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Meta Analysis
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The Relationship Between Maternal Nutritional Status and the Incidence of Stunting: A Meta-Analysis

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ABSTRACT

Background: Stunting remains a major global health concern, contributing to child mortality and long-term developmental consequences. Maternal nutritional status during pregnancy plays a crucial role in determining child growth outcomes. Understanding this relationship is essential for developing effective nutritional interventions to prevent stunting.
Subjects and Method: This study is a systematic review and meta-analysis examining the association between maternal nutritional status and stunting in children under five. Relevant studies published between January 2019 and July 2024 were retrieved from PubMed, Science Direct, Google Scholar, and BMJ. Data from nine studies across Asia and Africa were analyzed using Review Manager (RevMan) 5.3.
Results: The analysis revealed that underweight mothers had a 1.22 times higher risk of having stunted children, while overweight mothers had a 1.02 times higher risk. Both findings were statistically significant ($p<0.001$). These results highlight the critical influence of maternal nutritional status on child growth and the increased risk of stunting in both underweight and overweight mothers.
Conclusion: Maternal nutrition during pregnancy plays a vital role in preventing stunting among children under five. Targeted nutritional interventions for underweight and overweight mothers are essential to improve maternal and child health outcomes. Strengthening maternal nutrition programs can significantly contribute to reducing global stunting rates.

Keywords: nutritional pregnancy; stunting; meta-analysis.

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BACKGROUND

Stunting is a serious issue as it poses a higher risk of morbidity and mortality compared to obesity and non-communicable diseases. Malnutrition contributes to approximately 10.5 million child deaths annually, with 98% of these cases reported in developing countries (UNICEF, 2007).

According to the World Health Organization (WHO), stunting is defined as a height-for-age measurement below -2 standard deviations ((Fikawati, Syafiq and Veratamala, 2017), (WHO, 2010)). In 2020, an estimated 149.2 million children under five years old worldwide were affected by stunting. Stunting prevalence has declined globally, from 40% in 1990 to 22% (equivalent to 114 million children) in 2021 (WHO, 2021). This condition accounts for 45% of deaths among children under five in low- and middle-income countries (Black et al., 2013).

The Sustainable Development Goals (SDGs) aim to eliminate various forms of malnutrition by 2030, with an intermediate target set for 2025 to reduce stunting and wasting in children under five, as well as to address malnutrition among adolescent girls, pregnant and lactating mothers, and the elderly (Ministry of Health, 2017). In Indonesia, data from the 2018 Basic Health Research (Riskesdas) indicate a stunting prevalence of 30.8%. This figure represents a decline from 37.2% in 2013; however, it still exceeds the WHO target of 20% (Ministry of Health, 2018).

The process leading to stunting is prolonged, beginning in the critical "golden period" during pregnancy, particularly when maternal malnutrition occurs. A mother's nutritional status during pregnancy significantly influences the nutritional status of the newborn (Hijrawati et al., 2021). The third trimester of pregnancy is considered the most critical phase compared to the preceding trimesters, as maternal nutrition affects fetal brain development. By the 20th week of gestation, brain cells begin to develop, and inadequate maternal nutrition can hinder optimal brain cell formation. This impairment may subsequently affect a child's cognitive ability and concentration, as well as Intelligence Quotient (IQ), ultimately impacting the quality of future generations (Fahmida et al., 2022).

This study aims to estimate the average effect size of maternal nutritional status on the icidence of stunting. To the best of our knowledge, no similar study has been conducted using meta-analysis. Meta-analysis enables a critical evaluation and statistical synthesis of findings from previous research. This study follows a fundamental research design, as its primary objective is to contribute to existing knowledge by systematically analyzing and integrating findings from a collection of scholarly articles, thereby generating comprehensive and meaningful data.

SUBJECTS AND METHOD

1. Study Design

This study is a systematic review and meta-analysis. The articles in this study were obtained from databases including Google Scholar, PubMed, and Springer Link. Search with keywords 'Maternal nutritional status' AND 'Stunting', 'Maternal BMI status' AND 'Stunting' AND 'adjusted odds ratio', 'Mothers' body mass index' AND "Child malnutrition" OR "Stunting" "BMI mothers" AND "Stunting" AND "adjusted odds ratio". The population in this study were mothers of children under five, the intervention provided was abnormal maternal nutritional status, the comparison article was normal maternal nutritional status, the outcome article was incidence of stunting.

2. Steps of Meta-Analysis

1) Formulate problems using the PICO (Population, Intervention, Comparison, and Outcome) model.
2) Search for major study articles through databases such as Google Scholar, Springer Link, and PubMed.
3) Determine inclusion and exclusion criteria, conduct screening and critical assessment of primary studies .
4) Data extraction and entering data into RevMan 5.3

5) Interpreting values and drawing conclusions

3. Inclusion Criteria

The criteria for study inclusion are English-language articles with cross-sectional studies published between 2019-2024. The analysis used is a multivariate analysis with an adjusted odds ratio (aOR). The subjects of the study were mothers of children under five and the results analyzed were the incidence of stunting.

4. Exclusion Criteria

Study exclusion criteria are RCT (randomized controlled trials) studies, quasi-experiments, study protocols, preliminary studies, no-full text articles.

5. Operational Definition of Variables

Stunting is a condition of failure to thrive due to long-term (chronic) malnutrition indicated by a height/age (years) z-score <-2 SD.

Abnormal maternal nutritional status is a deficiency, excess or imbalance in the maternal intake of energy and/or nutrients as assessed by body mass index (BMI) and classified as underweight (BMI <18.5), overweight (BMI ≥ 25.0 to 29.9) and obese (BMI ≥30).

6. Study Instruments

Primary studies that have been screened are subjected to critical appraisal or study review to determine the feasibility of the study. The assessment instrument used Critical Appraisal Cross-sectional Study and Case-control Study for Meta-analysis Study published by Master of Public Health, Sebelas Maret University Surakarta (2023).

7. Data Analysis

The collected articles were screened with the help of PRISMA diagrams. The main articles that met the inclusion criteria were analyzed using RevMan 5.3. The analysis will include observational studies that report Adjusted Odds Ratios (AOR). This meta-analysis will estimate the overall risk probability, present a 95% confidence interval (CI) for effect models, and measure data heterogeneity using the I^2 statistic.

RESULTS

1. Study Characteristics

The baseline data resulted in 1,610 potentially relevant articles. The PRISMA literature search flowchart and results are shown in Figure 1.

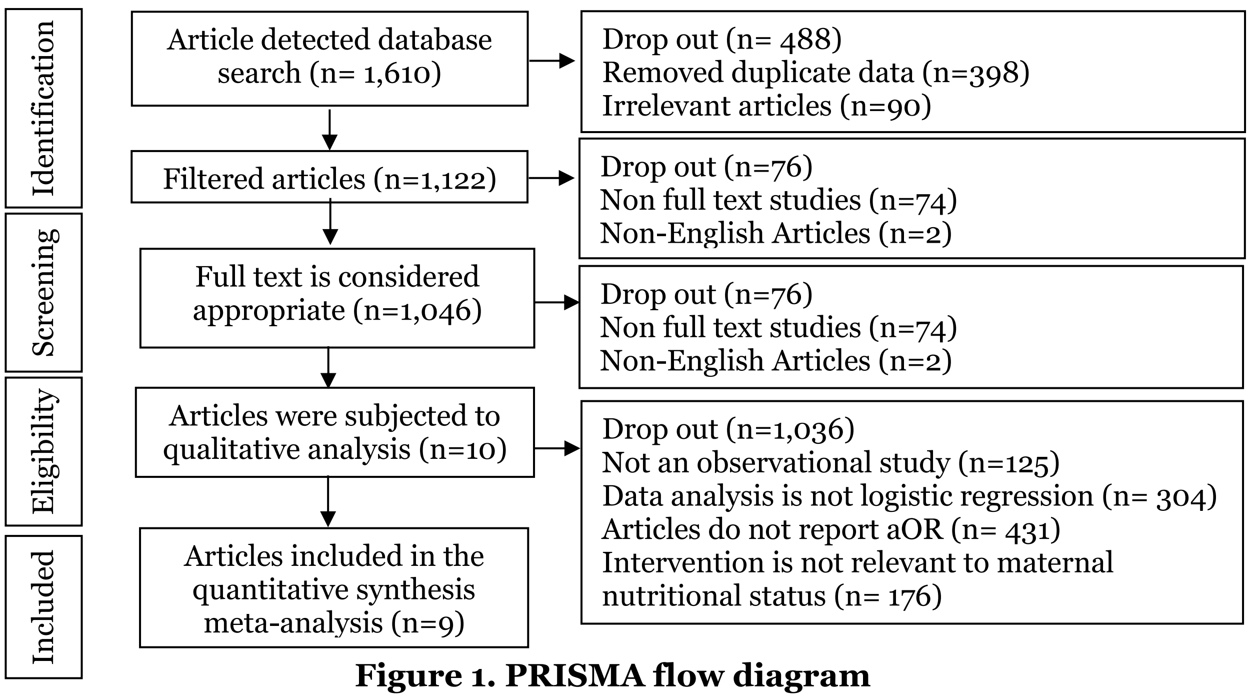

Figure 1. PRISMA flow diagram

Based on the selection criteria, a total of 921 articles were identified for further full-text screening. Finally, 9 full-text articles were included in the meta-analysis. The article review process can be observed in the following search flow (Figure 1).

Research on the impact of abnormal maternal nutritional status on stunting includes nine studies from two continents: Asia and Africa. Six studies were conducted in Asia (one in Indonesia, two in India, two in Pakistan, and one in Bangladesh), while three studies were conducted in Africa (Ethiopia, Nigeria, and Eswatini) (Figure 2).

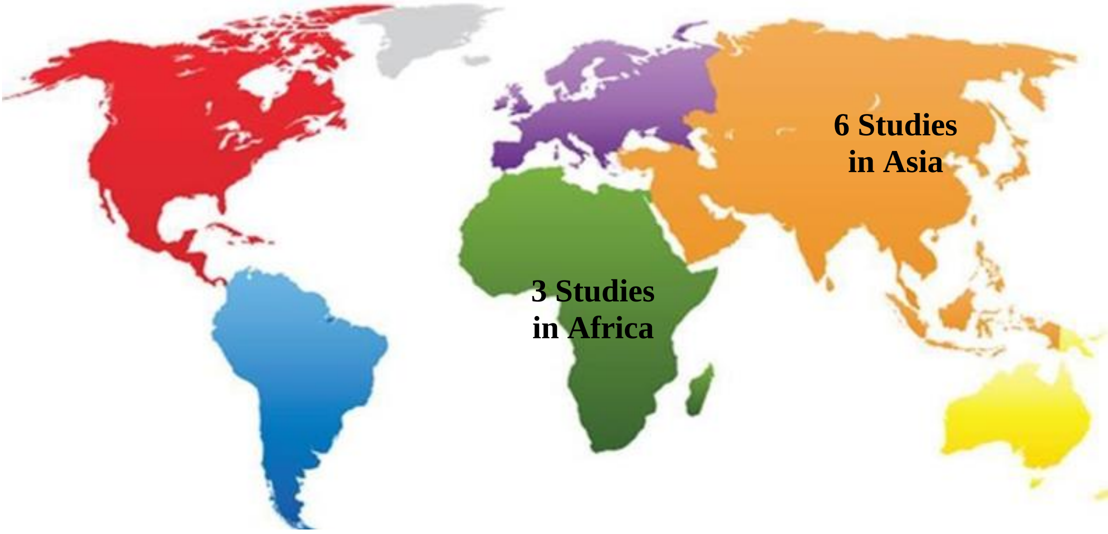

Figure 2. Map of the study area of the relationship between maternal nutritional status and the incidence of stunting

Tabel 1. Critical appraisal for cross-sectional study of maternal nutritional status and the incidence of stunting

Authors (Year)	Criteria													Total
	1a	1b	1c	1d	2a	2b	3a	3b	4	5	6a	6b	7	
Muche and Dewau (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Halli et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Khan et al. (2019)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Porwal et al. (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Li et al. (2023)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Siramaneerat et al. (2024)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Haque et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Siddiqa et al. (2023)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Tesfaw and Fenta (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Muche and Dewau (2021)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Halli et al. (2022)	2	2	2	2	2	2	2	2	2	2	2	2	2	26
Khan et al. (2019)	2	2	2	2	2	2	2	2	2	2	2	2	2	26

Description of the question criteria case control study:

1. Formulation of study questions on PICO

a. Is the population in the primary study the same as the population in the PICO meta-analysis?

b. Is the operational definition of the intervention, i.e. exposure status in the primary study the same as the definition intended in the meta-analysis?

c. Is the comparator, i.e. non-exposure status used by the primary study the same

as the definition intended in the meta-analysis?
d. Are the outcome variables studied in the primary study the same as the definitions intended in the meta-analysis?
2. Methods for choosing a subject of study
a. In cross-sectional analytical studies, do researchers randomly select samples from the population (random sampling)?
b. Alternatively, if in an analytically cross-sectional study the sample is not randomly selected, do researchers select the sample based on outcome status or based on intervention status?
3. Methods for measuring exposure (intervention) and outcome variables (outcome)
a. Were both exposure and outcome variables measured with the same instruments in all primary studies?
b. If variables are measured on a categorial scale, are the cut-offs or categories used the same between primary studies?
4. Design-related bias
If the sample is not randomly selected, has the researcher made efforts to prevent bias in choosing the study subject? For example, in selecting subjects based on outcome status not affected by exposure status (intervention), or in selecting subjects based on exposure status (intervention) not affected by outcome status?
5. Methods to control confusion
Has the primary study researcher made efforts to control for the influence of confusion (e.g., performing multivariate analyses to control for the influence of a number of confounding factors, or performing matching)?
6. Statistical analysis methods
a. Did the researchers analyze the data in this primary study with multivariate analysis models (e.g., multiple regression analysis, multiple logistic regression analysis)?
b. Does the primary study report the effect size or relationship of the multivariate analysis results (e.g. adjusted OR, adjusted regression coefficient)?
7. Conflict of interest
Is there no possibility of a conflict of interest with the study sponsor that causes bias in concluding study results?

Assessment Instruction:
1. If the study is case-control, the total number of questions = 14 question items
2. The answer "Yes" to each question is given a score of "2". The answer "Undecided" was given a score of "1". The answer "No" is given a score of "0".
3. Maximum total score = 14 questions x 2 = 28.
4. Minimum total score = 14 questions x 0 = 0. So, the total score ranges for a primary study between 0 and 28.
5. If the total score of a primary is ≥24, then the study can be included in the meta-analysis. If the total score of a primary study is <24, then the study is excluded from the meta-analysis.

Table 2. Description of primary studies included in meta-analysis about the effect of underweight and overweight on stunting

Author (Year)	Country (Sample) Study Design	Population	Intervention	Comparison	Outcome
Muche and Dewau (2021)	Ethiopia (8,122) Cross-sectional	Children aged 6–59 months	Underweight, Overweight	Normal	Stunting
Halli et al. (2022)	India (22,002) Cross-sectional	Children aged 0–59 months	Underweight, Overweight/ Obese	Normal	Stunting

Author (Year)	Country (Sample) Study Design	Population	Intervention	Comparison	Outcome
Khan et al. (2019)	Pakistan (3,466) Cross-sectional	Children aged 0–59 months	Underweight, Overweight	Obese	Stunting
Porwal et al. (2021)	India (30,600) Cross-sectional	Children aged under 5 years	Underweight, Overweight	Normal	Stunting
Li et al. (2023)	35 LMICs (299,353) Cross-sectional	Children aged 12 to 59 months	Underweight	Normal	Stunting
Siramaneerat et al. (2024)	Indonesia (2,428) Cross-sectional	children aged 24–59 months	Underweight, Overweight	Normal	Stunting
Haque et al (2022)	South and South-East Asian states (213,730) Cross-sectional	Children under five	Underweight	Healthy-weight	Stunting
Tesfaw and Fenta (2021)	Nigeria (11,314) Cross-sectional	Under-five children	Overweight	Thin	Stunting
Siddiqa et al. (2023)	Pakistan (4,226) Cross-sectional	Children of age less than 5 years	Overweight and Obese	Underweight	Stunting

2. Abnormal Maternal Nutritional Status (Underweight) relationship to the incidence of stunting

The interpretation of meta-analysis results can be visualized through a forest plot (Figure 3). The forest plot results indicate that mothers with abnormal nutritional status (underweight) have a 1.22 times higher risk of giving birth to stunted children compared to mothers with normal nutritional status, with statistical significance ($p<0.001$). The heterogeneity of the study data is indicated by $I^2= 98\%$, suggesting that the data distribution is heterogeneous, thus justifying the use of a random-effects model.

Figure 4 presents a funnel plot which is a graphical representation that estimates the effect size of each study against the measure of its precision, typically represented by the standard error. Based on funnel plot, publication bias is evident, as indicated by the asymmetrical distribution of plots on the right and left sides, with five plots on the right and two on the left.

Table 3. The Value of aOR and 95% CI of abnormal maternal nutritional status (underweight) on stunting

Author (Year)	aOR	95% CI	
		Lower Limit	Upper Limit
Muche and Dewau (2021)	0.52	0.37	0.72
Halli et al. (2022)	1.06	1.03	1.10
Khan et al. (2019)	1.72	0.96	3.03
Porwal et al. (2021)	1.36	1.28	1.46
Li et al. (2023)	1.64	1.57	1.71
Siramaneerat et al. (2024)	1.359	0.926	1.995
Haque et al. (2022)	1.27	1.24	1.30

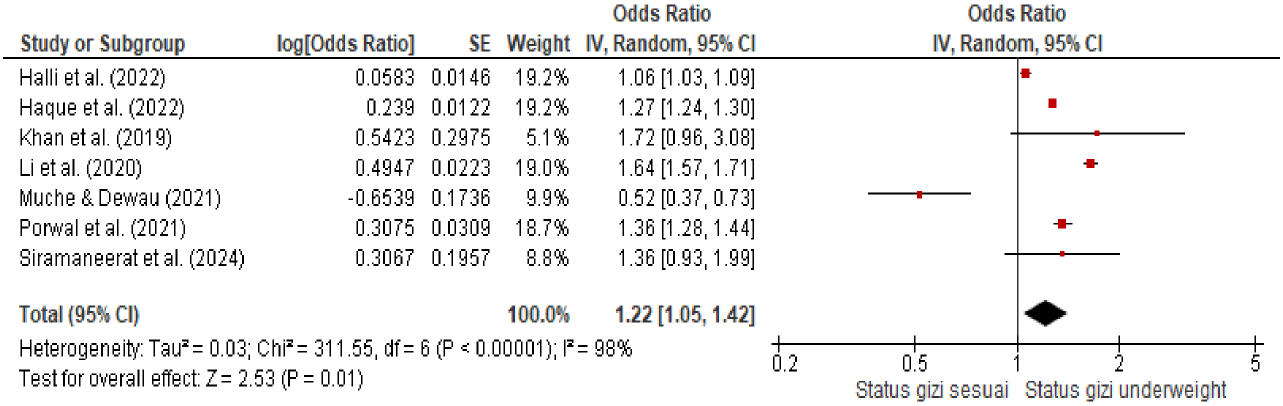

Figure 3. Forest plot of underweight effect on stunting

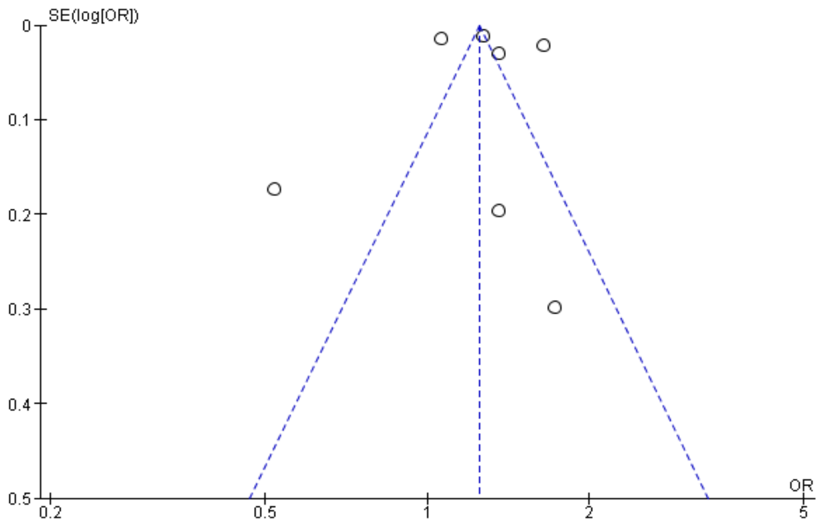

Figure 4. Funnel plot of underweight effect on stunting

3. Abnormal maternal nutritional status (overweight) relationship to the incidence of stunting

The interpretation of meta-analysis results can be visualized through a forest plot (Figure 5). The forest plot results indicate that mothers with inadequate nutritional status (overweight) have a 1.02 times higher risk of giving birth to stunted children compared to mothers with normal nutritional status, with statistical significance ($p<0.001$). The heterogeneity of the study data is indicated by $I^2 = 94\%$, suggesting that the data distribution is heterogeneous, thus justifying the use of a random-effects model.

A funnel plot is a graphical representation that estimates the effect size of each study against the measure of its precision, typically represented by the standard error. Based on Figure 6, there is no indication of publication bias, as evidenced by the symmetrical distribution of plots on both the right and left sides, with three plots on the right and four on the left. The plots on the left side of the graph exhibit standard errors ranging between 0.5 and 0.7, while the plots on the right side have standard errors between 1 and 5.

Table 4. The Value of aOR and 95% CI of Abnormal Maternal Nutritional Status (Overweight) on Stunting

Author (Year)	aOR	95% CI	
		Lower Limit	Upper Limit
Muche and Dewau (2021)	3.43	2.21	5.33
Halli et al. (2022)	1.01	0.97	1.069
Khan et al. (2019)	1.36	0.86	2.12
Porwal et al. (2021)	0.79	0.74	0.85
Siddiqa et al. (2023)	0.724	0.488	1.076
Siramaneerat et al. (2024)	1.164	0.952	1.424
Tesfaw and Fenta (2021)	0.632	0.529	0.755

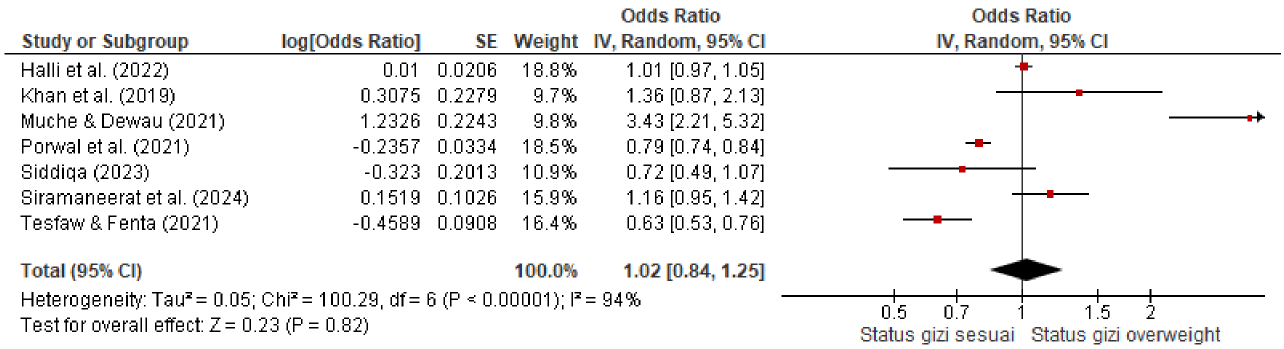

Figure 5. Forest plot of overweight effect on stunting

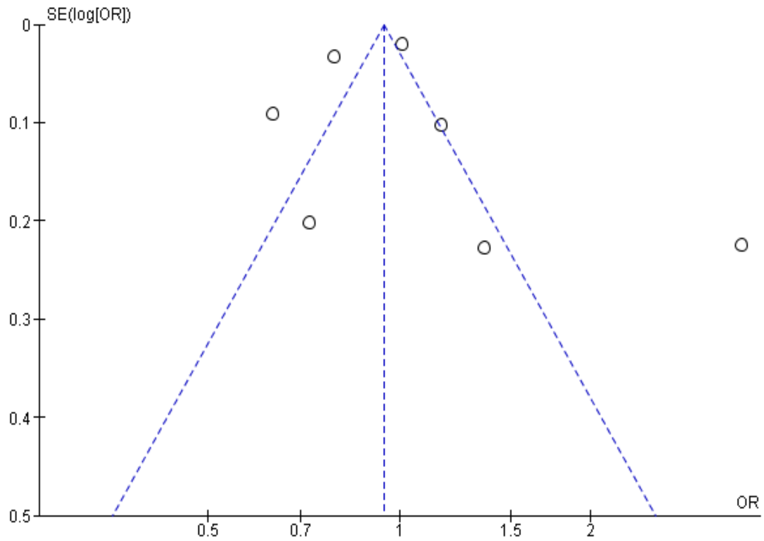

Figure 6. Funnel plot of overweight effect on stunting

DISCUSSION

Stunting is a chronic nutritional problem resulting from inadequate nutrient intake over an extended period. This condition leads to growth disturbances characterized by a height-for-age (H/A) z-score of ≤ -2SD (Ministry of Health, 2018). As a nutritional issue with both short- and long-term consequences, stunting remains a public health concern. This is further supported by the persistently high prevalence of stunting in various countries, regardless of geographic region, economic development status, or income classification. While its direct cause is linked to prolonged inadequate nutrient intake, stunting is influenced by multiple indirect factors (multifactorial causes).

Among the countries included in the analysis, nearly all report a stunting prevalence exceeding 30%. The prevalence of stunting in South and South East Asian was 35.1% in 2014 and declined to 32.1% in 2017/18 (Haque et al., 2022), which is lower than Pakistan's prevalence of 44.4% in 2019 (Khan, 2019). In 2021, the prevalence of stunting among children under five was 36.2% in Nigeria (Tesfaw and Fenta, 2021) and 39% in India in 2022 (Halli, Biradar and Prasad, 2022). Additionally, in 2020, 38.8% of children under five in 35 lower-middle-income countries (LMICs) were stunted (Li, 2020).

All studies included in this research provided data on stunting among children under five years of age. However, the distribution of stunting cases by characteristics varies significantly. For example, in Pakistan and Nigeria, most stunted children were male and lived in rural areas (Khan, 2019; Tesfaw and Fenta, 2021). In contrast, in India, a higher proportion of stunted children were female (Halli et al., 2022).

According to Thompson (2021), boys have a higher risk of infection and malnutrition due to sex-based differences in growth trajectories and immune function, which begin during the prenatal period. However, these biological differences are interpreted by parents within a household context shaped by social and cultural norms, influencing child-rearing and feeding practices. Furthermore, Purwita (2022) highlights that the high prevalence of stunting in rural areas is attributed to factors such as maternal education, household income, maternal nutrition knowledge, exclusive breastfeeding practices, early complementary feeding, zinc and iron adequacy, history of infectious diseases, and genetic factors.

As previously stated, stunting is a complex and multifactorial nutritional problem. Research findings on its determinants are comprehensive, as stunting results from growth disturbances during the first 1,000 days of life (HPK). This means that the issue may originate during fetal development. One of the primary risk factors associated with stunting is maternal nutritional status during pregnancy. Malnourished mothers are more likely to give birth to infants with low birth weight (LBW), increasing the risk of childhood stunting. A study by Harding et al. (2018) in Maternal & Child Nutrition emphasizes that adequate maternal nutrition during pregnancy is crucial in preventing stunting in children.

Exclusive breastfeeding also plays a vital role in preventing stunting. Breast milk provides all the essential nutrients required for optimal infant growth and development. (Black et al., 2013) assert that infants exclusively breastfed for the first six months have a lower risk of stunting. Unfortunately, exclusive breastfeeding practices continue to face challenges, particularly in developing countries.

Another crucial factor is sanitation and access to clean water. Poor sanitation and limited access to clean water increase the risk of infections in children, contributing to stunting. Prendergast and Humphrey (2014) state that recurrent infections, such as diarrhea, hinder nutrient absorption, leading to growth retardation. Therefore, improving sanitation and clean water access is essential in stunting prevention efforts. Maternal nutritional status during pregnancy plays a significant role in stunting prevention. The risk of LBW increases in infants born to malnourished mothers (Harding et al., 2018). Conversely, mothers who meet their nutritional needs through a healthy diet during pregnancy are more likely to have children with optimal growth, reducing the risk of stunting (Victoria, 2008).

Maternal nutritional status during pregnancy can be assessed through pre-pregnancy Body Mass Index (BMI), which serves as a reference for recommended weight gain during pregnancy, both weekly and throughout the entire gestational period. Monitoring maternal weight gain during pregnancy is a key indicator of the quality and quantity of maternal nutrient intake.

Underweight mothers during pregnancy are at an increased risk of having stunted children. Mothers with a BMI <18.5 kg/m² generally face challenges in meeting their nutritional needs, which may impair fetal growth and development. This increases the likelihood of LBW, which, if not properly addressed, can lead to stunting. Nguyen et al. (2018) found that underweight mothers during pregnancy are more likely to give birth to stunted children compared to mothers with normal nutritional status. This finding underscores the importance of adequate maternal nutrition during pregnancy as a critical strategy for stunting prevention.

Beyond underweight status, maternal overweight status during pregnancy can also contribute to an increased risk of childhood stunting. Overweight pregnant women are at higher risk of developing conditions such as gestational diabetes and hypertension, which negatively affect fetal growth. Monitoring maternal weight gain during pregnancy ensures that mothers meet their nutritional needs while preventing excessive weight gain. Popkin et al. (2012) report that the rising prevalence of overweight individuals in LMICs is driven by rapid changes in food systems, particularly the increased availability of affordable ultra-processed foods, and a significant decline in physical activity at work, during transportation, at home, and during leisure due to technological advancements. This phenomenon has led to a "double burden of malnutrition" (DBM) at the household level, where stunted children and overweight mothers coexist under the same roof (IFPRI, 2014).

AUTHOR CONTRIBUTION

Tyas Aisyah Putri, Dinda Anindita Salsabilla, and Tis'a Salma Muthi'ah as a researcher who selects topics, analyzed the data and reviewed the study documents. Tania Vergawita and Komisah searches and collects study data.

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CONFLICT OF INTEREST

There is no conflict of interest in this study.

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