

## Malnutrition of children and food supplements: a bibliometric approach

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Academic Editor: Prof. Elisabetta Albi – University of Perugia, Italy

Received: 21 June 2025; Accepted: 19 September 2025; Published: 1 January 2026

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RESEARCH ARTICLE

### Abstract

Food supplements are used to eliminate nutritional deficiencies in children, increase immunity, minimize the risk of health problems, and support their growth and development. Both synthetic and natural food supplements can be used for malnourished children according to age, physiological needs, and current health status. For this reason, a comprehensive review of studies on food supplements used against malnutrition in children—from past to present—to determine trends, research gaps, and prominent themes in the literature is of great importance. In this study, research and review articles addressing malnutrition and food supplements in the context of children were examined using the bibliometric analysis method. The research data were obtained from the Web of Science database, and the keywords “malnutrition\*” AND “supplement\*” AND “child\*” were entered in the relevant search section. A total of 2,972 articles including the concepts of malnutrition, supplement, and child were identified. The analysis of these articles was conducted according to year of publication, journals, keywords, countries, and frequently used concepts using the Bibliometrix R package. It was determined that the most publications were from the USA (n=3743), United Kingdom (n=1081), India (n=1054), Canada (n=507), and Australia (n=498), and that these countries produced the most articles between 2024 and 2025. Studies on the use of food supplements, especially in children, will raise awareness among parents who prefer to use food supplements and thus contribute to the healthy growth, development, and adequate nutrition of children.

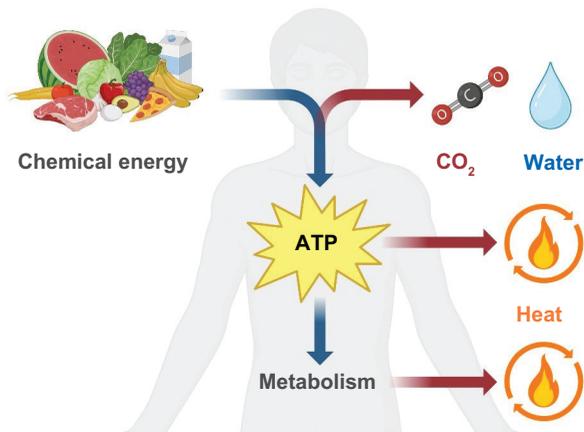
*Keywords:* children, food supplement, growth, health, malnutrition

### Introduction

Nutrition is known as a basic process involving the use of nutrients by the body for growth, development, and maintenance of health (Figure 1).

Each individual should consume nutrients in an adequate and balanced way throughout life (Precious *et al.*, 2023). Child nutrition is especially important for establishing healthy eating habits from the first years of life, ensuring normal growth and development, and reducing the risk of chronic diseases in later years (İkiz and Keskin, 2024).

Therefore, it is necessary to ensure healthy nutrition to improve the general health and well-being of children and to support their physical, cognitive, and emotional development. Malnutrition, which occurs when healthy nutrition is not provided, poses both individual and global risks, as it is one of the leading causes of death in children under five years of age (World Health Organization, 2024). In addition, malnutrition weakens the immune system—essential for defense against diseases—and reduces the body’s ability to fight infections (De and Chattopadhyay, 2019). Studies show that children exposed to severe acute malnutrition at an early age experience poor cognitive



**Figure 1. Nutrition and energy [Created in BioRender. Keskin, M. (2025) <https://BioRender.com/j52qff1>].**

function, low academic performance, and behavioral problems (Ayalew *et al.*, 2020; Beasley *et al.*, 2000; Kirolos *et al.*, 2022; Suryawan *et al.*, 2022).

Today, food supplements have been developed to help supply the micro- and macronutrients that cannot be adequately obtained through regular nutrition. Food supplements are products containing vitamins, minerals, amino acids, essential fatty acids, probiotics, herbal extracts, and other biologically active substances (National Institutes of Health, 2021). Individuals turn to these products for reasons such as living conditions, stress, unbalanced nutrition, environmental toxins, and the prevalence of chronic diseases (World Health Organization, 2022). The use of these supplements is widely preferred to achieve health goals such as strengthening immunity, increasing energy levels, supporting the musculoskeletal system, maintaining mental performance, and delaying the effects of aging (Mason *et al.*, 2021). In addition, the use of food supplements is common among people with cardiovascular diseases such as hyperlipidemia, atrial fibrillation, and heart failure (Davis *et al.*, 2013). They are usually available in capsule, tablet, powder, or liquid form (Gibney *et al.*, 2022). Incomplete or inaccurate content and labeling information on some products in the market can mislead consumers and create various problems in terms of quality assurance, compliance with standards, and reliability (EFSA, 2020). Therefore, food supplements should be recommended by health professionals, taking into account individual factors such as age, gender, current health status, dietary habits, and lifestyle (Elmadfa and Meyer, 2022). In addition, the purity of the supplement, correct dosage, potential food–drug interactions, absorption profiles, and possible side effects should also be considered when using food supplements (Ríos-Hoyo and Gutiérrez-Salmeán, 2016).

Food supplements are not recommended alone for the treatment of a disease but are used to meet the body's

need for certain nutrients and to facilitate the improvement of health problems. It is also important to ensure good nutritional conditions when using supplements (Bullock *et al.*, 2020). Pharmacological effects of supplements may interact with drugs, or overdose may lead to toxic effects; therefore, it is important to use supplements consciously in consultation with health professionals (Geller *et al.*, 2020). With the increasing user awareness in recent years, scientific studies on food supplements have also gained momentum; multidisciplinary studies evaluating the bioavailability, efficacy, and safety of products have enabled these supplements to become part of personalized, sustainable, and goal-oriented nutrition approaches (Gibney *et al.*, 2022).

Food supplements have nutritional and physiological effects with concentrated forms of vitamins, minerals, or other substances of plant or animal origin such as fish oil, probiotics, and vegetables of natural origin to support nutrition (Wierzejska, 2021). Artificial food supplements include synthetic products such as multivitamins, folic acid tablets, vitamin C, vitamin D, ferrous sulfate, and omega 3 tablets (Mason *et al.*, 2021). In children, food supplements are generally used by parents to reduce the risk of health problems or to support immunity (Bailey *et al.*, 2013). For children with an adequate diet, food supplements are not necessary, and excess intake may even be harmful (Woźniak *et al.*, 2022). The inadequate intake of fruits and vegetables in children, the lower cost of supplements than food, and the use of supplements to promote growth and weight gain in children are preferred by parents. The most preferred supplements in children are multivitamins, vitamin C, vitamin D, calcium, probiotics, and omega-3 (Barretto *et al.*, 2024). Most of the multivitamins available in the market do not meet 100% of the child's needs with the micronutrients they contain. Vitamin D is a fat-soluble vitamin and is also described as a prohormone that is produced in the skin after exposure to UVB radiation and converted to its active form by hydroxylation in the liver and kidneys. It can also be taken orally by eating foods such as egg yolks, butter, fish, and fatty cheeses or through dietary supplements. Excess vitamin D can cause hypercalcemia, hypercalciuria, or nephrocalcinosis. To prevent toxicity, it is recommended to monitor serum levels of 25-hydroxyvitamin D in children receiving long-term supplementation equal to or above the maximum intake level (Martini *et al.*, 2020). The daily dietary requirements of 35 and 75 mg of vitamin C are usually met by the recommended daily consumption of fruits and vegetables (Ran *et al.*, 2020). Since melatonin is considered a natural, low-cost, over-the-counter product that promises to improve sleep quality, there has been a significant increase in its consumption over the past decade (Rishi *et al.*, 2023). Moreover, many supplements do not contain the amount of melatonin stated on the label (Erland and Saxena, 2017).

Adverse effects of supplementation include diarrhea or constipation, increased urinary excretion of calcium and phosphorus, and nephrocalcinosis (Mihatsch *et al.*, 2021). Some studies show that zinc supplementation improves growth in children aged 6 months to 12 years, especially where the risk of zinc deficiency is relatively high (Imdad *et al.*, 2023). Omega-3, when metabolized, leads to the long-chain polyunsaturated fatty acids DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid). DHA contributes to cognitive and visual development (Swanson *et al.*, 2012). Regarding probiotic supplementation, there is no consensus on the supplementation of specific probiotic strains in attention deficit hyperactivity disorder, obesity, hepatic steatosis, and depression in the pediatric age group (Szajewska *et al.*, 2023).

It was important to conduct a bibliometric analysis to examine the publications in the literature on malnutrition, food supplements, and children, and to analyze the characteristics of the research in this field. In this study, the aim was to perform a bibliometric analysis of articles published in the Web of Science database that address malnutrition and food supplements in the context of children.

## Methods

### Research design

In the study, the bibliometric analysis method was used to provide comprehensive information about studies

addressing the issue of malnutrition in the context of children and food supplements. Bibliometric analysis is a method that provides detailed information by investigating the studies in the literature on the subject to be examined (Donthu *et al.*, 2021). Using the bibliometric analysis method, the characteristics of publications in the subject area can be quantified, and the trends of change and development in studies within the relevant field can be determined (Kasemodel *et al.*, 2016).

### Research strategies

The data analyzed within the scope of the study were obtained from the Web of Science database. First, the inclusion and search criteria were determined by the researchers. Accordingly, all articles published in all indexes of the Web of Science database (Emerging Sources Citation Index, Conference Proceedings Citation Index, Book Citation Index, Arts & Humanities Index, Science & Humanities Index, Science Citation Index, and Social Sciences Citation Index) in the category of “article and review article” were included in the data collection process of the research. Studies published in other types (books and conference proceedings) were set as the exclusion criteria. Malnutrition, supplement, and child were determined as the keywords to be searched in the study. The keywords (“malnutrition\*” AND “supplement\*” AND “child\*”) were entered into the Web of Science database (Figure 2).

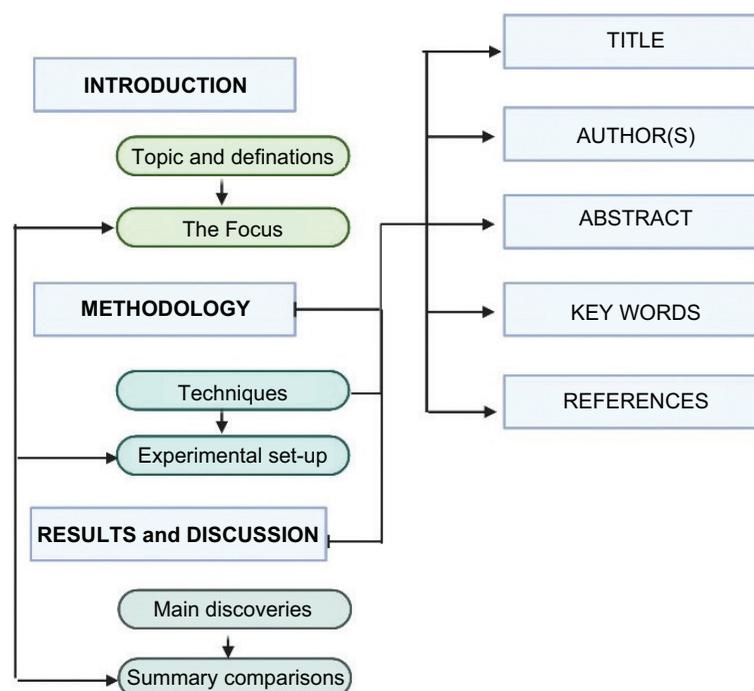


Figure 2. Diagram of research strategies.

The asterisk symbol used after the keywords in the research was employed to include different word variations appearing in the articles. No year or subject limits were applied in the study, and a total of 2,972 articles were retrieved. These articles were downloaded as Bibtext files for statistical analysis. The data in the Bibtext files were directly transferred to the RStudio (2024.04.2+764) program. The analysis of the relevant data was carried out using the Bibliometrix program developed by Aria & Cuccurullo (2017), which is one of the tools available in RStudio. The visuals and graphs obtained from the analyses, conducted in line with the purpose of the research, are interpreted and presented in the findings section.

## Results

In this study, 2,972 articles containing the keywords malnutrition, supplement, and child were accessed through the Web of Science database. The data from these 2,972 articles were then analyzed using the RStudio program, and the findings obtained are presented below.

When the data set was analyzed, it was observed that the number of articles increased at an annual growth rate of 6.24%, with publications spanning from 1980 to 2025. The articles in the data set were produced by a total of 16,772 researchers; 189 of the articles were single-authored, and 44.11% of the articles were conducted through international collaboration. In addition, it was determined that the analyzed articles referenced a total of 100,029 sources.

The line graph showing the distribution of the articles in the data set according to years was presented in Figure 3.

When Figure 3 was analyzed, it was observed that the number of articles on the subject had shown a significant increase over the years. Studies on the topic, which began in 1980, reached their highest number in 2024. However, since this research was conducted during the first months of 2025 and the year is not yet complete, the number of articles for 2025 is not reflected in the graph above.

The distribution of the countries were presented in Figure 4.

In the world map shown in Figure 4, the dark blue color indicates a high number of articles on the subject. As the shade of blue becomes lighter, the number of studies conducted decreases. Areas in grey represent countries where no research on the subject was found. When the number of articles by country was analyzed, it was determined that the USA ( $n=3,743$ ), United Kingdom ( $n=1,081$ ), India ( $n=1,054$ ), Canada ( $n=507$ ), and Australia ( $n=498$ ) had the highest number of articles in the data set. In the relevant data set, it was also shown that 112 articles were produced in Turkey, indicated with light blue color.

The line graph showing the number of publications by year in the countries were presented in Figure 5.

When Figure 5 was analyzed, it was observed that, by country, most articles on the relevant subject were published between 2024 and 2025.

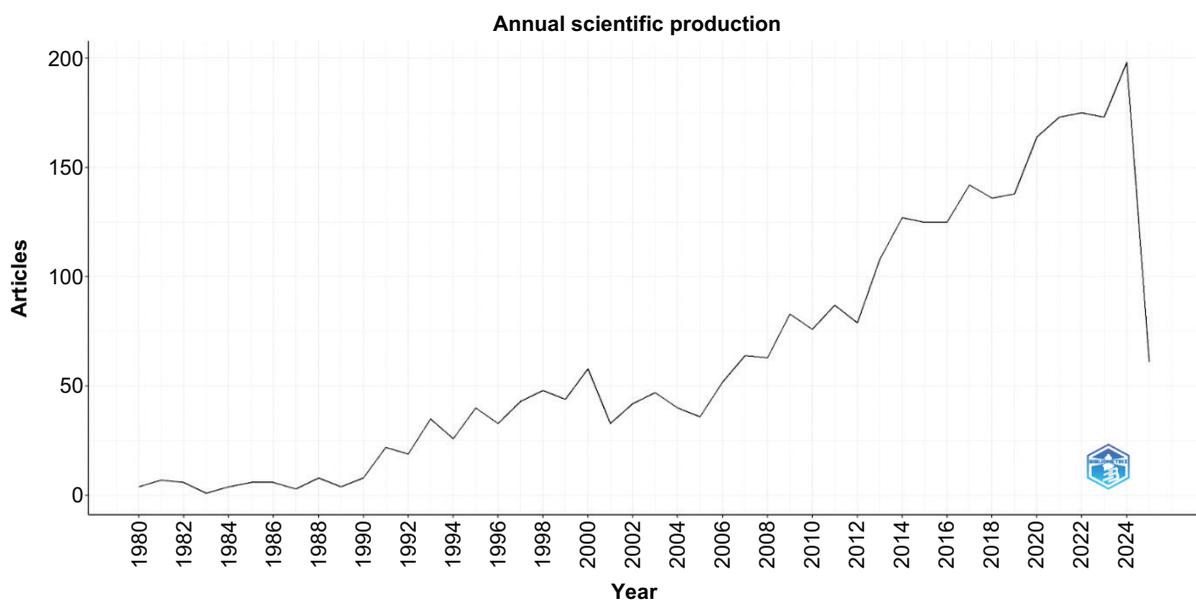


Figure 3. Distribution of articles by year.

Country scientific production

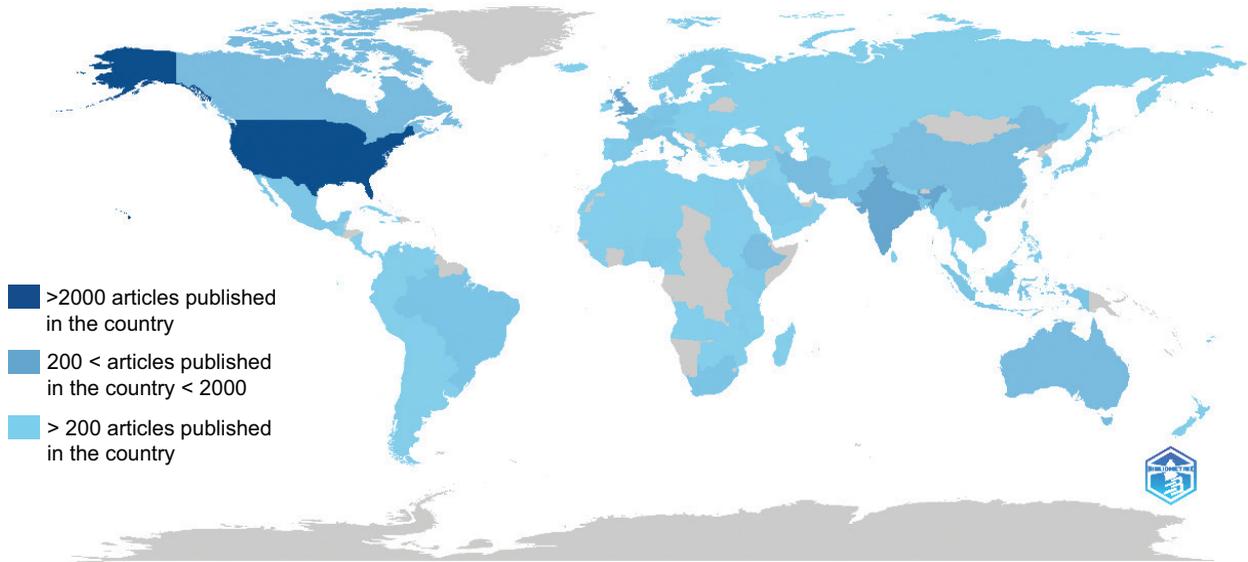


Figure 4. Distribution of articles by country.

Country production over time

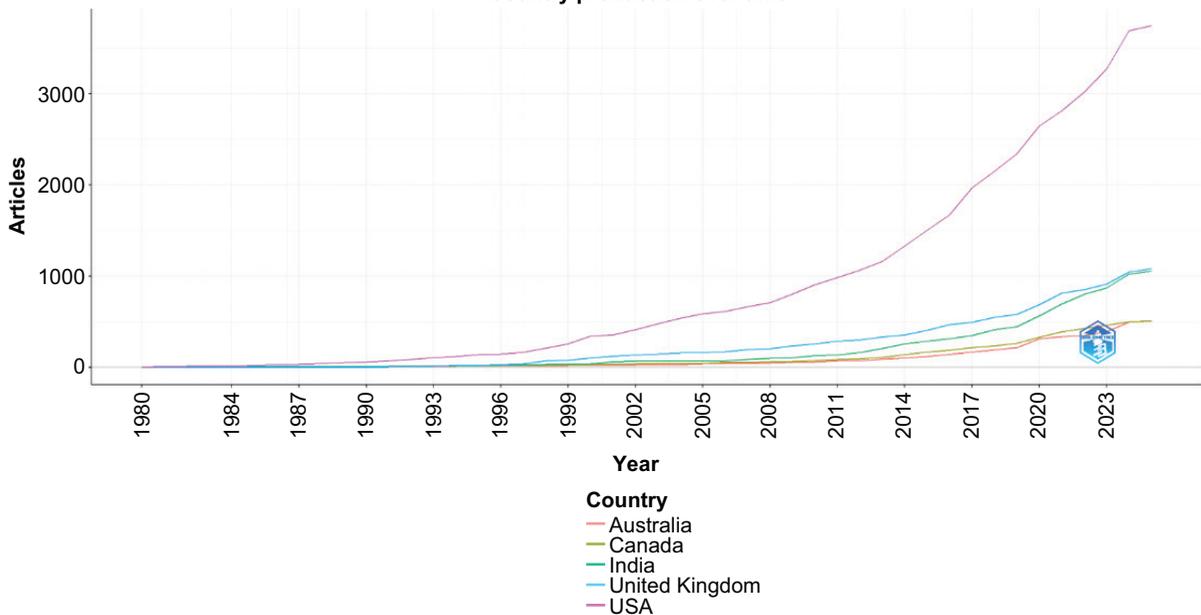


Figure 5. Distribution of the number of publications per countries by years.

The graph showing the distribution of published journals is presented in Figure 6.

When Figure 6 was analyzed, it was observed that most research on the relevant subject was published in the *American Journal of Clinical Nutrition* (n=119), *Journal of Nutrition* (n=119), *Nutrition* (n=100), and *Maternal and Child Nutrition* (n=94). These journals were followed by the others indicated in the graph in Figure 5.

The graph showing the most cited journals in the data set analyzed within the scope of the research was presented in Figure 7.

When Figure 7 was analyzed, it was determined that the most cited journals in the data set were the *American Journal of Clinical Nutrition* with 8,036 citations, *The Lancet* with 5,084 citations, and *Journal of Nutrition* with 4,838 citations. The other journals shown in Figure 7

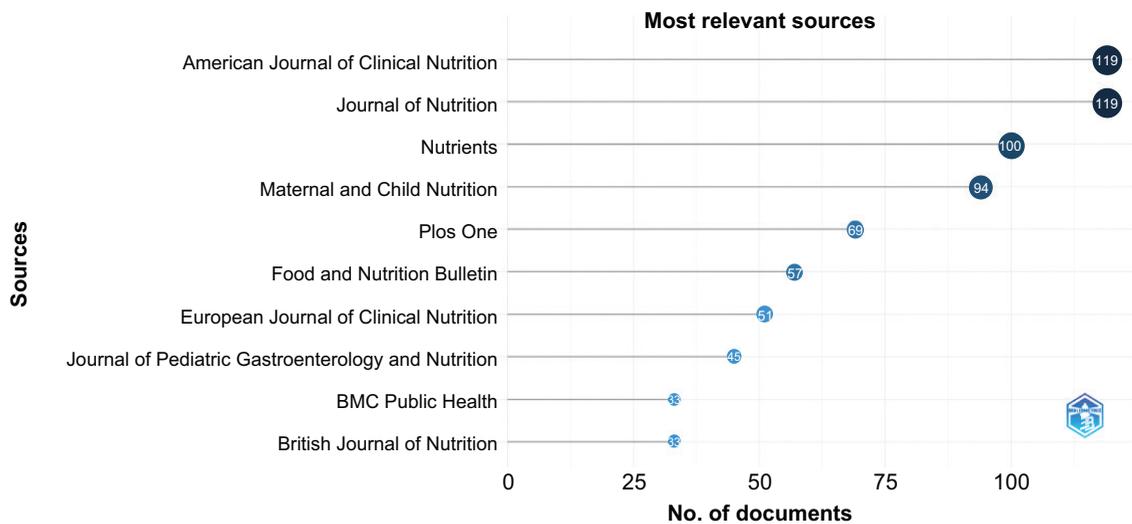


Figure 6. Distribution of journals in which the articles were published.

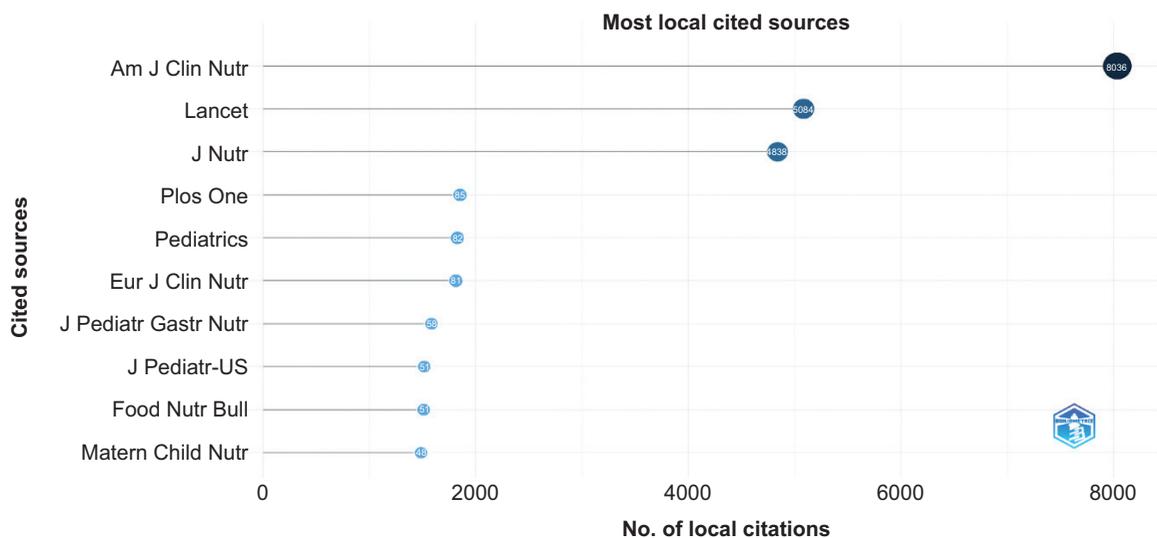


Figure 7. Distribution of journals cited on the subject.

follow these in terms of the number of citations they received on the subject.

The visual showing the cloud of keywords used in the data set was presented in Figure 8.

The larger size of words in the word cloud indicates that those words were used more frequently. As the word sizes decrease, it shows that the frequency of their use as keywords was lower. In this context, when Figure 8 was examined, it was demonstrated that the words *malnutrition*, *supplementation*, *children*, *growth*, *nutrition*, and *mortality* were the most frequently used keywords in the articles on the subject.

The thematic graph showing the co-use of the keywords used by the authors in the articles was given in Figure 9.

When the thematic graph in Figure 9 was examined, it was observed that there were four themes: Niche Themes, Motor Themes, Emerging or Declining Themes, and Basic Themes. The graph shows the thematic distribution based on the co-occurrence of keywords used by authors in the articles. According to Figure 9, *health*, *nutrition*, and *undernutrition* were popular keywords used together. *Malnutrition*, *supplementation*, and *children* were identified as basic keywords currently in use. *Metabolism*, *body composition*, and *therapy* were relatively less popular than the other keywords.



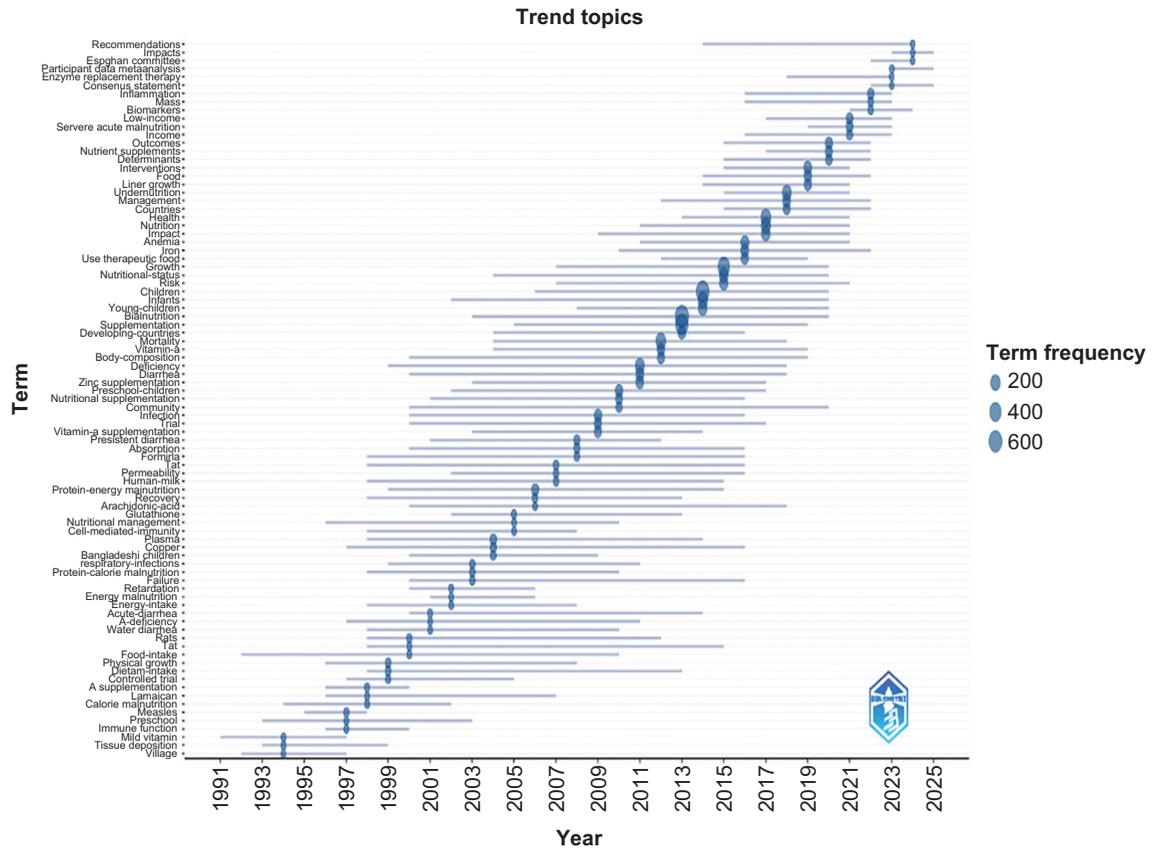


Figure 10. Distribution of concepts used in the articles by years.

is a need for products with high nutritional value and adequate nutrition. On the other hand, it is important to identify the diseases that may occur due to malnutrition and to develop the necessary treatment policies to raise sustainably healthy individuals. For this reason, a review of the literature revealed various multidisciplinary studies focusing on malnutrition, children, and food supplements. For example, Chowdhury *et al.* (2024) conducted a study on the trends and socioeconomic inequalities in taking vitamin A supplements among children aged 6–59 months in Bangladesh between 2004 and 2017. According to this study, there were fluctuations in the use of vitamin A supplements during the specified period in Bangladesh: 78.68% in 2004, 62.09% in 2011, and 79.29% in 2017. The data obtained indicated that supplement use in Bangladesh was related to welfare and education levels, and that supplement use should be encouraged. In a study by Reggi *et al.* (2024), ready-to-use supplementary food biscuits were produced with low-cost ingredients for malnourished children in sub-Saharan Africa. The chemical characterization, storage conditions, and nutritional evaluation of the biscuits were assessed, and it was stated that the product would be suitable for use by disadvantaged children with malnutrition. Kiguli *et al.* (2024) conducted a phase 2 randomized controlled trial

on nutritional supplementation (COAST-Nutrition) in children with severe pneumonia in Uganda and Kenya. Children aged 6–12 years were fed RUTF (plus the usual diet) for 180 days under specific and controlled conditions. At the end of 180 days, it was found that this feeding did not improve outcomes in children with severe pneumonia. Venigalla *et al.* (2024) studied the prevalence of anemia in children with severe acute malnutrition in a pediatric tertiary care hospital in South India. In this study, anthropometric measurements of malnourished children under 60 months of age were recorded, and laboratory examinations revealed complete blood count, serum iron, serum ferritin, serum folate, and serum vitamin B12 levels. It was stated that these children were prone to anemia and that food supplements should be used starting from the womb to prevent anemia.

In this study, a bibliometric analysis of malnutrition and food supplements in the context of children was carried out. When the results obtained from the research were evaluated, it was observed that the number of studies containing the three keywords increased over time. It was seen that different dimensions of the subject were examined through studies conducted in various fields such as health, nutrition, and food supplement development.

Although many countries have carried out research on the subject, it was understood that further studies should be conducted with different variables to both raise parental awareness and enable countries to develop sustainable health policies. Supporting the healthy growth and development of children and fostering healthy generations in society underscores the importance of studies in this area. Presenting a bibliometric analysis of studies examining malnutrition and food supplements in the context of children will contribute to researchers by facilitating access to the current literature and providing a roadmap for future studies.

## Acknowledgments

None.

## Author Contributions

All authors contributed equally to this article.

## Conflict of Interest

The authors declare no conflict of interest.

## Funding

The was no funding for the study.

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