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EFFECT OF STUNTING ON COGNITIVE DEVELOPMENT OF CHILDREN: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT
Stunting is a critical global health issue, with Indonesia ranking third in Southeast Asia for prevalence. This study examines the impact of stunting on cognitive development, its determinants, and interventions in Low- and Middle-Income Countries (LMICs). A systematic review was conducted across ProQuest, Ebsco, PubMed, and SpringerLink for English peer-reviewed articles (2009–2019). Using the PICOS framework, the review focused on stunted children (0–16 years) in LMICs. After screening 157 records and performing quality appraisals, 13 high-quality studies (scores >8/12) were selected for qualitative synthesis. Findings across Africa, Asia, and South America show stunting prevalence between 15.6% and 41.4%. Stunting typically manifests in the first three years due to chronic malnutrition and infectious diseases. Key risk factors include low socioeconomic status and parental education. Stunted children scored significantly lower in memory, spatial ability, and attention compared to non-stunted peers. While some children achieving catch-up growth showed improved results, those who recovered often still lagged behind children who were never stunted. Evidence confirms a strong correlation between stunting and impaired cognitive development. Despite global data, there remains a significant research gap regarding this specific correlation in Indonesia over the last decade.

Keywords: children; cognitive development; low and middle income; stunting

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INTRODUCTION

On a global scale, Asia is home to over half (55%) of the world's children under five suffering from stunting, followed by Africa at 39%. Of the 83.6 million affected children in Asia, the burden is disproportionately concentrated in South Asia (58.7%), while Central Asia exhibits the lowest regional proportion (0.9%). Based on World Health Organization (WHO) metrics, Indonesia is positioned as the third-highest nation for stunting prevalence within the South-East Asia Region (SEAR). Between 2005 and 2017, the mean stunting rate among Indonesian toddlers was documented at 36.4%.

Domestic data indicates that Indonesia's stunting rates persisted at roughly 30% from 2010 through 2018 (Balitbangkes, 2018).). The WHO classifies a 30-39% prevalence threshold as a critical public health emergency. Developmental and growth impairments in the toddler demographic, specifically those involving motor skills, remain a significant concern, with approximately 3 million children (27.5%) currently impacted (UNICEF, 2012). Furthermore, any subtle developmental anomaly that bypasses early screening or adequate clinical intervention can fundamentally erode the future quality of a nation's human capital (Miller, et al, 2016)

Stunting stands as a primary nutritional obstacle globally, with a profound impact on low-income and developing territories. This condition is a pivotal health priority because it correlates with elevated mortality and morbidity, as well as impaired neurological maturation that triggers delays in cognitive and motor progression. Children affected by stunting are statistically more likely to enter

adulthood with lower educational outcomes, diminished economic status, poorer health, and an increased vulnerability to chronic non-communicable conditions.
Empirical work in Guatemala established a clear link between linear growth and developmental milestones during the formative first three years (Lasky et al., 1975). Similarly, longitudinal observations in Jamaica among stunted infants aged 6–24 months tracked changes in stature alongside intellectual performance over a two-year period. Evidence revealed that physical growth patterns in the first year were predictive of cognitive shifts in the second, even when accounting for growth variables in the latter period. It is established that growth failure occurring within the initial 36-month window often results in irreversible, long-term deficits (Powell, et al, 1995)

The body of research cited above confirms that stunting and the associated developmental lags often beginning in utero persist across the lifespan. This highlights physical growth as a meaningful surrogate measure for an individual's cognitive capacity. This study seeks to explore the relationship between stunting and cognitive milestones in children from birth to 16 years old, as well as the determining factors in low- and middle-income nations. These insights are intended to serve as a scientific cornerstone for the design and optimization of stunting eradication and intervention strategies.

METHOD

This study used a systematic literature review through four stages, namely: identification, screening, eligibility, and inclusion. The inclusion criteria for this literature search were: 1) the subjects consisted of stunted children; 2) the research outcome was cognitive development; 3) the articles were research results from the keywords used; and 3) the articles were published between July 2009 and July 2019. The literature search also compiled factors related to stunting on cognitive development. The comparison used was low- and middle-income countries in the world. This study is a systematic literature review with electronic literature searches of academic journals published in the last 10 years, with a time frame from July 2009 to July 2019 and in English. The research methods used were not limited. The electronic literature search was conducted in four databases (ProQuest, Ebsco, PubMed, and SpringerLink) from May to July 2019.

All references found were managed using Mendeley software. Data extraction and analysis from each article were performed by the authors themselves, taking into account the study design, study procedures, and dimensions of cognitive development measured, and the articles had to discuss the material that was the subject of this article. Research quality was assessed using standard criteria that tested classification, selection, and reporting errors by evaluating the following factors: sampling strategy, sample adequacy, anticipation of bias, focus of intervention and comparison group, analysis, statistical test appropriateness, description of intervention procedures, establishment of inclusion and exclusion criteria, research limitations, and reporting of results. Study quality is classified as: high (score 8 to 12), moderate (score 5 to 7), or low (score 4 to 0). Articles used are those with a Quality Assessment score >8.

Data analysis was conducted thematically and organized according to theme analysis and written narratively. The results of the article search were presented using the Preferred Reporting Items for Systematic Reviews & Meta Analysis (PRISMA) instrument and a flow chart compiled based on the 2009 PRISMA checklist guidelines, sequentially excluding articles that did not meet the identified criteria, screening, eligibility, and downloading of the expected articles. This study will be analyzed using a qualitative approach (Moher et al., 2016)

RESULT

Article Characteristics

From the literature search using the systematic literature review technique, 157 articles were obtained with the keywords stunting, children, cognitive development, low and middle income country. After selecting duplicates and open access articles, 150 articles remained. Screening was then conducted, resulting in the exclusion of 137 articles (134 articles did not meet PICOS criteria, and 3 articles were systematic reviews/protocol studies), leaving 13 articles with full text that met all the requirements for synthesis (Figure 1).

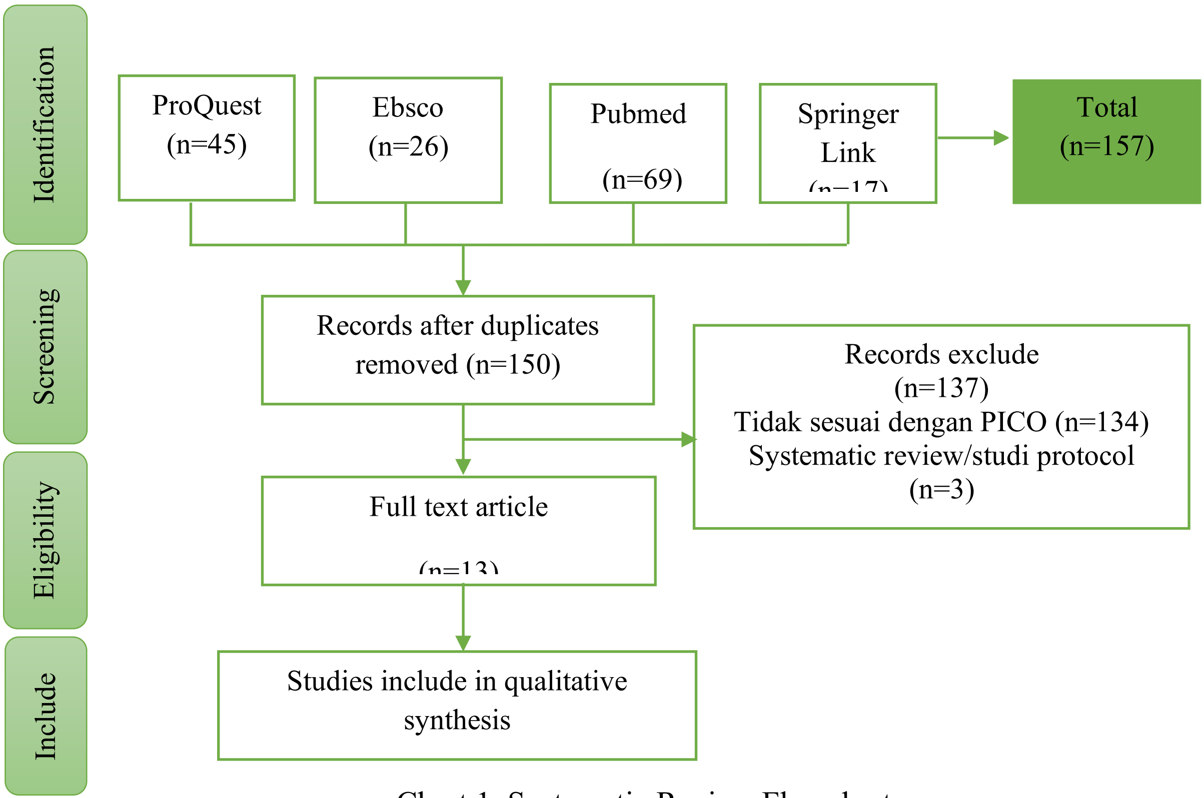

Chart 1. Systematic Review Flowchart

Of the 13 articles synthesized, 6 articles were from Africa, 3 articles were from Asia (the Philippines, India, and Cambodia), 1 article was from America, and 3 articles were from 3 continents (Africa, Asia, and America) that met the criteria for discussing the objectives of this study. Most of the articles obtained (9 articles) were published in the last 5 years. The characteristics of the articles obtained are listed in Table 1.

Table 1.
Article Characteristics

No	Researcher /Year	Article	Location	Research Method	Sampling	Number of Samples	Data Set	Quality Assesment (0-12 point)
1	Sanou et al., 2017)	Association between *stunting* and neuro-psychological outcomes among children	Afrika	Cohort	Tidak disebutkan	532 anak umur 6–8 tahun	• PROMISE SB (Saving Brain) • PROMISE EBF (Exclusive Breast Feeding)	11 High quality
2	(Cheung & Lam, 2009)	Three estimates of the association between linear growth failure and cognitive ability	Filipina	Cohort	Multistage sampling	• 1105 pairs of siblings (11.5 and 9.2 yo) • Child birth (1983-1984) followed until 11 years (1993-1995)	The Cebu Longitudinal Health and Nutrition Survey	11 High quality
3	(Crookston et al.,	Postinfancy growth, schooling, and	Ethiopia, India	Cohort	Tidak disebutkan	• 8062 children	Young Lives	11 High quality

No	Researcher /Year	Article	Location	Research Method	Sampling	Number of Samples	Data Set	Quality Assesment (0-12 point)
	2013)	cognitive achievement: Young Lives	(Andhra Pradesh), Peru, and Vietnam			(1-8y)		
4	(Ajayi et al., 2017)	Factors associated with the health and cognition of 6-year-old to 8-year-old children	Africa	Prospective Cohort	Tidak disebutkan	• 1581 children (4–6 yo) • 1383 children (6-8-yo)	study clinic where the child received a clinical examination	10 High quality
5	(Gashu et al., 2016)	*Stunting*, selenium deficiency and anemia are associated with poor cognitive performance in preschool children	Ethiopia	Randomize control trial	Tidak disebutkan	541 children (54–60 mo old)	study clinic	9 High quality
6	(Pinkerton et al., 2016)	Early Childhood Diarrhea Predicts Cognitive Delays in Later Childhood Independently of Malnutrition	Brazil	Cohort	Tidak disebutkan	131 children (5.6–12.7 years) was monitored from birth to 24 months	Brazilian cohort living in Gonçalves Dias	9 High quality
7	(Sunny et al., 2018)	Does early linear growth failure influence later school performance?	Malawi	Cohort	Tidak disebutkan	• 1595 at birth (0-4m) • 1239 (11-16 m) 1044 (4-8 y)	Malawi Epidemiology and Intervention Unit	11 High quality
8	(Sokolovic et al., 2013)	Catch-up growth does not associate with cognitive development	India	Cohort	Tidak disebutkan	1040 subjects (6 to 12 yo)	Three nutritional intervention studies	10 High quality
9	(Perignon et al., 2014)	*Stunting*, Poor Iron Status and Parasite Infection Are Significant Risk Factors for Lower Cognitive Performance	Kamboja	Randomized Control Trial	Tidak disebutkan	2443 children (6–16 y) from 20 primary schools	FORISCA (Fortified RIce for School meals in Cambodia)	10 High quality
10	(Crookston et al., 2011)	Impact of early and concurrent *stunting* on cognition	Ethiopia, India, Peru and Vietnam	Prospective cohort	Multistage sampling	2052 children aged (6–18 months) from 74 communities	Young Lives	11 High quality
11	(McCoy et al., 2016)	Early Childhood Developmental Status in Low- and Middle-Income Countries	Africa, Asia, Amerika latin	Cohort	cluster random sampling	100,000 children (3-4 yo)	Early Childhood Development Index (ECD)	10 High quality
12	(Casale & Desmond, 2019)	Recovery from *stunting* and cognitive outcomes in young children	Africa	Prospective cohort	Tidak disebutkan	• 2 y (n = 1839) • 5 y (n = 1586).	South African longitudinal cohort, the Birth to Twenty Study (Bt20)	9 High quality
13	(Onifade, et al, 2016)	Nutritional status as a determinant of cognitive development	Nigeria	Cross sectional	Multistage sampling	220 school children (2-5 yo)	A self administered questionnaire	11 High quality

The articles found used various research methods. Ten articles used cohort studies, two articles used randomized controlled trials, and one article used a cross-sectional approach. The most commonly used sampling technique was multistage sampling (three articles). The children's ages ranged from 0 to 16 years. The quality of the studies used was generally high. This systematic literature review traced all types of studies that aimed to assess the effect of stunting on children's cognitive development. The findings of this systematic literature review are summarized in Table 2.

Tabel 2.
Attributes of studies evaluating the effect of stunting on cognitive development

No	Researcher/ Year	Factor Associated with Stunting	Cognitive development assesment tool	Result	Conclusion	Recommendations
1	(Sanou et al., 2018)	Sosio economic status, child's age, schooling, sex (female), stimulation, fathers education, mother employment, breast feeding	• Kaufman Assessment Battery for Children, 2nd edition (KABC-II):memory, spatial abilities, reasoning, general cognition • CCT-1: cognitive flexibility Test of Variable of Attention (TOVA): attention and inhibition	• Prevalence of stunting: 15,6% • Stunted children performed significantly poorer for memory, spatial abilities, general cognition and attention with a small effect size compared to non-stunted children.	Stunting is associated with poorer neuro-psychological outcomes	Joint prevention strategies may then have important roles in reducing poor nutrition and improving neuro-psychological outcomes
2	(Cheung & Lam, 2009)	Socio economic status (SES), Mother education, Wealth index, number of persons per room, sibling, gender (male)	The Philippines Non-Verbal Intelligence Test: analytic and reasoning skills	Random-effects and between-cluster estimators showed strong association between linear growth and cognitive ability, even after adjustment for a range of socio-economic variables	Residual confounding by socio-economic situations may explain a substantial proportion of the observed association between linear growth and cognition in studies that attempt to control the confounding by means of multivariable regression analysis. • For every increase of one Z-score in linear growth, cognitive ability increased by about 0.08 standard deviation	• Replication of similar analysis in other countries is warranted. • SES as a confounding factor is difficult to measure. • It is important to consider factors other than SES, such as genetics.
3	(Crookston et al., 2013)		• Early Grade Reading Assessment: • Peabody Picture Vocabulary Test • Mathematic achievement test	Stunting at 1 year was inversely associated with overage for grade and positively associated with mathematics achievement, reading comprehension, and receptive vocabulary	• Improvements in child growth after early faltering might have significant benefits on schooling and cognitive achievement. • Hence, although early interventions remain critical, interventions to improve the nutrition of preprimary and early primary school–age children also merit consideration.	Improving growth in children who are stunted in infancy and maintaining nutrition in children who otherwise might falter may have significant benefit for schooling and cognitive achievement.
4	(Ajayi et al., 2017)	Paternal level education,	Grover-Counter Scale of	Area of residence, Paternal level of	Children with low cognitive scores	Health programmes at family level based on

		maternal education, pre scool education	Cognitive Development and subtests of the Kaufman Assessment Battery for Children, second edition (KABCII).	education statistically significant factors affecting cognitive test scores.	tended to be stunted (low height-for-age scores), lacked pre-school education and were younger.	the WHO Community Integrated Management of Childhood Illnesses
5	(Gashu et al., 2016)	Sex (male), Selenium deficiency, Anemia deficiency	Wechsler Preschool and Primary Scale of Intelligence and the school readiness test (WPPSI-III) : non verbal reasoning, erbal reasoning and school readiness	Stunted children had lower cognitive scores for all of the psychological tests. Selenium deficient children had lower scores on all cognitive tests than normal children	The present study finding linking chronic undernutrition and micronutrient deficiency to cognitive deficits suggests the need for designing effective intervention programmes to control for protein energy malnutrition and micronutrient deficiency and address cognitive development in children	Identifying the etiological factors and designing appropriate interventions for accelerated stunting reduction and anemia control is vital.
6	(Pinkerton et al., 2016)	Sex (male), Poverty, Household income	• TONI III: Test Nonverbal Intelliegence • NEPSY : verbal fluency WISC-III: coding tasks	ECD (Early Childhood Diarrhea), height for age (HAZ) at 24 months, and weight for age (WAZ) at 24 months were significant univariate predictors of the studies three cognitive outcomes: TONI, coding, and verbal performance	ECD and stunting may have independent effects on children's intellectual function well into later childhood	Both overt diarrhea and malnutrition (possibly related to covert enteric infections or to inadequate diets or both) in early childhood must be addressed by effective interventions if optimal cognitive development is to be achieved among children in impoverished areas
7	(Sunny et al., 2018)	Sex (male), Birth length, Birth weight (kg), Parental education, Sosio economic status, Mother age at birth Mother height	School outcomes	The effects of stunting on schooling were evident in early childhood but were more pronounced in late childhood. Children who were stunted in early childhood (9.3%) were less likely to be underage at enrolment, more likely to repeat Standard 1 and were 2–3 times more likely to be overage for their grade by the age of 11, compared to their non-stunted peers.	Stunting in early and late childhood was associated with poor school outcomes (late enrolment and poor progression through school)	While policies and programmes that prioritise improvements in nutritional status of children in the first 1000 days since conception remain crucial, improving nutrition beyond age 2 may also be beneficial.
8	(Sokolovic et al., 2013)	Paternal and maternal education, family income	• KABC-II • Indian version of Wechsler Intelligence Scale for Children (WISC/-R/-III) • NIMHANS neuropsychological test battery for children (NEPSY)	Stunted children had significantly poorer performance on short-term memory, retrieval ability and visuospatial ability tests. There was no significant difference in the change in cognitive scores following nutritional interventions over a	Evidently, stunting remains associated with cognitive ability in school-age children; however, the reversal of these effects in this age group may be quite difficult	Further research is necessary to disentangle the relative effects of intrauterine environments, early stunting, catch-up growth and present height-for-age on the various domains of cognition.

			The Rey Auditory-Verbal Learning Test (RAVLT) and Koh's Block Design	6-month period between those who remained stunted and those who were no longer stunted		
9	(Perignon et al., 2014)	Child Age, Child Gender, parasite infection, Socio economic status	• Raven's Colored Progressive Matrices test (RCPM) Wechsler Intelligence Scale for Children (WISC III)	• The prevalence of stunting was 40.0%, including 10.9% of severe stunting. Stunted children scored significantly lower than non-stunted children on all tests	• Poor cognitive performance of Cambodian school-children was multifactorial and significantly associated with long-term (stunting) and current nutritional status indicators (iron status), as well as parasite infection. • A life-cycle approach with programs to improve nutrition in early life and at school-age could contribute to optimal cognitive performance.	• Strategies at school-age like deworming, surveys for early recognition and prevention of iron deficiency before the onset of anemia, or interventions to prevent worsening of growth faltering should be considered to contribute to optimal cognitive development. • Combining nutrition specific interventions, such as food fortification, with nutrition sensitive interventions, such as deworming, might have synergistic benefits
10	(Crookston et al., 2011)	Maternal education, wealth index, number of siblings, area of residence	• cognitive development assessments (CDA) • Peabody Picture Vocabulary Test (PPVT)	• Children from urban areas performed better on verbal cognitive tests than those from rural areas • Thus, concurrent stunting had a greater impact on vocabulary test scores than early stunting. The impact of concurrent stunting on CDA scores appeared greater than the impact of early stunting	• Poor nutritional status alone does not account for children's cognitive deficits. The other factors such as wealth, maternal education, area of residence and number of siblings are also important determinants of verbal and quantitative ability	• Efforts to address stunting and poor cognitive performance must involve parents, clinicians, educators, programme planners and implementers, and policy makers. • Broad-based efforts to promote adequate nutrition should aim to reduce stunting during infancy and should continue at least to when children enter school.
11	(McCoy et al., 2016)		Human Development Index	The association between the prevalence of low ECDI scores and stunting, and the association between low ECDI scores and the HDI at the country level. Both correlations are strong	The number of children globally failing to reach their developmental potential remains large. Additional research is needed to identify the specific causes of poor developmental outcomes in diverse settings, as well as potential context-specific interventions that might promote children's early cognitive and socioemotional well-being	Programs that aim to reduce poverty, improve nutrition, enhance stable and stimulating caregiving, improve highquality early educational opportunities, and promote gender equity have the potential to counteract the multitude of risk factors many children continue to experience, and to positively impact children's developmental outcomes across the life span
12	(Casale & Desmond, 2019)	Sex(boy), birth weight, mother education, mother is main caregiver	Revised Denver Prescreening Developmental Questionnaire	• Children who recover from early stunting perform worse on cognitive assessments than	Catch up growth does not mitigate the impact of early growth retardation on later cognitive	Further research is required to investigate the extent to which the negative cognitive impact fades over time,

				those who were never stunted. • The better performance of the catch up group in relation to the persistently stunted group was significant	outcomes	and if it fades equally for moderately and severely stunted children.
13	(Onifade, et al, 2016)	Type of school, Age, low educational level in parents	Developmental checklist developed by the American Academy of Pediatrics	Stunting the most common malnutrition indicator. Stunting was found to have a statistically significant association with cognitive development.	Stunted children have multiple functional disadvantages that persist throughout childhood and poor nutrition almost certainly plays a role.	• Need for the Nigerian Government to intervene by ensuring that policies that will enhance capacity to deliver effective a appropriate nutrition intervention to all, especially the vulnerable groups are • implemented as this will ensure that the health and nutrition needs of preschool children are put in place even before they are born. It will contribute immensely to reduction in the burden of disease and also enhance national productivity

Prevalence of stunting
Overall, the prevalence of stunting ranges from 0.2 to 41.4%. The age of children varies across studies, ranging from 0 to 12 years old. The results of the review show that the prevalence increases with age group.

Factors associated with cognitive outcomes in the study
Of the 13 articles found, the most consistent factors associated with stunting were low maternal education (6 articles). The incidence was higher in boys than in girls (6 articles). Socioeconomic status and paternal education level also influenced cognitive development in stunted children (5 articles). This review did not consider the importance of the quality and quantity of stimulation in children and the genetic potential for stunting (1 article), while the intellectual intelligence (IQ) of the mother or father was not considered in this study.

Cognitive development assessment tool
Various cognitive assessment instruments were used. There were 18 different instruments designed to provide an estimate of overall cognitive ability. The most widely used were the Kaufman Assessment Battery for Children, second edition (3 articles), the Weschler Intelligence Scale, third edition (3 articles), the Peabody Pictures Vocabulary Test (2 articles), and the Neuropsychological Test Battery for Children (2 articles). Some also use school test scores for various subjects as a measure of children's cognitive abilities (1 article). For all cognitive tests, higher scores indicate better performance. Of the 13 articles found, the majority measured children's cognitive development during early childhood (10 articles), middle childhood (7 articles), and late childhood (5 articles).

Cognitive achievement
From 0 months to 5 years (early childhood)
Stunting has a significant relationship with cognitive development. The effects of stunting are evident in early childhood but are more pronounced in late childhood. Stunting at 1 year of age is associated with mathematics achievement, reading comprehension, and vocabulary.

From 5 to 8 years (middle childhood)
Children with stunting perform significantly worse in memory, spatial ability, retrieval ability, visuospatial ability tests, general knowledge, and attention compared to children without stunting. Stunting is associated with poor academic performance (delayed enrollment and poor school performance).

From 8 to 12 years (late childhood)
Stunting remains associated with cognitive abilities in school-aged children. Stunting significantly impairs performance in memory, retrieval abilities, visuospatial ability tests, and poor school performance.

DISCUSSION

This systematic literature review has accessed many sources from various accredited journals. However, this systematic literature review is limited to journals that can be accessed through online sites, and does not access other literature in the form of grey materials. In this review, the prevalence of stunting in boys was higher than in girls. This is similar to the situation in Indonesia, where the prevalence of stunting in boys is 45% higher than in girls (Beal et al., 2018). According to research by Coly et al.(2006), this is because boys experience a growth spurt earlier than girls. In the first year of life, boys are larger than girls, so they require a greater energy intake(Wamani et al., 2007). According to Nzala et al. (2011) differences in parenting styles also have an impact. In Zambia, for example, boys are accustomed to eating with their fathers, which means they receive less food. Girls, on the other hand, are accustomed to eating with their mothers and receive more food. However, other studies have found that gender has no significant correlation with the incidence of stunting (Ekpo, Omotayo, & Dipeolu, 2008).

This review found that low maternal education levels are one of the factors consistently associated with stunting. Higher maternal education means greater use of health services, access to modern medicine, and greater female autonomy, which influence health-related decisions that improve child nutrition outcomes and enable mothers to recognize health problems experienced by their children (Akombi et al., 2017). This is in line with research findings in Brazil and Peru, which found that mothers with higher levels of education can reduce the prevalence of stunting in children (Monteiro et al., 2010). In Indonesia, the educational level of fathers and mothers is a strong determinant of stunting. Children are significantly more likely to be stunted if their mothers have a low level of education, at 43.4%, compared to children whose mothers have a high level of education (Torlesse et al., 2016).

Similarly, higher levels of education among fathers are associated with higher household income and greater food security. Food availability and access are crucial to ensuring adequate nutrition for children. There is a positive correlation between higher levels of education and increased income (Chirande et al., 2015). Households with low-educated parents tend to have low incomes, resulting in inadequate nutrition, greater vulnerability to stunted growth due to lack of access to sufficient food of adequate quality, poor living conditions, lack of access to basic health services, and vulnerability to disease. This review does not consider the importance of the quality and quantity of stimulation in children and the genetic potential for stunting (1 article), while the intellectual intelligence (IQ) of the mother or father is not considered in this study.

The most widely used cognitive development assessment instruments are the KABC-II and WISC-III. The KABC-II is a psychological diagnostic test for assessing the cognitive development of children and adolescents aged 3-18 years (Lichtenberger, 2005). The KABC-II has been widely used in several countries in Africa and elsewhere, as it has good reliability and its testing procedures are age- and culture-appropriate (AGS Publishing, 2005). The WISC-III is widely used in various studies to examine the characteristics of intelligence test results in children aged 5-15 years, such as insight and interest in knowledge, concentration and short-term memory, and various abilities, including: language, mathematics, logical and abstract thinking, visual-motor coordination, visual perception organization, visual-spatial relationships and field dependence, adaptation to the environment, understanding of social norms, and creativity (Beres, Kaufman, & Perlman, 2000).

Most cognitive development assessment instruments are designed using English in high-income countries. Challenges arise when using them in low-income countries (Grantham-McGregor, et al 1997). Despite the localization of many developmental assessment tools through translation into local languages, these instruments may still fail to adequately capture the developmental realities of children growing up in poverty, thereby increasing the risk of biased evaluation results (Prado & Dewey, 2014). Research on child development across eight low-income countries underscored the need for substantial time and careful effort in tailoring developmental assessment tools, establishing and applying standard operating procedures, and maintaining rigorous data quality across multiple study contexts (Murray-Kolb,et al., 2014).

The majority of studies included in this systematic review were carried out in Africa, a region where stunting continues to represent a major public health issue. Stunting influences children's cognitive outcomes through three primary mechanisms: inadequate nutritional intake may disrupt neurological development; reduced energy levels can limit children's participation in peer interactions, thereby constraining learning opportunities; and children who are stunted often experience lower levels of stimulation than their peers of the same age because they are perceived as younger and physically smaller (Brown & Pollitt, 1996).

The review indicated that early childhood stunting is strongly linked to diminished cognitive development, affecting areas such as mathematics achievement, reading comprehension, and vocabulary skills. The age of three represents a particularly sensitive period in early childhood. During the first three years, children undergo rapid development, rendering them especially vulnerable to factors that can positively or negatively impact their physical growth, brain maturation, and cognitive abilities (Scharf et al., 2018). By the age of three, a child's brain has generated billions of neurons and trillions of synapses. In cases of malnutrition or chronic illness, children do not receive adequate nutrients to sustain the development of neural networks or the myelination of neural pathways (Georgieff, 2007).

The review indicated that children who experience stunting during middle childhood demonstrate notably weaker cognitive development, with deficits observed in memory, spatial reasoning, retrieval abilities, visuospatial tasks, general knowledge, and attention compared to their non-stunted peers. Stunting is also linked to poorer academic outcomes, including delayed school entry and lower overall school performance. These results align with a study conducted in Bangalore on children aged 5–7 years, which found that stunted children faced challenges in attention, memory, learning, and visuospatial processing. Thus, stunting can impair cognitive development not only at specific stages but also at higher-order levels, potentially resulting in long-term cognitive deficits (Kar et al., 2008).

The review indicates that stunting during late childhood is closely connected to cognitive performance in school-aged children. Children affected by stunting show notably lower abilities in memory, retrieval, visuospatial skills, and overall academic outcomes. Although the impact of stunting is observable in early childhood, it becomes more pronounced in late childhood. Those who were stunted during early childhood (9.3%) are less likely to reach greater height by age 11 compared to peers without stunting. This underscores the importance and benefit of improving nutrition beyond the age of two, highlighting that interventions should extend beyond the first 1,000 days after conception (Sunny et al., 2018). Chang et al. (2002) conducted a similar study investigating the effects of stunting on cognitive development in children between 9 and 24 months of age. The study found that, relative to children with typical growth, those who were stunted exhibited reduced cognitive abilities by the ages of 11–12, as evidenced by weaker skills in arithmetic, spelling, word reading, and reading comprehension. As a result, stunted children tended to achieve lower educational outcomes compared to their non-stunted peers (Chang, Walker, & Powell, 2002).

In general, stunted children demonstrate lower average cognitive development scores compared to their non-stunted peers, and this difference is significant, suggesting that variations in nutritional status play a role in cognitive development outcomes (Gashu et al., 2016). Children affected by stunting show notably lower performance in memory, spatial skills, overall cognitive functioning, and attention, with a small effect size, relative to their non-stunted peers (Sanou et al., 2018).

Policy Implication

The results of a systematic review show that the causes of poor cognitive development in stunted children are multifactorial and significantly long-term (stunting), with indicators being iron status and parasitic infection (Perignon et al., 2014). A life-cycle approach with programs that improve nutrition in early life and during school age can contribute to optimal cognitive development. The main cause of stunting is malnutrition. Stunting has a significant relationship with cognitive development (Onifade et al., 2016). This review also found that anemia and selenium deficiency are associated with poor cognitive abilities. Therefore, it is necessary to design effective intervention programs by controlling etiological factors to manage protein-energy malnutrition and micronutrient deficiencies in order to accelerate the reduction of stunting and emphasize the importance of controlling anemia (Gashu et al., 2016). Prevention strategies for stunting in school-aged children can be implemented by combining specific nutritional interventions (such as food fortification) with nutrition-sensitive interventions (such as treating intestinal worms), providing synergistic benefits in preventing iron deficiency before anemia develops in stunted children. Addressing stunting is not easy; it requires strong government commitment, the implementation of integrated, sustainable multisectoral programs, and a relatively long time frame.

CONCLUSION

In the last 10 (ten) years, research publications on the effect of stunting on cognitive development have been limited to assessing the relationship between nutritional status and cognitive development in children at the same time. There have been no articles on the nutritional status of mothers before and during pregnancy, psychosocial data, and consumption patterns that affect children's cognitive abilities as an indicator of family welfare. In Indonesia, there have been no publications on this topic, so research is needed to examine the effect of stunting on children's cognitive development with more comprehensive variables such as the nutritional status of mothers before and during pregnancy, consumption patterns, and psychosocial factors in various domains of cognition.

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