother's education level (1.14, 0.80-1.62)	100%
Mulaw et al., 2020 (3) Ethiopia	Case-Control Study	381 children	Maternal education (0.34, 0.16-0.77), Number of under-five children (2.66, 1.38-5.10), Maternal BMI (2.91, 1.51-5.60), Child age (1.76, 1.01-3.09), Colostrum feeding (3.03, 1.62-5.66), Exclusively breastfeed for the first 6 months (3.20, 1.72-5.95), Functional latrine ownership (0.28, 0.15-0.55)	87%

Tafesse et al., 2021 (21) Ethiopia	Case-Control Study	237 children	Sex of children (2.37, 1.22–4.59), Total family size (0.49, 0.17–1.38), Number of <5 year children (2.18, 1.03-4.64), Maternal educational status (3.28, 1.56-6.92), Wealth Index (1.169, 0.53–2.53), Diarrhea, preceding 2 weeks (2.71, 1.42–5.16), Exclusive breastfeeding (2.07, 1.06–4.01) , Source of drinking water (1.44, 0.73–2.83)	100%
Ara et al., 2024 (22) Pakistan	case-control study	280 children	Gender (1.45, 0.90–2.32), Monthly Household Income (3.16, 1.41-7.06), Migration (1.48, 0.9–2.41), Mother's Education (1.84,1.1–2.97), Father's, Education (2.56, 1.47-4.40), Mother's Working Status (1.2, 0.6–2.4), Father's Employment Status (0.79, 0.2–3.0), Father's Job Type (1.78, 0.1–2.86), Birth Weight (1.17, 0.6–2.22), Immunization (1.56, 0.88–2.73), Breastfeeding (3.78, 2.22-6.40)	100%
Hasan et al., 2018 (23) Bangladesh	case–control study	296 children	Dietary Diversity (1.72, 1.04–2.87), Maternal Height (4.67,2.28–9.56), Maternal education (2.05, 0.82–5.13), Monthly Family Income (1.19, 0.65–2.17), Sanitation (7.48, 0.85–65.72)	100%
Habtamu et al., 2023 (24) Ethiopia	Case–Control Study	544 children	Educational status of mothers (2.5, 1.43–4.18), Family size of households (1.0, 1.0–2.91), Number of under-five children (2.22,1.37, 3.6), Sex of children (1.45, 1.01-2.08), Mother height (4.25, 2.71–6.66), Exclusive breastfeeding (3.16, 1.97–5.10), Birth interval (1.05, 0.96–2.50)	87%
Marume et al., 2023 (25) Zimbabwe	Case–Control Study	450 children	Child's age (0.95, 0.92–0.97), Sex (0.57, 0.30–1.07), Low birth weight (3.25, 2.03-5.22), Short birth length (1.39, 1.16–3.92), Maternal age (0.42, 0.22–0.80), Maternal occupation (0.60, 0.32–1.14), Maternal education (1.73, 1.02–5.72), Number of siblings (6.15, 2.95–19.68), Breastfed (3.97, 2.26-5.19), Child illness (5.91, 2.89–12.65), ANC attendance (4.03, 1.11–11.24)	87%
Tadesse et al., 2020 (26) Ethiopia	Case–Control Study	321 children	BMI of mothers/care-givers (2.64,1.28–5.43), Exclusive breastfeeding (2.44,1.15–5.17), Education status of mothers/caregivers (2.36,0.81–6.88), Meat (2.35, 1.21–4.58), Type of illness (Diarrhea) (2.00,1.07–3.86)	100%
Hayuningsih et al., 2024 (27) Indonesia	Case–Control Study	154 children	Anemia history during pregnancy (2.75, 1.31–5.78), Job statuses of the mothers (2.81, 1.24–6.37), Education of the mothers (2.4, 1.15–5.12), Antenatal Care Record (1.3, 0.49–3.24), Maternity nutritional cognition (2.3, 1.11–4.57), Parenting pattern (2.1, 1.09–3.97), Per-capita income (2.7, 1.12–6.28), Acute respiratory tract infection (1.1, 0.59–2.09), Low birth weight (3.98, 1.54–10.27), Food diversity (2.2, 1.10–4.44), Breast milk food supplementary (1.5, 0.77–2.89), Basic immunization (4.02, 1.66-9.74)	100%
Derso et al., 2017 (28) Ethiopia	Cross-sectional study	587 mother-child	Maternal education (2.20, 1.39-3.46), Maternal occupation (2.58, 1.49-4.47), Father education (1.45, 1.03-2.05), Wealth status (2.36, 1.56-3.57), Main source of family food (1.71, 1.14–2.57), Source of drinking water (1.21, 0.79–1.84), Availability of latrine (1.76, 1.17–2.66), Maternal Vitamin A supplementation (1.54, 1.02–2.33), Dietary diversity score (1.17, 0.69–4.04), Child age (3.24, 2.24–4.69)	100%
Dranesia et al., 2019 (29) Indonesia	Cross-sectional study	290 children	Sex (1.8, 1.12–2.89), History of exclusive breastfeeding (0.59, 0.37–0.95), History of basic immunization (1.41, 0.68–2.93), History of infectious diseases (1.36, 0.86–2.17), Mothers' education (3.66, 0.68-19.75), Economic status (1.60, 0.94–2.72), Age of pregnant mother (0.82, 0.42–0.62), Availability of clean water (0.89, 0.44–1.8), History of ANC (0.81, 0.43–1.52)	100%
Astuti et al., 2024 (30) Indonesia	Cross-sectional study	706 children	Child age (8.98, 1.40–57.60), Child sex (1.47, 1.10–1.98), Child size (12.55, 2.90–54.21), Preceding birth interval (15.83, 3.46–72.56), Maternal education (3.56, 2.33-5.45), Maternal working status (1.36, 1.01–1.83), Household income (3.51, 1.36–9.06), Early initiation of breastfeeding (2.65, 1.38–5.10), Exclusive breastfeeding (3.19, 1.57–	87%

			6.50), Duration of breastfeeding (3.38, 1.63–7.00), Basic vaccination status (4.90, 1.26–19.05)	
Hamam Hadi et al., 2021 (31) Indonesia	Cross-sectional study	408 children	Sex (1.52, 1.02-2.24), Exclusive Breastfeeding (0.82, 0.55-1.22), Age (0.20, 0.13–0.33), Caregiver Type (0.38, 0.14–1.03), Monthly Household Expenditure (2.28, 1.12-4.64), Mother's Education (1.96, 1.08-3.55), Mother's Occupation (8.40, 1.00–70.29), Father's Occupation (0.96, 0.53–1.72)	87%
Yuliastini et al., 2020 (32) Indonesia	Cross-sectional study	612 children	Sex (1.19, 0.86–1.64), Age (0.57, 0.41–0.79), History of infectious diseases (1.23, 0.86–1.76), Education level of mothers (1.08, 0.73–1.61), Mother's occupation (1.16, 0.74–1.82), Income per month (1.04, 0.74–1.46), Age during pregnancy (0.76, 0.51–1.13), Parity (1.25, 0.66–2.36), Exclusive breastfeeding (1.50, 1.03–2.17)	87%
Batiro et al., 2017 (33) Ethiopia	Cross-sectional study	465 children	Educational status of father (1.70, 0.64–4.47), Under-5 child size (0.56, 0.15–2.03), ANC follow up (7.82, 0.25–9.35), Birth interval (3.27, 0.98–10.86), ARI during last 2 weeks (3.04, 1.04–12.35), Vaccination status (6.38, 2.54–17.10), Type of water source for drinking (7.06, 4.40–20.42)	87%
Shaka et al., 2020 (34) Ethiopia	Case–Control Study	302 children	Sex (0.72, 0.40-1.32), Mother age (0.58, 0.22–1.53), Mother occupation (1.71, 0.84-3.49), Father occupation (1.12, 0.76–1.74), Mother education (4.63, 1.76–12.14), Father education (3.43, 1.04–11.29), Wealth index (2.32, 1.20–4.49), Age at first birth (1.12, 0.55–2.30), ANC visit (1.32, 0.78–2.24)	100%
Fikadu et al., 2014 (35) Ethiopia	Case–Control Study	242 children	Family size (2.97, 1.41–6.29), Number of under 5 children (3.77, 1.33–10.74), Maternal occupation (3.92, 1.89–8.16), Maternal occupation (4.03, 1.60–10.17), Duration of breastfeeding (5.61, 1.49–11.08), Duration of EBF (7.62, 1.80–12.23), Method of feeding (3.30, 1.33–8.17)	100%
Agussalim et al., 2024 (36) Indonesia	Case–Control Study	260 children	Age of the mother during pregnancy (1.95, 1.03–3.73), Mother's work (0.81, 0.30–2.16), Family income (1.94, 1.01–3.82), Antenatal care (1.82, 1.00–3.33), Anemia during pregnancy (2.25, 1.33–3.82), Child birth weight (2.59, 1.25–5.57), Exclusive breastfeeding (2.44, 1.24–4.96), Household sanitation (2.22, 1.01–5.13)	87%
Atamou et al., 2023 (37) Indonesia	Cross-sectional study	238 children	Gender (2.25, 1.04–4.86), Birth spacing (0.30, 0.09–1.06), History of infectious disease (2.86, 1.11–7.37), Maternal knowledge (5.31, 0.67–41.99), Mothers parenting pattern (3.03, 1.19–7.87), Parents income (2.71, 1.11–6.64), Health service utilization (2.42, 0.66–8.79), Household sanitation (2.61, 1.11–6.15)	100%
Gebreayohanes & Dessie, 2022 (38) Ethiopia	Cross-sectional study	554 children	Economic status (5.50, 2.52–12.00), Sex of the child (0.76, 0.54-1.08), Age of the child (2.51, 1.25–5.04), Initiation of breastfeeding (1.89, 1.17–3.06), Exclusive breastfeeding (3.49, 2.25-5.42), Frequency of feeding (1.03, 0.69–1.53), Minimum dietary diversity score (1.94, 1.04–3.64)	100%
Usman et al., 2021 (39) Indonesia	Case–Control Study	82 children	History of exclusive breastfeeding (1.80, 0.70-4.30), Birth weight (11.20, 1.30-93.50), Family income (0.30, 0.10-0.70), Mother's education level (0.20, 0.10-0.40)	100%
Nurhayati et al., 2020 (40) Indonesia	Case–Control Study	158 children	Sex (0.74, 0.40–1.38), Child's age (3.80, 1.17–12.26), Mother's education level (1.00, 0.38–2.67), Father's education level (0.73, 0.33–1.59), Number of children under 5 within household (1.37, 0.54–3.47), Household economic status (0.66, 0.25-1.80), Birth length (0.36, 0.16–0.83), Birth weight (0.67, 0.20–2.20), Exclusive breastfeeding (1.48, 0.66–3.32), Infectious diseases (1.62, 0.68–3.86)	87%

Table 2. Characteristics of the study based on region, sample age, residence, and study years

Variables	n	%
Region		
Africa	10	45.45
Asia	12	54.55
Children's age		
0-23 month	6	27.27
6-12 month	1	4.55
6-35 month	1	4.55
6-59 month	9	40.91
24-59 month	2	9.09
< 59 month	3	13.64
Residence		
Rural	14	63.64
Urban	4	18.18
Urban & Rural	4	18.18
Study years		
≥ 2020	17	77.27
< 2020	5	22.73

Table 2 summarizes the characteristics of the included studies. Most studies were conducted in Asia (54.55%) and involved children aged 6–59 months (40.91%). The majority were carried out in rural areas (63.64%). Additionally, most studies (77.27%) were published in 2020 or later, indicating a predominantly recent evidence base.

Table 3. Summary of the effects of sociodemographic associated with stunting in children under five

Variabel	OR (95% CI)	Heterogeneity (I^2, p-value)	Egger's P-value	Total studies
Mother's education				
Low	1.63 (1.11-2.41)	84.64%, <0.001	0.6122	17
High	1			
Father's education				
Low	1.66 (1.05-2.61)	55.64%, <0.07	0.7077	5
High	1			
Mother's occupation				
Not employed	1.59 (1.09-2.32)	71.16%, <0.75	0.2090	10
Employed	1			
Father's occupation				
Not employed	1.10 (0.81-1.50)	0.00%, <0.001	0.9612	4
Employed	1			
Household income				
Low	1.83 (1.30-2.58)	73.72%, <0.001	0.9902	14
High	1			
Number of under-five children				
> 2 children	2.34 (1.65-3.30)	23.89%, <0.09	0.4999	7
≤ 2 children	1			

Table 3 shows the association between sociodemographic factors and stunting in children under five. Low maternal education was linked to higher odds of stunting (OR = 1.63; 95% CI: 1.11–2.41), as was low paternal education (OR = 1.66; 95% CI: 1.05–2.61). Non-working mothers also had higher odds of stunting (OR = 1.59; 95% CI: 1.09–2.32), while father's occupation was not significantly associated (OR = 1.10; 95% CI: 0.81–1.50). Low household income increased the odds of stunting (OR = 1.83; 95% CI: 1.30–2.58), and having more than two children under five was linked to higher stunting risk (OR = 2.34; 95% CI: 1.65–3.30).

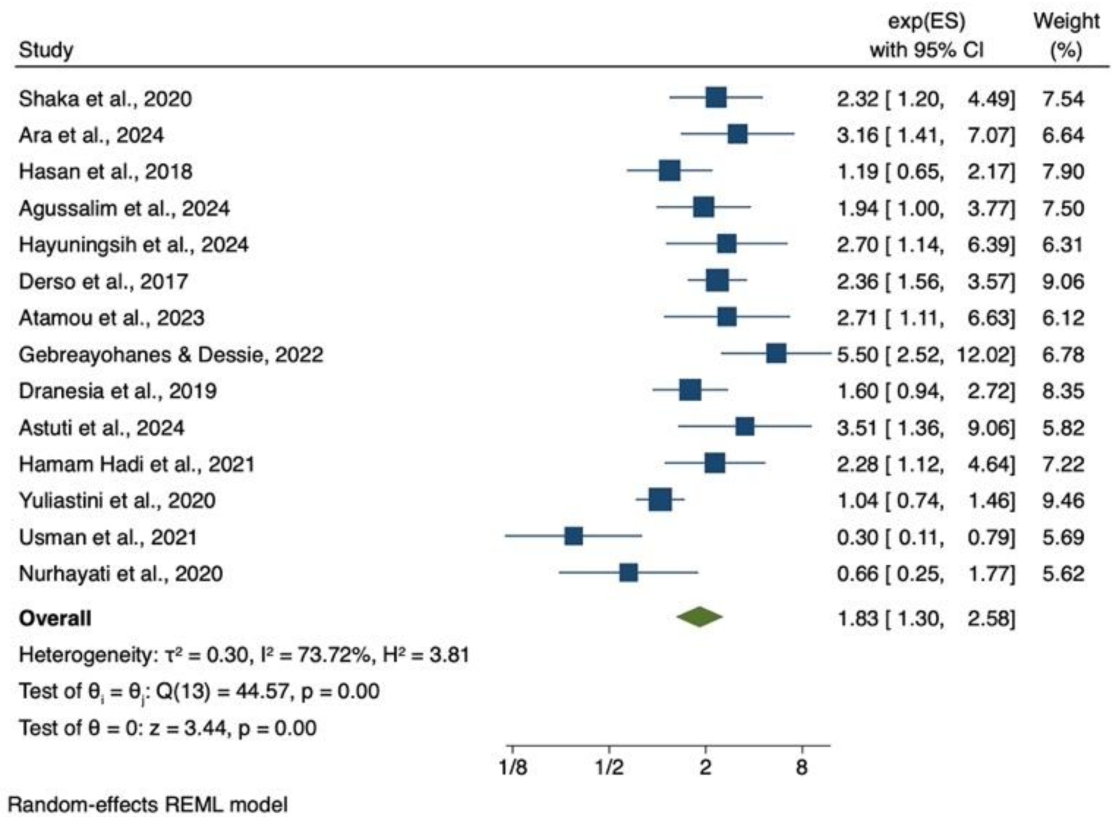

Figure 2. Forest plot showing the association between stunting and household income

Table 4. Summary of the effects of health service associated with stunting in children under five

Variable	OR (95% CI)	Heterogeneity (I^2, p-value)	Egger's P-value	Total studies
Antenatal Care				
Incomplete	1.62 (1.07-2.47)	41.71%, 0.09	0.0257	7
Complete	1			
Exclusive breastfeeding				
No	2.21 (1.60-3.03)	80.25%, <0.001	0.2807	16
Yes	1			
Immunization				
Incomplete	2.77 (1.48-5.19)	63.58%, <0.03	0.0175	5
Complete	1			
Birth weight				
Low birth weight	2.72 (1.61-4.66)	65.71%, <0.001	0.2307	7
Normal	1			
History of infectious diseases				
Yes	1.96 (1.36-2.82)	64.06%, <0.01	0.0603	9
No	1			

Table 4 shows the results of the analysis of the effect of maternal and child health factors on the incidence of stunting in children under five years of age. Based on the analysis, incomplete antenatal care was associated with increased odds of stunting (OR = 1.62; 95% CI: 1.07-2.47). Non-exclusive breastfeeding was associated with higher odds of stunting (OR = 2.21; 95% CI: 1.60-3.03) **(Figure 3)**. Incomplete immunisation was also associated with an increased risk of stunting (OR = 2.77; 95% CI: 1.48-5.19). Low birth weight was associated with an increased risk

of stunting (OR = 2.72; 95% CI: 1.61–4.66). Lastly, history of childhood infectious disease was associated with stunting (OR = 1.96; 95% CI: 1.36–2.82).

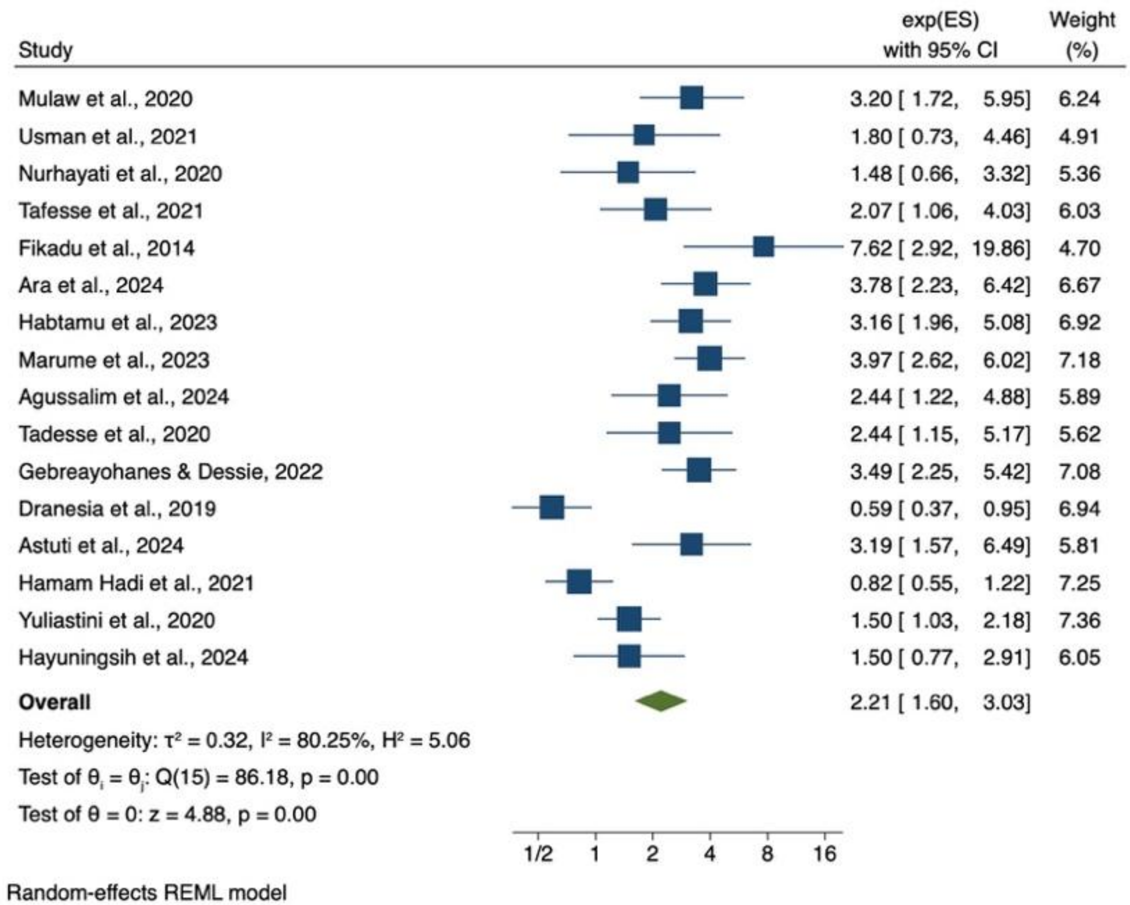

Figure 3. Forest plot showing the association between stunting and maternal and exclusive breastfeeding

DISCUSSION

The meta-analysis showed that mothers with low education levels have a 1.63 times higher risk of having stunted children compared to highly educated mothers. This is consistent with studies in Indonesia and Bangladesh, reinforcing education as a significant determinant of child health (41–43). This underscores the need for policies that promote women's education, particularly in areas with high stunting prevalence, and strengthen community nutrition education programs like posyandu. Fathers with low education levels had a 2.41 times higher risk of stunting in their children, emphasizing the role of fathers' economic involvement and education in children's health. This finding aligns with studies in Cambodia and Indonesia, which showed lower stunting risk in children of fathers with secondary education (44,45).

Non-working mothers had a 1.38 times higher risk of having stunted children compared to working mothers, suggesting that maternal employment is an important factor in fulfilling children's nutritional needs. However, this relationship was inconsistent across studies, with some, like those in Ethiopia and Nigeria, showing higher stunting in children of non-working mothers due to income and access to nutrition information disparities (46,47). Father's employment status did not significantly impact stunting, though research in Indonesia and Tanzania found that irregular or informal employment increased the risk of stunting (48,49). Children from low-income families had a 2.13 times higher risk of stunting, as income limitations affect access to nutritious food, health services, and sanitation. A cross-country study found that absolute income accounted for more than 50% of stunting variation, far exceeding relative wealth indicators. In South Jakarta, children from families earning below the regional minimum wage had a 6.6 times higher chance of being stunted.(50) Additionally, households with more than two children under five had a 1.72 times higher risk of stunting, which is consistent with studies in Rwanda and Ethiopia linking increased household size to higher stunting risk (51,52).

Adequate antenatal care (ANC) is crucial in preventing stunting by enabling early detection of risks, nutrition education, and fetal growth monitoring. This meta-analysis showed that mothers with incomplete ANC visits had a 1.51 times higher risk of having a stunted child. A study in Indonesia confirmed that mothers without ANC visits had a 1.21 times greater risk of stunting (41). A global study found that at least four ANC visits reduced the likelihood of stunting by 1.41% (53). Exclusive breastfeeding for the first six months significantly reduces stunting. The meta-analysis showed that children who were not exclusively breastfed had a 2.35 times higher risk of stunting. A study in Klaten, Indonesia, revealed a 3.61 times higher risk, while another found a 4.57 times higher risk (54,55). The provision of complete basic immunisation to children has been demonstrated to contribute to the prevention of stunting, a condition characterised by impaired nutrient absorption and growth, by mitigating the occurrence of recurrent infections.

Complete immunisation also helps prevent stunting by reducing infections. This meta-analysis found that children with incomplete immunisation had a 1.82 times higher risk of stunting. A study in Indonesia showed that children with incomplete immunisation had a 1.18 times higher risk, rising to 1.27 times for those with no immunization (56). Other studies indicate that fully immunised children have a significantly lower stunting risk when paired with good nutrition and hygiene (57). Low birth weight (LBW) is a strong risk factor for stunting. The meta-analysis revealed that children born weighing less than 2500 grams had a 3.64 times higher risk of stunting. A study in Aceh Besar found that LBW children had a 9.43 times greater risk.(55,58) Another study from Aceh Besar reported that LBW children had a 9.43 times greater risk of stunting than normal birth weight. Infectious diseases like diarrhoea and ARI are significant contributors to stunting. This meta-analysis showed that children with a history of infections had a 2.26 times higher risk. A study in Southeast Sulawesi found that 31.4% of stunted children had a history of infections (59). Another study in Pekanbaru showed a 4.19 times increased risk of stunting due to infections, alongside factors like complementary feeding and parenting quality (60). Overall, the occurrence of stunting is influenced by sociodemographic factors and maternal-child health services, such as parental education, household income, ANC visits, immunisation, and breastfeeding. These factors interact to shape a child's development environment, emphasizing the need for multi-sectoral interventions in education, health, social protection, and food security to reduce stunting prevalence.

In line with the reviewer's suggestions, these findings also align closely with current global frameworks. The WHO Global Nutrition Targets 2025 emphasize improving maternal nutrition, increasing exclusive breastfeeding, and expanding access to essential health services as core strategies to reduce stunting. Similarly, the UNICEF Nutrition Framework underscores the importance of addressing immediate causes (disease and inadequate diet), underlying causes (household food insecurity, caregiving practices, and health service access), and basic structural causes (socioeconomic and political factors). Positioning our findings within these frameworks strengthens their global relevance and demonstrates how the identified determinants directly map onto internationally endorsed intervention pathways. This alignment reinforces the significance of our results in guiding actionable, evidence-informed policies to accelerate progress in stunting reduction efforts worldwide.

This study has several limitations. Most of the included studies were from developing countries, which may limit the generalisability to developed countries. The high heterogeneity between studies indicates significant contextual differences in measurement methods, study design, and populations. Additionally, limitations in accessing individual data and potential publication bias may affect the results. Future research should use a cross-country longitudinal approach, explore interactions between variables, and assess the effectiveness of integrative policy interventions to reduce stunting.

CONCLUSION

The systematic review and meta-analysis show that stunting in children under five is influenced by various sociodemographic factors and maternal-child health services, including parental education, maternal employment, household income, number of young children, antenatal visits, exclusive breastfeeding, immunisation, birth weight, and infectious disease history. These factors impact children's nutritional status directly and indirectly. To reduce stunting, a multisectoral approach is needed, focusing on nutrition, education, economic empowerment, healthcare, and hygiene. It is recommended that governments and policymakers integrate these programs into national policies for effective and sustainable stunting reduction.

AUTHOR'S CONTRIBUTION STATEMENT

Fikitri Marya Sari: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. Wulandari Wulandari: Investigation, Data curation, Resources, Software, Writing – original draft. Danur Azissah Roeliana Sofais: Project administration, Supervision, Validation, Writing – review & editing. Novega Novega: Visualization, Formal analysis, Writing – review & editing. Ravika Ramlis: Funding acquisition, Supervision, Writing – review & editing. Yusran Fauzi: Conceptualization, Methodology, Resources, Writing – original draft. Bintang Agustina Pratiwi: Data curation, Investigation, Project administration. Agung Sutriyawan: Resources, Software, Visualization, Writing – review & editing.

CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest. They affirm that there are no financial or personal relationships with any organizations or entities that could influence the impartiality or objectivity of this research.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that no generative artificial intelligence (AI) tools or AI-assisted technologies, such as ChatGPT, Grammarly, or DeepL, were used in the writing or preparation of this manuscript. All work was completed manually by the authors to ensure academic integrity and originality.

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