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A SYSTEMATIC LITERATURE REVIEW WITH BIBLIOMETRIC ANALYSIS OF BALANCED NUTRITION AS THE FOUNDATION FOR COGNITIVE DEVELOPMENT IN EARLY CHILDHOOD

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ABSTRACT

Interest in studies on balanced nutrition and early childhood cognitive development has increased significantly over the past decade. This study aims to analyze research trends, identify dominant terms, and evaluate the inclusion of social and educational aspects in the related literature. Data were obtained from the Scopus database and analyzed using a bibliometric approach and VOSviewer for visualization. The results reveal a dominance of biomedical terms such as brain development and cognitive development, while issues like caregiving, stimulation, and education remain underrepresented. Balanced nutrition is often understood separately from the child's social context, even though the effectiveness of nutritional interventions is strongly influenced by the quality of caregiving and the learning environment. This review concludes that sectoral research approaches are insufficient to address the complexity of early childhood development. The implication is that research models and nutrition interventions must be developed not only from a health perspective but also by integrating educational and social perspectives to support the creation of more holistic, needs-based policies for children.

Keywords: balanced nutrition; caregiving; cognitive development; early childhood; holistic approach.

INTRODUCTION

Balanced nutrition is a crucial factor in supporting the growth and development of young children, including cognitive development, which lays the foundation for thinking, learning, and problem-solving. Malnutrition during early childhood can impair brain development and reduce long-term learning capacity. As noted by De and Chattopadhyay (2019)Malnutrition negatively affects children's mental, physical, and future learning abilities, particularly in regions experiencing nutritional disparities and inadequate caregiving. During the so-called golden age of development, the brain undergoes rapid growth and relies heavily on essential nutrients such as protein, iron, and essential fatty acids. This is consistent with the findings of Suryawan et al. (2022), who reported that nutritional deficiencies, including stunting and underweight conditions, significantly affect neurocognitive development, while cognitive recovery remains possible if nutritional status improves before age 8. Thus, fulfilling balanced nutrition from an early age not only supports physical health but also establishes a vital foundation for future cognitive functioning.

From a neurodevelopmental perspective, early childhood represents a critical period characterized by rapid synaptogenesis, neural differentiation, and heightened brain plasticity. Neurodevelopmental models emphasize that cognitive development is not solely determined by

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genetic programming but emerges through dynamic interactions between biological maturation and environmental inputs (Stiles, 2017). Nutrition constitutes one of the most influential environmental factors, as it supports neuronal growth, myelination, synaptic connectivity, and neurotransmitter production. Inadequate nutritional intake during this sensitive period may disrupt these processes, leading to long-term impairments in attention, memory, and executive functioning. Consequently, nutritional adequacy during early childhood is widely recognized as a key determinant of optimal brain development and cognitive outcomes.

The relationship between nutrition and cognitive development has also been explained through the nutrition–cognition pathway, which highlights specific biological mechanisms linking dietary intake to cognitive functioning. Previous studies demonstrate that adequate intake of macronutrients and micronutrients—such as protein, iron, iodine, and essential fatty acids—regulates neuroinflammation, hippocampal functioning, and synaptic plasticity, all of which are essential for memory, problem-solving skills, and executive function. (Spencer et al., 2017). Dipasquale et al. (2020) Further, it is argued that energy and protein deficiencies during childhood adversely affect brain function, resulting in developmental delays and reduced learning capacity. Similarly, Bhutta et al. (2017) Emphasize that severe malnutrition, including wasting and kwashiorkor, is strongly associated with an increased risk of neurological disorders and diminished cognitive potential later in life. These findings reinforce the notion that nutrition is not merely a health-related issue but a fundamental component of early cognitive development and learning readiness.

From a broader ecological perspective, nutritional adequacy should be understood within a complex system of child development involving caregiving practices, educational environments, and socio-cultural contexts. Evidence from public health and developmental research indicates that children who receive adequate nutrition are more likely to demonstrate better attention, engagement, and self-regulation in learning environments, thereby enhancing their ability to benefit from early childhood education programs. (Scarmeas et al., 2018). This perspective aligns with holistic models of child development, which emphasize the interdependence of biological, psychological, and educational factors in shaping cognitive outcomes. Therefore, examining balanced nutrition as a determinant of cognitive development is highly relevant within early childhood education research and practice.

Despite the growing body of research on nutrition and early childhood development, many studies continue to examine nutrition and education as separate domains. Ibrahim et al. (2017) Highlight that childhood malnutrition affects immune function, neurological development, and cognition; however, much of the existing literature remains fragmented, focusing on single dimensions rather than integrated mechanisms linking nutrition to learning capacity. Bibliometric evidence from the Scopus database further indicates that keywords combining “early childhood development” and “nutrition” appear less frequently than terms such as “education” or “cognition” when examined independently. This suggests a persistent gap in comprehensively understanding how balanced nutrition contributes to cognitive development during early childhood.

To address this gap, this study employs a Systematic Literature Review (SLR) combined with bibliometric analysis to explore research trends, keyword distributions, and scientific collaborations related to balanced nutrition and cognitive development in early childhood. These complementary approaches allow for both an in-depth qualitative synthesis and a broad quantitative mapping of the literature. Accordingly, this article aims to identify and analyze scientific publications discussing the relationship between balanced nutrition and cognitive development in early childhood over the past decade. The urgency of this study lies in the need to build data-driven awareness of nutrition’s strategic role in supporting early childhood education, particularly cognitive development, which underpins future academic achievement and social competence. The findings of this review are expected to provide theoretical and practical insights for educators, health professionals, and policymakers in designing holistic and integrative interventions for young children.

METHOD

This study combines the Systematic Literature Review (SLR) method with bibliometric analysis, using secondary data from Scopus to evaluate relevant prior studies and findings. (Carrera-Rivera et al., 2022; Inamdar et al., 2021). Data collection was conducted on 10th July 2025. The data were filtered using the following keywords: (TITLE-ABS-KEY ("Early childhood" OR "preschool" OR "kindergarten") AND TITLE-ABS-KEY ("Nutrition") AND TITLE-ABS-KEY ("Cognitive development" OR "Brain development")) AND PUBYEAR > 2014 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar")). The research instruments used include: (1) Mendeley Reference Manager (Mendeley) to store and manage references, (2) VOSviewer to analyze and visualize the data, and (3) Microsoft Excel to process and visualize the data. Article selection is detailed in Table 1.

Table 1: Article selection criteria.

No.	Inclusion criteria	Exclusion criteria
1.	Articles in English	Articles not in English
2.	Articles with high relevance	Articles with low relevance
3.	Publications from the last 10 years (2015-2024)	Publications outside the 2015-2024 range
4.	Articles with more than one author	Articles with only one author
5.	Articles from the Scopus database with full access	Articles with access limited to abstracts or specific sections
6.	Clearly defined research methods that can be replicated	Unclear research methods that cannot be replicated

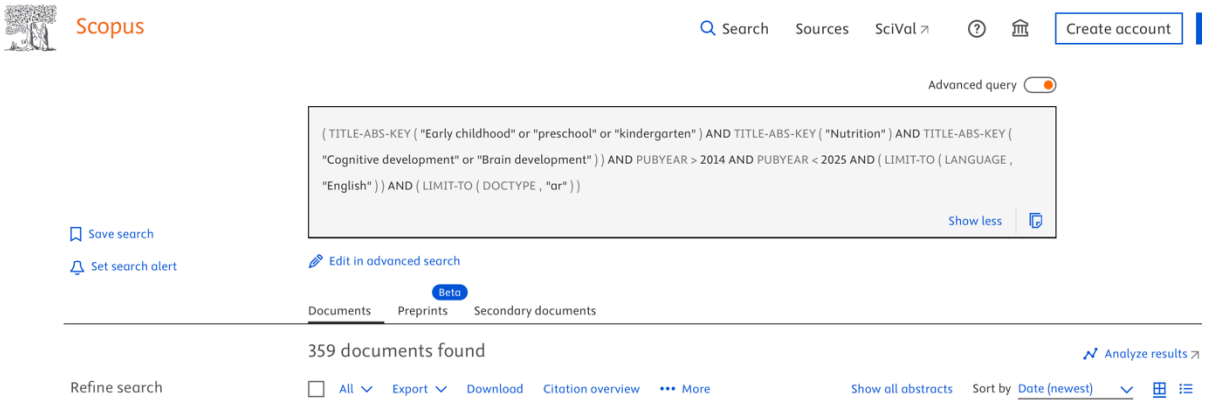
Source: Data processed by Author, 2025.

The main focus of this study is the provision of nutrition and balanced dietary intake in relation to early childhood cognitive development. Accordingly, the research aims to identify: (1) research trends, (2) keywords, (3) publishing journals, (4) author collaboration, (5) affiliations, (6) articles by country, and (7) related scientific fields relevant to the research topic.

RESULTS AND DISCUSSION

Data collection was conducted using the predefined keywords and criteria (Figure 1).

Figure 1: Scopus database search.



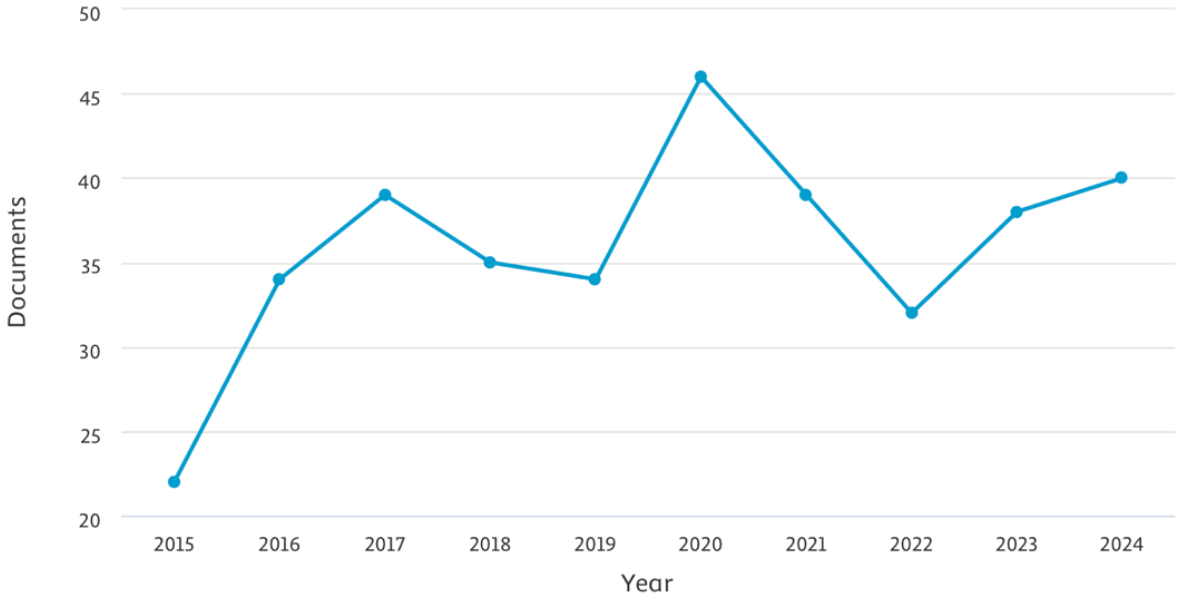
Source: Scopus.com, 2025.

A total of 359 articles were identified based on the specified keywords. This indicates that over the past 10 years, nearly 36 articles per year have been published on nutrition and early

childhood cognitive development. This figure is quite encouraging, reflecting a growing awareness of the importance of balanced nutrition in supporting children's growth and development.

Frequency distribution per year

Figure 2: Global research trends.



Source: Scopus.com, 2025.

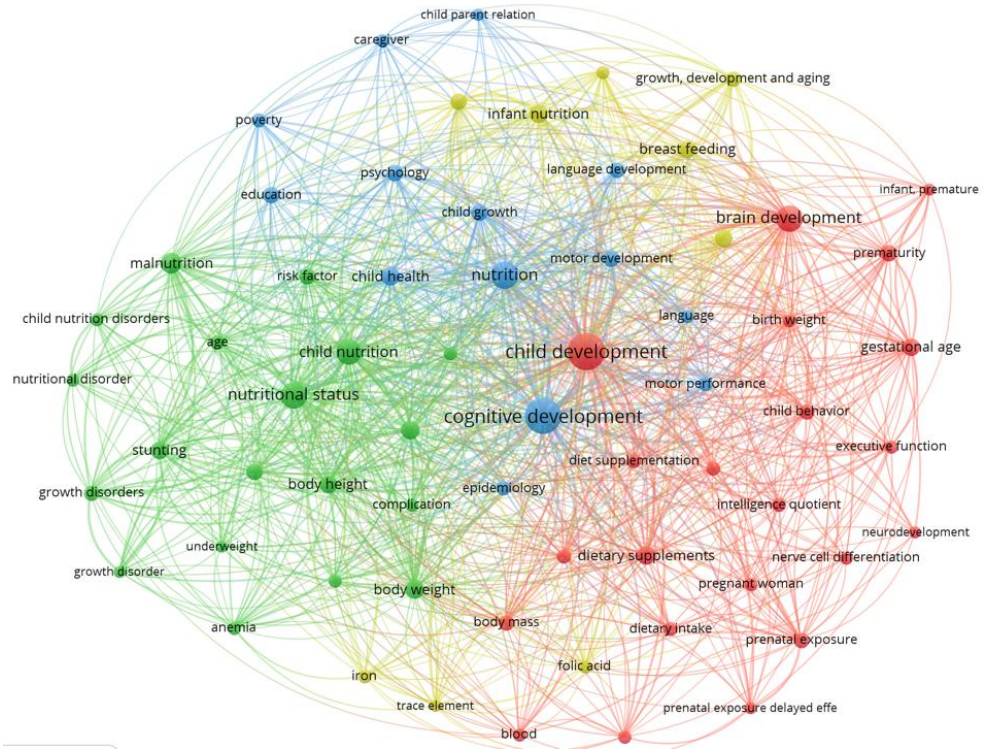
The publication trend graph shows a growing research interest in this topic over the past decade. The year 2015 marked the start, with the lowest number of documents at 22, followed by a significant increase in 2016 to 34 documents. The first peak occurred in 2017 and 2018, with 39 and 35 documents, respectively. In 2020, there was a notable surge in publications, reaching 46 documents, making it the year with the highest publication count. This spike may be associated with increased awareness of the importance of nutrition and early childhood education during the COVID-19 pandemic. However, after this peak, the number of publications declined in 2022 (32 documents), although the trend began to rise again in 2023 (38 documents) and 2024 (40 documents).

Overall, the graph indicates that the topic of balanced nutrition and early childhood cognitive development continues to attract academic attention. The steady trend over the past five years suggests that this issue remains relevant and essential, particularly in supporting evidence-based family intervention policies and early childhood education services. If this trend continues, the number of publications in 2025 and beyond is expected to grow further, given the consistent and upward pattern in recent years.

Keyword Analysis, Overlay Visualization, and Density Visualization

The following image (Figure 3) presents a keyword network visualization generated with VOSviewer.

Figure 3 Keyword network visualization.



Source: Vos Viewer, 2025.

Based on the keyword co-occurrence visualization generated using VOSviewer, it is evident that studies on nutrition and early childhood cognitive development are closely interconnected within several major thematic clusters, each represented by a different color. The dominant keywords at the center of the network—"child development," "cognitive development," and "nutrition"—indicate that research on this topic often explores the relationship between nutritional status and various aspects of child development holistically.

The red cluster focuses on biological and neurological aspects, with keywords such as "brain development," "gestational age," "executive function," "birth weight," and "neurodevelopment." This suggests that studies in this cluster emphasize the link between nutrition and brain function from the prenatal stage through early childhood, including the effects of prenatal exposure and maternal health.

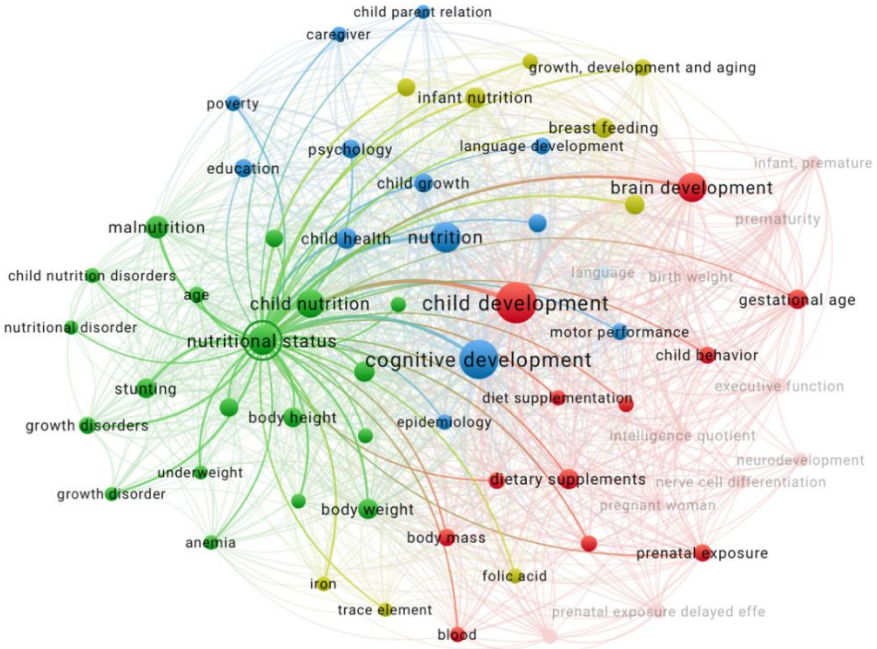
Meanwhile, the green cluster groups issues such as "nutritional status," "malnutrition," "stunting," "anemia," "underweight," and "growth disorders," reflecting a strong concern with undernutrition and its impact on children's physical growth. Keywords such as "child health," "child nutrition," and "risk factor" further indicate a focus on risk factors and the long-term consequences of poor nutrition.

The blue cluster is more closely associated with behavioral and social development, with keywords such as "psychology," "education," "caregiver," and "child-parent relation" highlighting the link between caregiving practices, the social environment, and nutritional influences on psychosocial development.

The yellow cluster centers on early life stages, with keywords such as "infant nutrition," "breastfeeding," "language development," and "motor development," reinforcing the critical role of nutrition from infancy in supporting foundational aspects of child development.

Overall, this visualization illustrates that research on nutrition and early childhood cognitive development is multidimensional, encompassing biological, social, behavioral, and environmental aspects. The dense interconnections among keywords also reflect the close relationships among topics and the importance of interdisciplinary approaches for comprehensively understanding and addressing issues related to child growth and development.

Figure 4: The relationship between balanced nutrition, cognitive development, and child development.



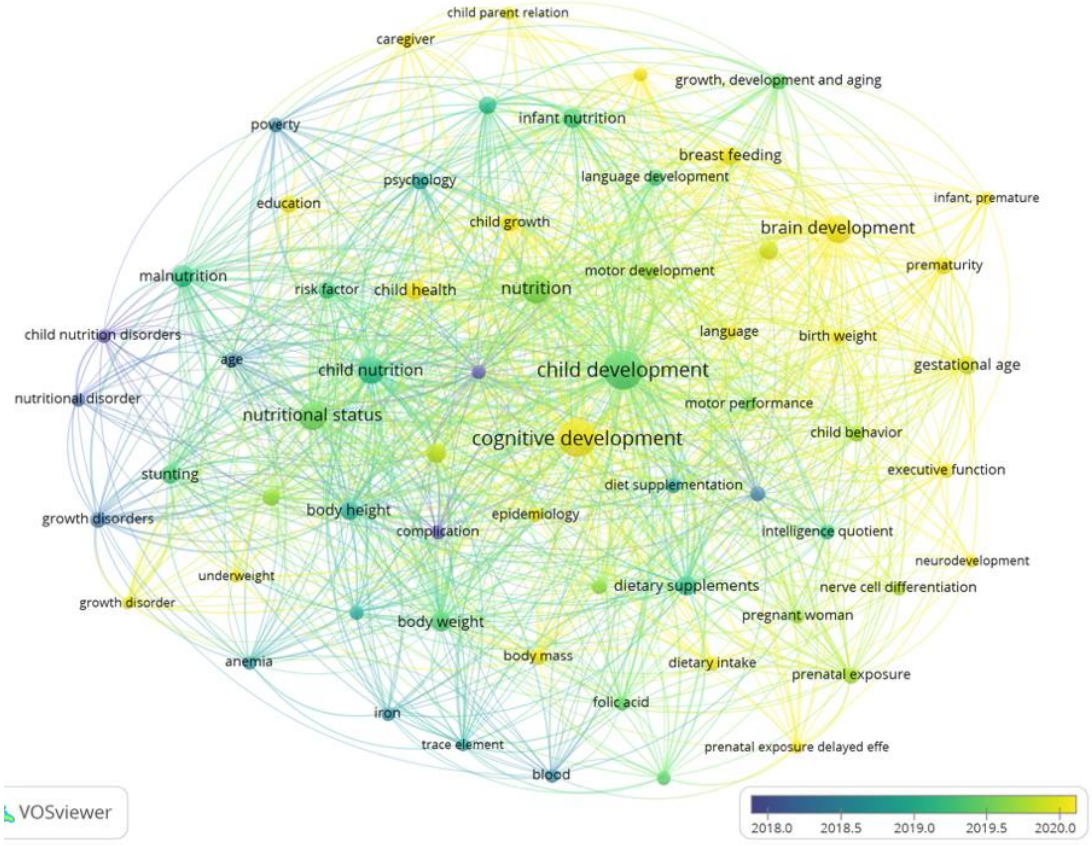
Source: Vos Viewer, 2025.

The relationship between nutritional status, cognitive development, and child development is clearly illustrated through strong and layered connections, both directly and via intermediary keywords. A child's good nutritional status—reflected in indicators such as body weight, height, and micronutrient adequacy—significantly contributes to cognitive development. This is reinforced by the dense links between nutritional status and keywords such as iron, folic acid, dietary supplements, and brain development, indicating that nutritional deficiencies can directly affect brain function, learning, memory, and attention in early childhood.

In addition, the connection between nutritional status and child development is also highly prominent. The node "child development" is closely linked to terms related to physical growth and motor skills, such as child growth, motor performance, and birth weight. This shows that nutritional status affects not only cognitive aspects but also overall development, including motor, socio-emotional, and behavioral capabilities. This relationship is further clarified by prenatal factors, such as gestational age and prenatal exposure, highlighting that maternal nutrition during pregnancy also plays a vital role in supporting fetal brain development and a child's readiness for postnatal growth and learning.

Overall, these findings emphasize that nutritional status is a fundamental pillar in optimizing cognitive and overall child development. The three are closely interconnected within a complex, multidimensional system. Therefore, proper and sustained nutritional interventions from the prenatal period through early childhood are strategic steps to prevent developmental delays and maximize children's potential. This visualization also provides strong scientific evidence for the importance of mainstreaming nutrition into early childhood education policies and practices.

Figure 5 Overlay visualization.



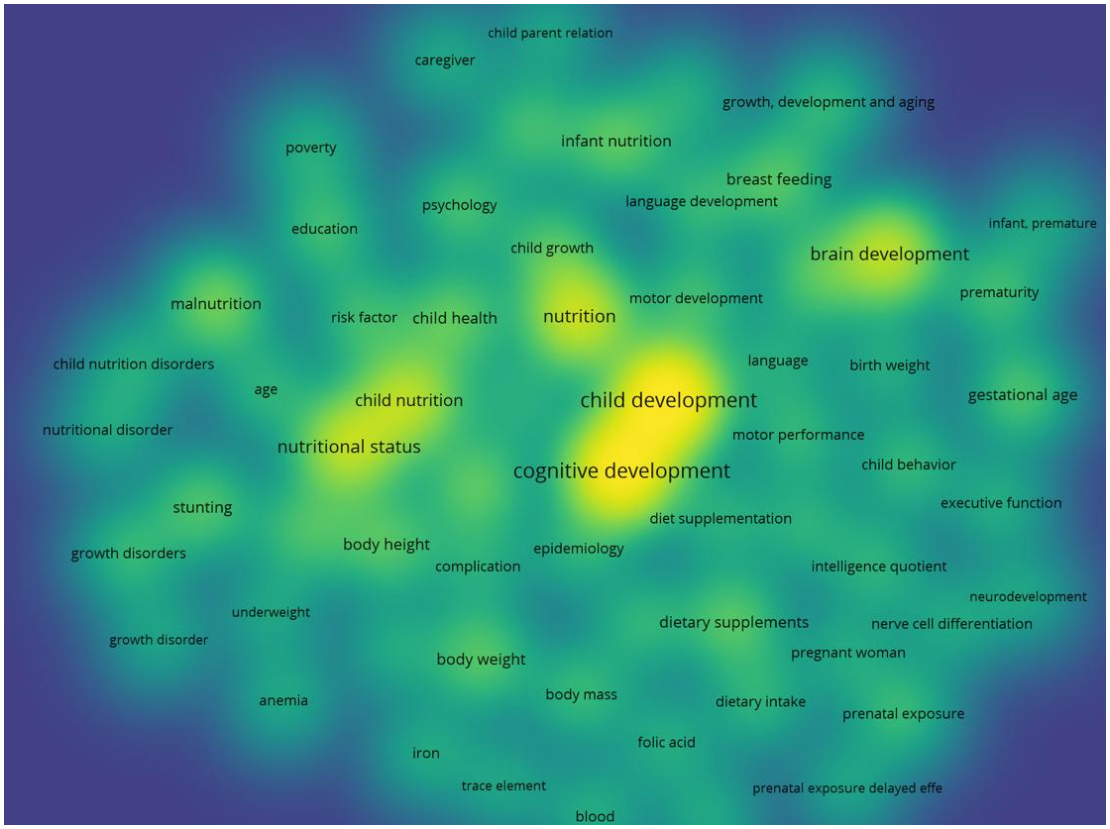
Source: Vos Viewer, 2025.

In Figure 5, the colors represent the temporal distribution of publications, where blue indicates earlier years (around 2018), while yellow reflects newer or emerging topics up to 2020. This map provides additional insights into the evolution of themes and research trends related to nutritional status and early childhood development. Overall, core terms such as nutritional status, child nutrition, child development, and cognitive development appear in green, indicating that these topics have been consistently studied from 2018 to 2019. However, several more recent keywords, including brain development, prenatal exposure, executive function, language development, and gestational age, are shown in bright yellow. This suggests a recent shift in research focus toward prenatal and neurocognitive dimensions of child development linked to nutritional status.

Interestingly, terms such as education, poverty, and caregiver appear in blue-to-green areas, indicating that socioeconomic factors and caregiving patterns in the context of child nutrition have been recognized since early on but have seen limited recent development. In contrast, topics such as dietary intake, neurodevelopment, and executive function—related to specific aspects of brain function—have received greater attention in recent years.

Thus, it can be concluded that current research increasingly emphasizes the relationship between a child's nutritional status—including from the prenatal period—and more complex cognitive aspects such as brain development, executive functioning, and language processing. This shift indicates that early childhood nutrition research has evolved beyond physical growth to a deeper understanding of how nutrition underpins cognitive abilities and school readiness. These findings reinforce the urgency of designing nutritional interventions that are not only quantitative but also qualitative and sensitive to the critical phases of brain development from pregnancy through the early years of life.

Figure 6: Density visualization.



Source: Vos Viewer, 2025.

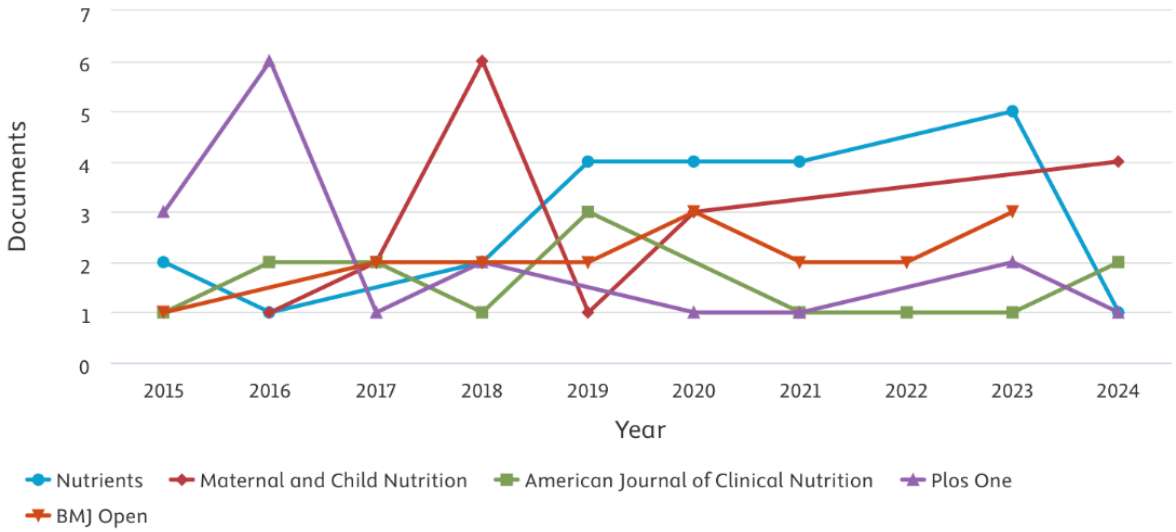
The density visualization in Figure 6 illustrates the concentration or frequency of keyword occurrences within scientific publications. Bright yellow areas indicate the highest density—meaning these keywords appear most frequently in the literature—while green, blue, and purple areas represent progressively lower frequencies. This analysis offers a clearer understanding of the primary research focus within the field of nutritional status and early childhood development.

It is evident that terms such *as* 'child development, nutritional status, child nutrition, and cognitive development' appear as the brightest points on the map, indicating that these four topics are at the core of current research and most commonly co-occur in the literature. This highlights the dominant focus on the relationship between nutritional status and child development, both in general and in cognitive development, over the past several years. Additionally, terms like 'brain development and nutrition' also show high density, reinforcing the growing attention to neurocognitive development in the context of early childhood nutrition.

Meanwhile, keywords such as 'malnutrition, stunting, anemia, iron, and dietary supplements' appear in moderately bright green zones, indicating that topics related to undernutrition and supplementation interventions are also actively researched, though not as intensively as the primary themes. On the other hand, terms like 'education, poverty, caregiver, and psychology' appear in dimmer blue to purple areas, suggesting that while social and psychosocial issues are relevant, they have not yet become dominant focuses in the scientific literature in this domain. Overall, this density map reinforces the finding that children's nutritional status—both in terms of adequacy and deficiency—is strongly linked to cognitive and overall child development.

Most Publishers

Figure 7: Top 5 most productive publishers.



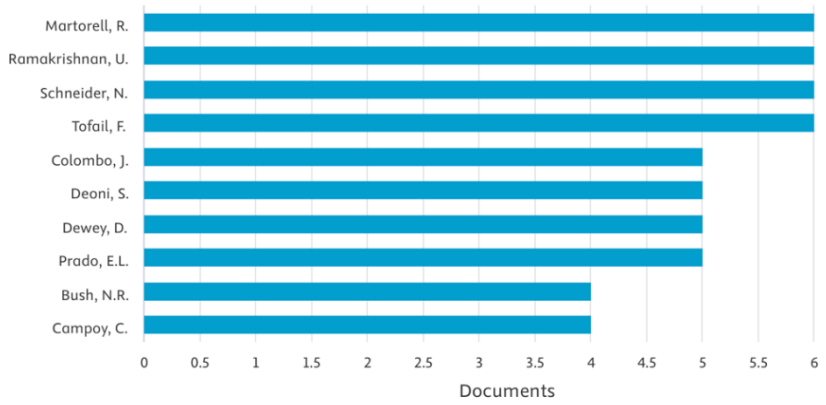
Source: Scopus.com, 2025.

Based on an analysis of Scopus publications, five journals have consistently published articles on balanced nutrition and early childhood cognitive development between 2015 and 2024. 'Nutrients' emerged as the most productive source with a total of 23 documents, highlighting its dominant role in disseminating research on this topic. It is followed by 'BMJ Open, Maternal and Child Nutrition, and PLOS ONE', each with 17 documents, and 'The American Journal of Clinical Nutrition' with 14 papers. The publication trend shows that *Nutrients* experienced a significant rise starting in 2018, peaking in 2023 before sharply declining in 2024. Meanwhile, 'Maternal and Child Nutrition' saw a notable increase in 2018 and maintained a gradual upward trend in the following years. 'BMJ Open' demonstrated relatively stable consistency, with 2–4 articles per year since 2020, while 'PLOS ONE' has shown a decline in contributions since 2016. 'The American Journal of Clinical Nutrition' displayed a fluctuating but steady output, whereas 'The Journal of Nutrition and Pediatrics' was more active earlier in the decade, contributing fewer articles in recent years.

This analysis concludes that the most active journals—particularly 'Nutrients and Maternal and Child Nutrition'—serve as key references and potential targets for researchers aiming to publish on the relationship between nutrition and early childhood development. The dominance of journals in nutrition and health also reflects the fact that balanced nutrition is not only a medical concern but is also powerfully relevant to supporting early childhood growth from educational and caregiving perspectives.

Author and Co-Authorship Analysis

Figure 8: Top 10 most productive authors.



Source: Scopus.com, 2025.

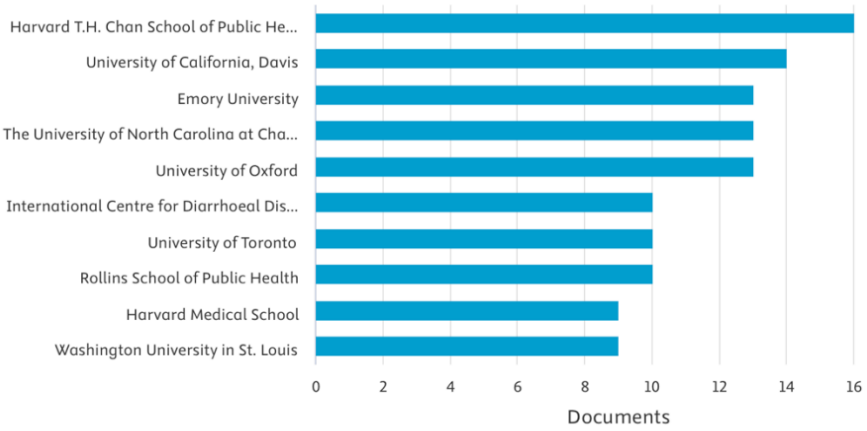
Based on the author's analysis of the document data, several researchers have consistently focused on balanced nutrition and early childhood cognitive development. The most productive authors in this field are Martorell, R., Ramakrishnan, U., Schneider, N., and Tofail, F., each of whom has published six documents on this theme. These four authors occupy the top positions and can be considered key figures or primary references in research on child nutrition and development. In addition, five other authors—Colombo, J., Deoni, S., Dewey, D., Prado, E.L., and Bush, N.R.—each contributed five documents, indicating a strong but slightly lower level of consistency in this area. One other name, Campoy, C., is listed with four documents.

The presence of these authors is significant as it highlights an active network of researchers exploring the relationship between nutrition, cognitive stimulation, and early childhood growth. Their work can serve as core references for literature reviews and as foundational sources for understanding theories and evidence-based interventions. Moreover, they offer potential for academic collaboration or as resource persons in the development of curricula and training programs in early childhood education and child nutrition.

Most Affiliates

Research on balanced nutrition and early childhood cognitive development, as shown in Figure 10, is dominated by several leading academic and research institutions worldwide.

Figure 10: Top 10 most active affiliated institutions.



Source: Scopus.com, 2025.

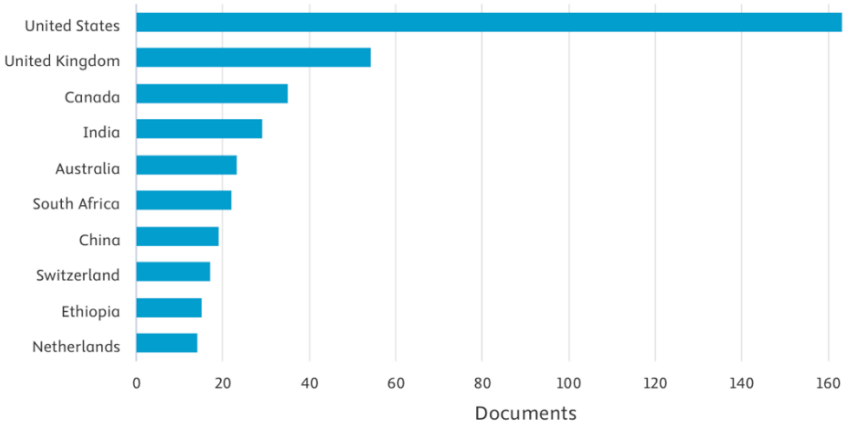
The institution with the highest number of publications is the Harvard T.H. Chan School of Public Health, with 16 publications, reaffirming its strategic position as a leading center for research in public health and child nutrition. Next, the University of California, Davis contributed 14 documents, followed by three institutions—Emory University, The University of North Carolina at Chapel Hill, and the University of Oxford—each contributing 13 papers. These institutions are renowned for their consistent support of multidisciplinary studies in health, early childhood education, and nutrition.

Furthermore, the International Centre for Diarrhoeal Disease Research, Bangladesh, the University of Toronto, and the Rollins School of Public Health each produced 10 documents, indicating that contributions from developing countries such as Bangladesh also play a significant role in global research on this topic.

Additionally, Harvard Medical School and Washington University in St. Louis are also among the top contributing institutions, each with nine documents. The involvement of these prestigious institutions underscores that the relationship between nutrition and cognitive development in early childhood is a strategic issue that has garnered significant attention from global research institutions.

Document by Country

Figure 11: Countries with the highest number of publications.



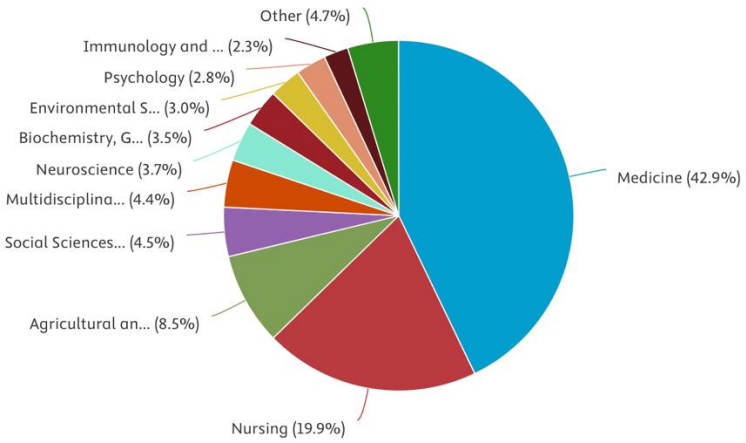
Source: Scopus.com, 2025.

Based on the analysis of publication distribution by country or region, the United States emerges as the top contributor to research linking balanced nutrition and early childhood cognitive development, accounting for 163 of the 359 analyzed articles. This number indicates a significant dominance compared to other countries. The United Kingdom ranks second with 54 documents, followed by Canada (35), India (29), and Australia (23). Notable contributions also come from countries such as South Africa (22 documents), China (19 documents), Switzerland (17 documents), Ethiopia (15 documents), and the Netherlands (14 documents). This demonstrates that the topic of nutrition and child development is not only a concern for developed nations but has also gained significant attention in developing countries—especially those facing early childhood nutrition challenges.

This geographical distribution shows that research on this topic has a global dimension, reflecting its importance across various social, economic, and cultural contexts. The diversity of regions involved also enriches research outcomes through varied approaches, nutrition policies, and specific child development conditions by region. Thus, the findings indicate that balanced nutrition as a foundation for early childhood cognitive development is a strategic, multidisciplinary global issue that contributes significantly to advancing early childhood education policies and practices worldwide.

Subject Area

Figure 12: Top 10 subject areas.



Source: Scopus.com, 2025.

Based on the subject area analysis of the 359 reviewed documents, most publications on balanced nutrition and early childhood cognitive development fall under the field of medicine, accounting for 246 papers (approximately 42.9% of the total). This indicates the strong relevance of the topic to child health and the prevention of stunting and malnutrition from an early age. Nursing ranks second with 114 documents (19.9%), reflecting significant attention from primary healthcare sectors, including the roles of nurses and midwives in monitoring child growth and development. The field of Agricultural and Biological Sciences contributes 49 documents, or 8.5%, highlighting the connections among food quality, food security, and child nutrition.

Meanwhile, the social sciences and multidisciplinary fields contribute 26 and 25 documents, respectively, indicating that this issue is viewed not only from a medical standpoint but also through sociocultural and interdisciplinary approaches. In addition, areas such as neuroscience, biochemistry, and molecular biology, and psychology are also quite significant, each contributing between 16 to 21 documents, highlighting the growing body of scientific research on the impact of nutrition on brain development and cognitive function in children.

Overall, this distribution reflects that the topic of nutrition and cognitive development in early childhood is interdisciplinary and increasingly approached from various scientific perspectives. The dominance of the medical and nursing fields emphasizes physical health. At the same time, contributions from the social sciences, agriculture, and psychology provide a comprehensive understanding of the environmental and behavioral factors that influence early childhood development.

DISCUSSION

This review shows that research trends on the relationship between balanced nutrition and early childhood cognitive development have significantly increased over the past decade, with a notable surge in 2020 that coincided with the COVID-19 pandemic. This increase reflects growing global awareness of the importance of early nutritional support for optimal child growth and development. These findings are consistent with Bhutta et al. (2017), who emphasized that early-life malnutrition is strongly associated with reduced neurological potential. Pinkerton et al. (2016) Further demonstrated that early-life diarrheal infections can impair cognitive function even when nutritional status is controlled, while De Silva and Sumarto (2018) Highlighted that economic growth alone is insufficient to reduce stunting, underscoring the need for integrated nutritional, educational, and sanitation interventions.

The keyword network visualization reveals that “child development,” “nutrition,” and “cognitive development” form the central cluster, closely connected with biological and

neurological terms such as “brain development” and “executive function.” These associations align with neurodevelopmental theories, which emphasize that the early years represent a sensitive period during which the brain is highly responsive to nutritional adequacy. Empirical evidence supports this linkage, as studies by Galler et al. (2021) and Nahar et al. (2020) Demonstrate that early malnutrition can lead to lasting structural brain changes and delays in language, motor, and cognitive development. This pattern indicates that balanced nutrition plays a foundational role in shaping early cognitive trajectories by supporting neural growth and functional brain organization.

However, despite the prominence of nutrition-related research, the bibliometric findings also reveal a critical conceptual gap. While biological and health-oriented outcomes dominate the literature, cognitive processes such as attention, learning readiness, and executive functioning are often treated as secondary or indirect outcomes rather than central constructs. This suggests that balanced nutrition has not yet been sufficiently positioned as a key determinant of cognitive development within the research landscape. As a result, the mechanisms by which nutritional adequacy translates into improved learning capacity and educational outcomes remain underexplored, particularly in early childhood education.

Other thematic clusters—covering stunting, anemia, and underweight—highlight the widespread consequences of chronic malnutrition and further reinforce the need for cross-sectoral approaches that integrate psychological, educational, and caregiving dimensions—studies by Ahmad et al. (2020) And Govender et al. (2021) Point to cultural norms, parental education levels, income inequality, and limited healthcare access as systemic barriers to the effectiveness of nutritional interventions. These findings suggest that nutritional inadequacy is not solely a biomedical issue but is deeply embedded within broader social and educational contexts that influence children’s cognitive development.

The bibliometric shift toward neurocognitive outcomes, including language development and executive function, indicates an emerging recognition of nutrition’s role beyond physical growth. Nevertheless, this shift remains limited in scope. While studies by Dipasquale et al. (2020) And Keats et al. (2021) Emphasize the importance of combining nutritional strategies with cognitive development targets; few studies explicitly integrate these findings into early childhood education frameworks or classroom-based interventions. This gap highlights the need to translate biological evidence into pedagogically meaningful practices that support children’s cognitive engagement and learning readiness.

Density visualization further confirms the dominance of biological keywords. In contrast, social and educational factors such as “caregiver,” “parental involvement,” and “education” remain underrepresented, despite their critical role in integrated early childhood development. Existing evidence indicates that inadequate caregiving practices and limited psychosocial stimulation can exacerbate developmental delays, even when nutritional status improves. This underscores the importance of situating balanced nutrition within holistic developmental models that consider both biological sufficiency and enriched learning environments.

Overall, this review's findings emphasize that balanced nutrition is not merely a preventive health measure but an inseparable foundation for enhancing early childhood cognitive development and educational quality. Adequate nutrition supports cognitive ability, learning readiness, emotional regulation, and executive functioning, all of which are essential for successful early learning experiences. Addressing the identified research gap requires sustained interdisciplinary collaboration among health professionals, early childhood educators, and policymakers to integrate nutrition and education into holistic, long-term intervention programs that effectively support children’s cognitive potential during the most critical stages of development.

CONCLUSION

Based on the findings of the systematic literature review and bibliometric analysis, this study concludes that balanced nutrition plays a fundamental role in supporting early childhood cognitive development. The empirical results demonstrate an apparent increase in scientific

interest over the past decade in examining the relationship between nutritional status and children's neurocognitive function, particularly during the golden age period. This trend is evident in the dominance of key terms such as child development, cognitive development, and brain development in the density visualization, indicating a shift in research focus from purely physical growth outcomes to more complex cognitive dimensions, including executive function, memory, and language development.

However, the bibliometric patterns also reveal a significant imbalance in the research landscape. While biological and medical dimensions of nutrition are extensively studied, social and educational factors—such as caregiving practices, academic environments, and psychosocial stimulation—remain underrepresented. This finding directly aligns with the discussion, which highlights that contextual factors beyond biological intake alone strongly influence the effectiveness of nutritional interventions. Moreover, evidence from the reviewed studies indicates that micronutrients, including iron, essential fatty acids, and protein, play a critical role in supporting brain structure and function, particularly in socioeconomically disadvantaged contexts. These results reinforce theoretical arguments that cognitive development emerges through the interaction of biological sufficiency and enriched environmental inputs.

Drawing on both empirical findings and neurodevelopmental perspectives discussed in this study, it is evident that malnutrition affects not only physical growth but also learning capacity, school readiness, and long-term cognitive potential. Therefore, balanced nutrition should be conceptualized not merely as a health-related issue but as a strategic foundation for early childhood cognitive development and educational quality. This study contributes to bridging medical and educational approaches by demonstrating the need for interdisciplinary frameworks that integrate nutritional science, developmental psychology, and early childhood pedagogy.

Accordingly, the conclusions from this review support the need for cross-sectoral, evidence-based interventions. Collaborative strategies among government institutions, healthcare professionals, early childhood educators, and communities are essential to translate research findings into effective practice. Strategic recommendations derived from the analysis include: (1) Integrating nutrition programs and early childhood education into PAUD curricula, including teacher training on the importance of stimulation and monitoring children's nutritional status; (2) Strengthening the role of integrated health service post (*posyandu*) and primary healthcare services as centers for growth monitoring and micronutrient education for parents; (3) Formulating multisectoral, data-driven policies involving health, education, and child protection sectors to create a healthy learning environment that supports brain development; (4) Increasing support for research examining the causal relationship between nutritional interventions and early childhood cognitive outcomes within Indonesia's local sociocultural contexts, particularly in Indonesia.

In conclusion, by explicitly linking bibliometric evidence with theoretical and empirical insights, this study affirms that balanced nutrition is not only a preventive health measure but also a critical pillar for inclusive, holistic, and sustainable early childhood education development.

REFERENCES

Ahmad, D., Afzal, M., & Imtiaz, A. (2020). Effect of socioeconomic factors on malnutrition among children in Pakistan. *Future Business Journal*, *6*(1), 30. https://doi.org/https://doi.org/10.1186/s43093-020-00032-x

Bhutta, Z. A., Berkley, J. A., Bandsma, R. H. J., Kerac, M., Trehan, I., & Briend, A. (2017). Severe childhood malnutrition. *Nature Reviews Disease Primers*, *3*(1), 1–18. https://doi.org/doi:10.1038/nrdp.2017.67

Carrera-Rivera, A., Ochoa, W., Larrinaga, F., & Lasa, G. (2022). How to conduct a systematic literature review: A quick guide for computer science research. *MethodsX*, *9*, 101895. https://doi.org/10.1016/j.mex.2022.101895

De, P., & Chattopadhyay, N. (2019). Effects of malnutrition on child development: Evidence from a backward district of India. *Clinical Epidemiology and Global Health*, *7*(3), 439–445. https://doi.org/https://doi.org/10.1016/j.cegh.2019.01.014

De Silva, I., & Sumarto, S. (2018). Child malnutrition in Indonesia: can education, sanitation, and healthcare augment the role of income? *Journal of International Development*, *30*(5), 837–864. https://doi.org/https://doi.org/10.1002/jid.3365

Dipasquale, V., Cucinotta, U., & Romano, C. (2020). Acute malnutrition in children: pathophysiology, clinical effects and treatment. *Nutrients*, *12*(8), 2413. https://doi.org/https://doi.org/10.3390/nu12082413

Galler, J. R., Bringas-Vega, M. L., Tang, Q., Rabinowitz, A. G., Musa, K. I., Chai, W. J., Omar, H., Rahman, M. R. A., Abd Hamid, A. I., & Abdullah, J. M. (2021). Neurodevelopmental effects of childhood malnutrition: A neuroimaging perspective. *Neuroimage*, *231*, 117828. https://doi.org/https://doi.org/10.1016/j.neuroimage.2021.117828

Govender, I., Rangiah, S., Kaswa, R., & Nzaumvila, D. (2021). Malnutrition in children under the age of 5 years in a primary health care setting. *South African Family Practice*, *63*(1), 5337. https://doi.org/doi.org/10.4102/safp.v63i1.5337

Ibrahim, M. K., Zambruni, M., Melby, C. L., & Melby, P. C. (2017). Impact of childhood malnutrition on host defense and infection. *Clinical Microbiology Reviews*, *30*(4), 919–971. https://doi.org/https://doi.org/10.1128/CMR.00119-16.

Inamdar, Z., Raut, R., Narwane, V. S., Gardas, B., Narkhede, B., & Sagnak, M. (2021). A systematic literature review with bibliometric analysis of big data analytics adoption from the period 2014 to 2018. *Journal of Enterprise Information Management*, *34*(1), 101–139. https://doi.org/https://doi.org/10.1108/JEIM-09-2019-0267

Keats, E. C., Das, J. K., Salam, R. A., Lassi, Z.S., Imdad, A., Black, R. E., & Bhutta, Z. A. (2021). Effective interventions to address maternal and child malnutrition: an update of the evidence. *The Lancet Child & Adolescent Health*, *5*(5), 367–384. https://doi.org/https://doi.org/10.1016/S0140-6736(21)00568-7

Nahar, B., Hossain, M., Mahfuz, M., Islam, M. M., Hossain, M. I., Murray-Kolb, L. E., Seidman, J. C., & Ahmed, T. (2020). Early childhood development and stunting: Findings from the MAL-ED birth cohort study in Bangladesh. *Maternal & Child Nutrition*, *16*(1), e12864. https://doi.org/DOI:10.1111/mcn.12864

Pinkerton, R., Oriá, R. B., Lima, A. A. M., Rogawski, E. T., Oriá, M. O. B., Patrick, P. D., Moore, S. R., Wiseman, B. L., Niehaus, M. D., & Guerrant, R. L. (2016). Early childhood diarrhea predicts cognitive delays in later childhood independently of malnutrition. *The American Journal of Tropical Medicine and Hygiene*, *95*(5), 1004. https://doi.org/doi:10.4269/ajtmh.16-0150

Scarmeas, N., Anastasiou, C. A., & Yannakoulia, M. (2018). Nutrition and prevention of cognitive impairment. *The Lancet Neurology*, *17*(11), 1006–1015. https://doi.org/http://dx.doi.org/10.1016/S1474-4422(18)30338-7

Spencer, S. J., Korosi, A., Layé, S., Shukitt-Hale, B., & Barrientos, R. M. (2017). Food for thought: how nutrition impacts cognition and emotion. *Npj Science of Food*, *1*(1), 7. https://doi.org/10.1038/s41538-017-0008-y

Stiles, J. (2017). Principles of brain development. *Wiley Interdisciplinary Reviews: Cognitive Science*, *8*(1–2), e1402. https://doi.org/doi:10.1002/wcs.1402.

Suryawan, A., Jalaludin, M. Y., Poh, B. K., Sanusi, R., Tan, V. M. H., Geurts, J. M., & Muhardi, L. (2022). Malnutrition in early life and its neurodevelopmental and cognitive consequences: a scoping review. *Nutrition Research Reviews*, *35*(1), 136–149. https://doi.org/doi:10.1017/S0954422421000159