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Nutritional Status and Cognitive Development in Children Aged 2-5: A Narrative Review

Fauziah Ismail[1*], Ulya Uti Fasrini[2], Anggia Perdana Harmen[3]

[1] Medical Student, Faculty of Medicine, Andalas University, Indonesia

[2] Department of Nutrition, Faculty of Medicine, Andalas University, Indonesia

[3] Department of Pediatric, Dr. M. Djamil Padang Hospital, Indonesia

* Corresponding author.
E-mail address: f.ismail.2000@gmail.com

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Abstract

Background: Meeting the nutritional needs of children is crucial for optimal growth and development. Children aged 2-5 years are in the preoperational stage, characterized by egocentric and intuitive thinking. Nutritional deficiencies can negatively impact their development, including cognitive abilities and learning capacity. Research worldwide has extensively studied the relationship between nutritional status and children's development, emphasizing the importance of proper nutrition for motor, speech, and behavioral skills essential for learning. This narrative review presents the results of relevant research from various countries on the relationship between nutritional status and the development of children aged 2-5 years in terms of motor skills, speech, and behavior.
Methods: This review is a narrative review of relevant articles from the last decade, focusing on the discussion of the cognitive development process of children and its relationship to nutritional status.
Results: Several studies have linked nutritional status with overall development, while some have specifically focused on motor or cognitive development. Although most results indicate a relationship between nutritional status and the development of children aged 2-5 years, the observed developmental levels and achievements are not entirely conclusive. Child development is also influenced by external factors.
Conclusion: A total of 11 articles from 18 articles stated that there was a significant relationship between nutritional status and children's cognitive development.

Keywords: *malnutrition, cognitive, development, 2-5 years old children, nutritional status*

Introduction

Growth and development are two distinct yet interconnected phenomena that cannot be dissociated. Growth entails a quantitative increase in the number and size of cells across the body, while development denotes the enhancement of more intricate bodily structures and functions through maturation.[1] Cognitive development stands out as a pivotal aspect, emphasizing the capacity for thinking, learning, problem-solving, rationality, and memory.[2,3]

Piaget's theory delineates four stages of cognitive development in children: the sensorimotor stage (0-2 years), the pre-operational stage (2-7 years), the concrete operational stage (7-11 years), and the formal operational stage (12 years and above). Toddlers aged 2-5 years, categorized under the preoperational stage, require heightened attention to foster their development. This stage is characterized by egocentric, intuitive thinking, and a greater reliance on symbolism compared to the sensorimotor stage (0-2 years).[4]

Risk factors associated with cognitive development issues in children can be categorized into internal and external factors. Internal factors encompass genetic predispositions, while external factors include early

stimulation, social circumstances, family economics, and nutrition. Nutrition emerges as a critical determinant of brain development from conception to age three.[5]

Nutritional status reflects the equilibrium between dietary intake and the body's metabolic requirements. Individual nutritional needs vary based on age, gender, and physical activity levels. Children's nutritional status is evaluated through four indices: weight for age (W/A), length/height for age (L/H or H/A), weight according to length/height (W/L or W/H), and body mass index for age (BMI/A).[6,7]

Global nutritional challenges encompass undernutrition and overnutrition. The Global Nutrition Report of 2020 revealed a worldwide prevalence of stunting among under-fives at 22%, wasting at 6.7%, and overweight children under five at 5.7%.[8] In Indonesia, the 2018 Basic Health Research (RISKESDAS) reported 3.9% of toddlers experiencing malnutrition, 13.8% with undernutrition, and 8% with overnutrition. Data from Balitbangkes RI for 2018 indicated that 6.7% of toddlers were underweight and 3.5% were severely underweight.[9]

Undernourished children face difficulties in concentration and learning due to inadequate nutritional intake, resulting in weakness and susceptibility to illness, which limits opportunities for play and education. Addressing nutritional challenges requires concerted efforts from families, healthcare providers, and governmental initiatives.[10] The successful preparation of well-nourished and intellectually developed children today is instrumental in shaping the future quality of human resources. Hence, the authors aim to investigate the nexus between nutritional status and cognitive development among children aged 2-5 years.

Methods

Study Design

This study employed a narrative review approach to elucidate the relationship between nutritional status and cognitive development among children aged 2-5 years. The review aimed to synthesize existing research findings and provide a comprehensive understanding of how nutritional factors influence early cognitive development. The study was conducted between March 2021 and April 2022, with the literature search spanning from October 2021 to March 2022.

Data Sources and Search Strategy

Relevant articles were retrieved from two electronic databases: PubMed and Google Scholar. A systematic search was conducted using predefined keywords and Boolean operators, including (Nutrition OR Nutritional Status) AND (Cognitive Development OR Brain Development OR Intelligence) AND (Toddler OR Under five years old OR Preschooler). The search was limited to articles published between 2011 and 2021.

Eligibility Criteria

To ensure the inclusion of relevant and high-quality studies, specific eligibility criteria were established. The inclusion criteria comprised research articles published between 2011 and 2021, original studies employing cross-sectional or cohort designs, articles available in either Indonesian or English, and full-text articles accessible for comprehensive review. Conversely, studies were excluded if they were duplicates, required paid access, or employed case study research designs, including case series, literature reviews, monographs, or symposium papers.

Study Selection and Data Extraction

The study selection process involved two independent reviewers who initially screened the titles and abstracts of identified studies. Articles meeting the inclusion criteria were retrieved in full text and further assessed for eligibility. Data extraction was performed using a standardized data extraction sheet, which included information on study characteristics, population, sample size, research design, outcome measures, and key

findings related to the relationship between nutritional status and cognitive development. Any discrepancies between the reviewers were resolved through discussion or consultation with a third reviewer.

Data Analysis

A narrative synthesis was conducted to summarize findings from the selected studies. Key themes related to nutritional status and cognitive development were identified, and variations in study results were examined. Due to the heterogeneity in study designs, populations, and outcome measures, no meta-analysis was performed.

Ethical Considerations

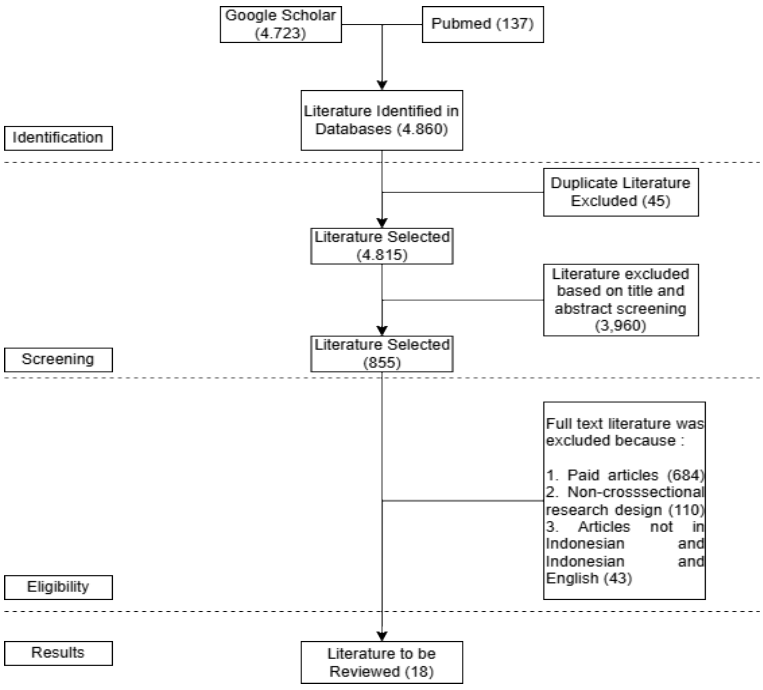
Since this study relied on previously published literature, direct ethical approval was not required. However, all included studies were rigorously reviewed to ensure adherence to ethical research standards, including obtaining informed consent from participants and securing ethical clearance from the relevant institutional review boards.

Results

Based on the literature search process using the predetermined keywords in each database, a total of 4,723 articles were identified on Google Scholar, while Pubmed yielded 137 articles. Thus, the combined total of identified articles across both databases amounted to 4,860. Following a meticulous selection process, 18 articles were chosen for inclusion in this narrative review. (Table 1)

The aggregate sample size of the selected articles was 2,745 individuals. Shimelash's (2015) study featured the largest sample size, comprising 626 participants, whereas Alestari's (2019) research included the smallest sample size, consisting of 34 participants.[10,11] All articles employed anthropometric methods to assess children's nutritional status and adopted a cross-sectional study design.

Geographically, the majority of the reviewed articles (13 in total) were conducted in Indonesia, with two articles originating from Nigeria, and one article each from Egypt, Ethiopia, and Malaysia.



Picture 1. Article Selection Flow

Table 1. Research Matrix

No.	Author, year of publication, sample size, title	Design	Sample Size	Data Analysis Variables	Results	Ref
1.	Reni MK, (2019) Relationship between Nutritional Status and Child Development Aged 24-60 Months in Bener Village, Yogyakarta	Cross Sectional	84 (Indonesia)	Nutritional Status, Child Cognitive Development (KPSP) Pearson Correlation Test	Based on the measurement of nutritional status in children aged 24-60 months in Bener Village, 81% of children with normal nutritional status were found, while 3.6% of children with very thin nutritional status. Based on the KPSP results, 89.3% were appropriate and 2.4% were deviant. There was no association between nutritional status and child development age 24-60 months in Bener Village, Yogyakarta	(12)
2.	Alestari (2019) et Relationship Nutritional al, The of Status with Development Cognitive Development of Children Aged 3-4 Years at Paud Mawar Tlogomas Village Malang.	Cross Sectional	34 Children (Indonesia)	Nutritional Status, Child Cognitive Development (KPSP) Spearman Rank Correlation Test	The results of this study obtained 85.3% (29 children) normal nutritional status and 79.4% (27 children) appropriate cognitive development. There is a relationship between nutritional status and cognitive development of children aged 3-4 years in Paud Mawar Tlogomas Village Malang	(10)
3.	Martha A et al, (2014) Relationship between Nutritional Status and Intake of Iron and Zinc Intake to Motor Function Motor Function of Children Aged 2-5 Years old.	Cross Sectional	91 Children (Indonesia)	Nutritional Status, Iron intake, Zinc Intake, Child Cognitive Development (KPSP) Pearson and Spearman Rank Correlation Test	The results showed that there was no relationship between nutritional status and children's motor development. However, there was a relationship between iron and zinc intake and children's motor development.	(13)
4.	Tekla WS et al, (2019) The Relationship between Nutritional Status and the Development of 3-5 Year Old Children at TK Negeri Pembina Ende	Cross Sectional	127 Children (Indonesia)	Nutritional Status, Child Cognitive Development (KPSP)	The results showed that 85% of children had normal nutritional status, and 80.3% of children were developmentally appropriate. There was a significant relationship between nutritional status and child development.	(14)
5.	Rezky et al, (2017) Relationship between Nutritional Status with Development Gross Motor Development of Pre-school Children in the Kalisongo Posyandu Working Area Dau Subdistrict	Cross Sectional	43 Children (Indonesia)	Nutritional Status, Child Development (KPSP) Spearman Rank Correlation Test	The results showed 58.1% (25 people) of children had good nutritional status, and 60.5% (26 people) had appropriate gross motor development. Based on the Spearman rank correlation test, there was a relationship between nutritional status and gross motor development of preschool children.	(15)
6.	Mariani GK, (2015) Relationship between Nutritional Status with Development Fine Motor Development in Pre-school Age Children at GMIM Solafide Kindergarten Uner Village District Kawangkoan Induk Minahasa Regency	Cross Sectional	42 Children (Indonesia)	Nutritional Status (BB/U), Fine Motor Development (Denver II Observation Sheet) Fischer Exact test	Based on the results of the study, 36 children (85.7%) had good nutritional status, and 6 children (14.3%) had poor nutritional status. Thirty-five children (83.3%) had appropriate fine motor development, while 7 children (16.7%) had inappropriate fine motor development. The chi-square test results showed that there was a relationship between nutritional status and children's fine motor development in preschool-aged children.	(16)
7.	Dewi N, (2018) The Relationship between	Cross Sectional	114 Children (Indonesia)	Nutritional Status, Gross Motor	Based on the results of the study, it was found that children with good nutritional	(17)

	Nutritional Status and Gross Motor Development in 2-3 Year Old Children at the Posyandu of the Situ Udik Health Center Working Area.			Development (DDST II) Chi-Square Test	status amounted to 32.5%, while children with nutritional status less than 64.9%. Children with appropriate gross motor development amounted to 39.5%, and delayed gross motor development was 47.4%. The results of the chi-square test show that there is a relationship between nutritional status and gross motor development of children aged 2-3 years	
8.	Lilik H et al, (2017) Relationship between Nutritional Status with Development Children aged 3-5 years at Posyandu Tawangsari Mojosongo Jebres Surakarta	Cross Sectional	40 Children (Indonesia)	Nutritional Status, Child Cognitive Development (KPSP) Chi-Square Test	The results showed that among children aged 3-5, nutritional status was as follows: very thin, 1 person (2.5%); thin, 7 people (17.5%); normal, 31 people (77.5%); and overweight, 1 person (2.5%). In terms of developmental variables, there were 7 people (17.5%) with inappropriate development and 33 people (82.5%) with appropriate development. The chi-square test results show that there is a relationship between nutritional status and the development of children aged 3-5 years.	(18)
9.	Desmika WS et al, (2012) Relationship between Nutritional Status and Gross Motor Development of Children aged 1-5 years at Posyandu Buah Hati Ketelan Banjarsari Surakarta.	Cross Sectional	40 Children (Indonesia)	Nutritional Status (BB/TB), Gross Motor Development (DDST II) Fischer Exact Test	Based on the results of the study, 67.5% of children had good nutritional status, while 15% had poor nutritional status. Children with appropriate gross motor development amounted to 85%, and delayed gross motor development was 5%. The Fisher exact test results show that there is no relationship between nutritional status and gross motor development of children aged 1-5 years.	(19)
10.	Entie RS et al. (2017). Relationship between Nutritional Status and Development of Children aged 1 5 years in Tidar Utara Village, Magelang City.	Cross Sectional	212 Children (Indonesia)	Nutritional Status, Child Cognitive Development (KPSP) Spearman Rank Correlation Test	Based on the results of the study, the number of children with adequate nutritional status and appropriate development is 3 children (1.42%), the number of children with good nutritional status and appropriate development is 123 children (58.02%), the number of children with less nutritional status and appropriate development is 16 children (7.55%), and the number of children with poor nutritional status and appropriate development is 2 children (0.94%). Based on the results of the Spearman rank test, it shows that there is no relationship between nutritional status and the development of children aged 1 5 years.	(20)
11.	Nuraeni A et al. (2020). Relationship between Nutritional Status and Development of Preschool-Aged Children in the Operational Area of Puskesmas Batua Raya.	Cross Sectional	196 Children (Indonesia)	Nutritional Status, Child Cognitive Development (KPSP) Chi-Square Test	Based on the results of the study, children with good nutritional status were 74.5%, 19.9% were undernourished, 4.1% were malnourished, and 1.5% were overnourished. The results for developmental variables showed that 73.5% of children had appropriate development, 23.5% had questionable development, and 3% had deviant development. The results of the chi-square test showed that there is a relationship between nutritional status and the development of preschool children	(21)
12.	Deni E et al. (2012). The Relationship between Nutritional Status and Participation in Growth and Development Services on Cognitive	Cross Sectional	55 Children (Indonesia)	Nutritional Status, Child Cognitive Development (KPSP) Chi-Square Test	The results showed that there were 22 children (40%) with good nutritional status, and 33 children (60%) with underweight nutritional status. The results of the cognitive development variable showed 58.9% had low cognitive ability, and 39.3% had high cognitive ability.	(22)

	Ability of 2-5 Year Old Children in Padang.				The results of the chi-square test showed that there was no relationship between nutritional status and cognitive abilities of children aged 2-5 years.	
13.	Oktarina W et al. (2012). Relationship between Nutritional Status, Psychosocial Stimulation, and Cognitive Development in Preschool Children in Indonesia.	Cross Sectional	58 Children (Indonesia)	Nutritional status, child cognitive development (Permendikbud developmental instrument), and KPSP. Chi-square test	The results of measuring children's nutritional status showed that 77.6% of preschool children had good nutritional status, 15.5% were underweight, and the rest were overweight. The largest percentage (48.2%) of children were in the moderate cognitive development category (60-79%), and as many as 31.2% of children were in the high category (> 80%) and the rest were in the low category (< 60%). The results showed that social stimulation and nutritional status (TB/U) had a positive effect on cognitive development of pre-school children.	(23)
14.	Oyepeju MO et al. (2016). Nutritional Status as a Determinant of Cognitive Development Among Preschool Children in South Western Nigeria.	Cross Sectional	220 Children (Nigeria)	Nutritional status (anthropometry), development of cognitive function (Milestone Checklist by CDC). Fischer Exact Test	The overall prevalence of malnutrition in this study was stunting (8.2%), underweight (6.8%) and wasting (1.8%). Most of the children had good cognitive performance (88.6%), while there was moderate cognitive performance (11.4%) and poor cognitive performance (5.5%). Among the various indicators of malnutrition measured in this study, stunting was found to have a statistically significant association with cognitive development.	(24)
15.	Tarek AAR et al. (2017). Assessment of Nutritional Status and Cognitive Development of Preschool Children at Minia Governorate, Egypt.	Cross Sectional	288 Children (Egypt)	Nutritional status (anthropometry), cognitive function ability (Stanford-Binet Intelligence Test, Arabic edition 4 (SBITA)). Pearson Product Moment Correlation Test.	Based on the results of BMI measurements by age, 2.1% of children were found to be wasting, 11.1% were malnourished, 18.8% were overweight, and 7.6% were obese. This study concludes that there is a relationship between nutritional status based on BMI measurements by age and children's cognitive function abilities	(25)
16.	Adenike OJ et al, (2018) Relationship between child development and nutritional status of under-five Nigerian Children	Cross Sectional	415 Children (Nigeria)	Nutritional status, child development (Schedule Growing Skills II)	The overall prevalence of malnutrition in this study was stunting (9.1%), underweight (3.8%), wasting (3.8%), and overweight (2.2%). Among the various indicators of malnutrition measured in this study, BW/U was found to have a statistically significant association with child development in the domains of hearing and language, and social interactive domains.	(26)
17.	Shimelash BW et al, (2015) Child development and nutritional status in 12–59 months of age in resource limited setting of Ethiopia	Cross Sectional	626 Children (Ethiopia)	Nutritional status, development child development (ASQ-3) Pearson correlation test	The overall prevalence of malnutrition in this study was stunting (34.1%), underweight (11.9%), and wasting (6.9%). Among the various indicators of malnutrition measured in this study, BW/U and TB/U were found to have statistically significant relationships with child development in the domains of communication, gross motor, fine motor, personal-social, and problem-solving	(11)
18.	Badriah AB et al, (2019). Child Development and Nutritional Status of Children Under Five: A Cross Sectional Study of a Fishermen Community in Terengganu, Malaysia	Cross Sectional	626 Children (Ethiopia) 60 Children (Malaysia)	Nutritional status (BMI/U, TB/U), child development (DDST II). Chi-square test.	Based on the BMI/U measurement results, the prevalence of children who were wasting (23.3%), severely wasting (13.3%), stunting (5.0%), severely stunting (1.7%), and at risk of overweight (1.7%). The results of the chi-square test showed that there was no association between nutritional status and the development of children under five years old.	(27)

Discussions

Assessment of Nutritional Status Using Anthropometric Methods:

Nutritional status assessment can be performed directly or indirectly. The anthropometric method, a direct assessment, is commonly utilized in research. It entails categorizing nutritional status based on specific reference standards. Frequently employed anthropometric reference standards include the WHO and CDC growth curves. This method utilizes four variables: age, gender, weight, and height. Data collection for weight and height can be direct or indirect. Indirect collection methods may include reviewing the KMS (Card Towards Health) book, as demonstrated by Rezky et al. (2017) in their research.[15]

Anthropometric indices include weight for age (W/W), height for age (TB/U), and weight for height (W/TB) or body mass index (BMI). The weight for age parameter (W/U) reflects protein, fat, water, and mineral content in the body. Mariani (2015) employed the BW/U parameter to assess children's nutritional status due to its sensitivity in detecting changes and providing a current overview.[16] Height serves as an indicator of chronic nutritional issues due to its slower rate of change over time. Hence, Badriah (2019) used TB/U and BMI parameters in their research to depict respondents' nutritional status. BMI compares weight (kg) to height (m) squared.[27]

Assessment of Cognitive Development in Children Aged 2-5 Years:

The preschool years, spanning ages 2-5, witness rapid development known as the preoperational stage. Various instruments are available to assess children's development, with the KPSP being one issued by the Ministry of Health of the Republic of Indonesia in 2007. It encompasses motor, language, communication, and social development assessments, making it a widely utilized tool in Indonesia. Lilik (2017) and Entie (2017) employed KPSP in their research due to its ease of use and applicability in basic health facilities.

The Denver Developmental Screening Test II (DDST II) is another tool for assessing development.[18,20] Mariani (2015) assessed fine motor development using DDST II (16), while Dewi (2018) evaluated gross motor development in 2-3-year-olds.[17] Badriah (2021) utilized DDST II to assess overall child development in a Malaysian fishing community.[27]

Additional screening questionnaires include the CDC Milestones, used in Oyapeju's (2016) study in Nigeria, and the Arabic edition of the SBITA (Stanford Binet Intelligence Test)[24], employed by Tarek (2017) in Egypt.[25] The Schedule of Growing Skills II (SGS II) assesses ten developmental domains, including cognitive, as utilized by Adenke (2018) in Nigeria.[26] Shimelash (2015) used ASQ-3 to assess communication, fine motor skills, gross motor skills, problem-solving, and personal-social development in Ethiopian children aged 12-59 months.[11]

Relationship Between Nutritional Status and Cognitive Development in Children Aged 2-5 Years:

Nutritional status, the balance between dietary intake and metabolic needs, significantly influences physical and mental development. Tekla (2019) asserts that maternal nutritional status during pregnancy affects children's development. Poor nutritional status can lead to lethargy and reduced enthusiasm, hindering optimal development.[14]

Studies by Lilik et al. (2017) and Shimelash (2020) supported a significant relationship between nutritional status and child development.[18,11] Conversely, Reni (2019) posited that parenting and parental education, rather than nutritional status, influence development.[12] Martha (2014) suggested that iron and zinc intake also impact motor development.[13]

Alestari et al. (2019) suggested that children with good nutritional status exhibited enhanced cognitive function,[10] corroborated by Nuraeni (2020), who linked malnutrition to delayed brain maturation and decreased cognitive function.[21] Oktarina (2012) emphasized the role of Early Childhood Education (PAUD) in supporting

cognitive development, alongside other factors such as family economic status, parenting patterns, and sociodemographic background.[23,28,29]

Conclusions

Based on the review of eighteen selected studies, several key conclusions can be drawn. The majority of children aged 2-5 years worldwide exhibited normal or good nutritional status, with 1,975 out of 2,745 children assessed falling within this category. Similarly, most children in this age group demonstrated age-appropriate developmental progress, as indicated by the 2,023 children who met expected developmental milestones. Furthermore, 11 out of 18 reviewed articles reported a significant association between nutritional status and cognitive development, suggesting that adequate nutrition plays a crucial role in supporting early brain function, learning capacity, and overall cognitive abilities. These findings highlight the critical importance of proper nutrition during early childhood as a foundational factor for optimal growth and neurodevelopment. Ensuring adequate nutritional intake in early life may contribute to long-term cognitive health and academic success, reinforcing the need for targeted nutritional interventions and public health policies aimed at improving early childhood nutrition.

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Declarations of competing interest

No potential competing interest was reported by the authors.

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