GLOBAL RESEARCH TRENDS ON HERBAL-BASED NUTRITION FOR STUNTING PREVENTION: A BIBLIOMETRIC ANALYSIS

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ABSTRACT

Stunting remains a major global public health challenge that requires effective preventive strategies based on adequate nutrition and functional foods. This study aims to map global research trends, thematic structures, and emerging directions related to the use of herbal-based nutrition for stunting prevention through a bibliometric approach. Bibliographic data were retrieved from the Scopus database in November 2025, covering English-language articles and reviews published between 2000 and 2024. A total of 531 documents were analyzed using descriptive bibliometric methods and network visualization techniques. Keyword and term co-occurrence analyses were conducted using VOSviewer, resulting in the identification of 75 frequently occurring terms grouped into four major thematic clusters. The dominant research themes were associated with nutrition, functional foods, medicinal plants, and bioactive compounds, with Moringa oleifera emerging as one of the most recurrent and recent research topics. Overlay visualization further revealed a temporal shift in research focus from general malnutrition and nutritional deficiencies toward the exploration of specific bioactive compounds, micronutrients, and alternative food sources. Overall, the findings indicate that research on stunting prevention has evolved toward more diversified and bioactivity-oriented approaches. This bibliometric mapping provides a foundation for future research and supports the development of locally based functional food interventions aimed at reducing stunting prevalence. Malnutrition and severe food insecurity are the underlying causes of stunting, and exacerbating hunger when food is scarce is harmful. Although some herbs can provide micronutrients, without a regular nutrient-rich diet, they are impotent.

Keywords: Herbal Medicine; Stunting; Bibliometric Analysis; Functional Foods; Term Co-Occurrence

INTRODUCTION

Malnutrition remains one of the most critical challenges in global health. It can take various forms, including undernutrition and overnutrition, and poses serious risks to human development. One of the most common consequences of chronic undernutrition is stunting, a growth disorder in children characterized by

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insufficient height for their age. This condition is a reflection of long-term nutritional deficiencies and continues to be a significant concern due to its lasting effects on physical growth, cognitive performance, and overall quality of life. Stunting is defined as impaired linear growth, where children under five years of age have a height significantly below the standard for their age due to chronic malnutrition [1].

Among the different manifestations of malnutrition, stunting has received particular attention because of its wide-ranging consequences for physical health, cognitive capacity, and overall quality of life in later years. It refers to a condition of impaired linear growth in which children under five years of age exhibit height-for-age measurements substantially lower than the reference standard, primarily as a result of prolonged nutritional deficiencies [2].

As a significant public health concern, stunting is not only a global issue but also a national priority in Indonesia. The Indonesian government is focusing on a free nutritious meal program in schools, which is part of an intervention strategy that reduces the prevalence of stunting [3].

According to the Studi Status Gizi Indonesia (SSGI) 2022, the prevalence of stunting decreased from 24.4% to 21.6% in 2021, underscoring the tangible impact of nutrition-focused policies on reducing stunting rates [4].

Beyond socioeconomic and dietary factors, biological mechanisms play a crucial role in linking early-life undernutrition with impaired development. Early malnutrition can provoke inflammation, disrupt leptin regulation, and elevate glucocorticoids, leading to epigenetic alterations that affect neurogenesis, apoptosis, and synaptic function, ultimately contributing to developmental delays [5]. Studies have demonstrated a strong relationship between stunting and the developmental progress of children aged 1–3 years, indicating that nutritional deficiencies during critical growth periods have long-term consequences [6]. In addition to the program aimed at improving nutritional status, herbal plants in nature can be harnessed as a valuable resource rich in nutrients that enhance nutritional status [7]. From an ethnomedicinal perspective, Curcuma xanthorrhiza (temulawak), Curcuma aeruginosa (temu hitam), and Boesenbergia pandurata (temu kunci) are traditionally used to increase appetite [8]. Several plants, including members of the Euphorbiaceae family, also demonstrated pharmacological activities such as anti-inflammatory, antioxidant, and metabolic modulation [9], which may indirectly contribute to improved appetite regulation, nutrient utilization, and overall growth.

To gain a better understanding of the research landscape in this field, bibliometric analysis serves as an effective method. Bibliometric studies utilize quantitative techniques to map and evaluate scientific production within a specific discipline, providing comprehensive insights into research trends, patterns, and structures. Through the analysis of keywords, titles, and abstracts, bibliometric approaches can identify well-explored topics while highlighting underexplored areas for future studies [3]. Thus, bibliometric analysis provides a systematic way to map the potential of herbal and natural products for stunting prevention, guiding future research and the development of innovative, evidence-based interventions.

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METHODS

Database and Search Strategy

This study employed a bibliometric approach with systematically structured procedures for data retrieval and analysis. All publication data were sourced exclusively from the Scopus database, which is widely recognized as the preferred platform for bibliometric research due to its extensive coverage, rigorous source selection, high-quality metadata, and integration with analytical tools. Scopus indexes peer-reviewed journals, conference proceedings, book series, trade publications, and patents, making it a comprehensive resource for mapping scientific literature [10,11].

A comprehensive search strategy was developed using a combination of keywords related to herbal-based nutrition and child undernutrition. The final search query was formulated as follows:

(TITLE-ABS-KEY (\"herbal nutrition\" OR \"herbal-based nutrition\" OR > \"plant-based nutrition\" OR \"herbal supplement\\" OR \"medicinal > plant\\" OR phytotherap\ OR \"functional food\\" OR > nutraceutical\) AND TITLE-ABS-KEY (stunting OR \"growth faltering\" > OR \"linear growth\" OR malnutrition OR \"child undernutrition\")

The search covered publications from 2000 to 2024, limited to articles and reviews written in English. All data were downloaded from Scopus on November 21, 2025, to avoid potential bias resulting from ongoing database updates.

Descriptive bibliometric analysis was conducted to summarize annual publication trends, contributing countries, institutions, journals, and authors. Annual publication growth was visualized using line charts to identify temporal patterns. Network-based analyses were performed using VOSviewer version 1.6.20 to map international collaboration among countries, co-authorship networks among authors, and institutional productivity.

Keyword and term co-occurrence analyses were further applied to identify major research themes and thematic clusters within the field. Overlay visualization based on the average publication year of terms was used to explore emerging topics and potential future research directions in herbal-based nutrition related to stunting prevention.

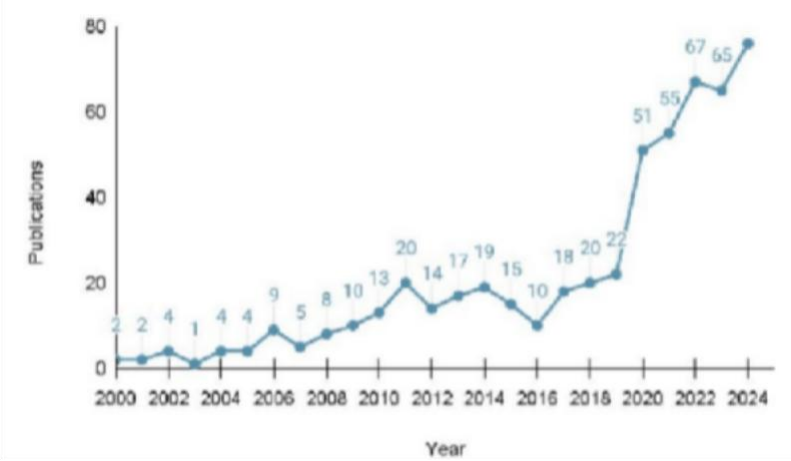
RESULTS

Trends of Annual Publications

An extensive bibliometric review spanning from 2000 to 2024 identified a total of 531 scholarly documents focused on herbal-based nutrition for stunting prevention. During the initial phase of the study period, specifically prior to 2019, the volume of scientific production was relatively limited. However, a remarkable upward surge in publication frequency has been recorded in the subsequent years, demonstrating a consistent growth trajectory. This escalating trend highlights the increasing global scientific interest and the strategic shift towards exploring natural and plant-based interventions to address malnutrition and growth failure.

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Figure 1. Growth trend of global research publications related to herbal interventions for stunting (2000–2024)



Country Distribution

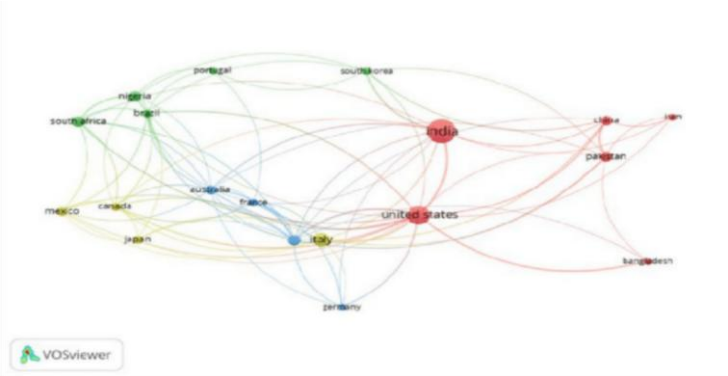
A total of 97 countries participated in the research regarding herbal-based nutrition for stunting prevention. According to the analysis, India emerged as the leading contributor, publishing the highest number of articles (n = 146; 27.49%). This was followed by United States (n = 77; 14.50%), Italy (n = 41; 7.72%), and United Kingdom (n = 28; 5.27%), as detailed in Table 1. Figure 2 illustrates the international collaborative network comprising 19 nations that met the threshold of at least 10 publications. The visualization features, particularly the magnitude of the nodes and the density of the connecting lines, reveal that India possesses the most extensive cross-border partnerships.

Table 1. Top 10 Countries with the Highest Publications in herbal-based nutrition for stunting prevention

Ranking	Country	Number of documents	% (of 531)
1st	India	146	27.49
2nd	United States	77	14.50
3rd	Italy	41	7.72
4th	United Kingdom	28	5.27
5th	Pakistan	25	4.71
6th	China	24	4.52
7th	Nigeria	24	4.52
8th	South Africa	23	4.33
9th	Australia	22	4.14
10th	Brazil	19	3.58

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Figure 2. Visualization of the global research collaboration network using a minimum threshold of 10 documents per country (n = 19). Closely clustered countries with numerous links indicate strong scientific cooperation, while peripheral countries with sparse connections show weak international collaboration. Generated with VOSviewer version 1.6.20.



Institutions

A total of 446 institutions contributed to this field. The largest share of publications came from ICAR – Indian Agricultural Research Institute, New Delhi (n = 8, 1.79%), followed by the University of Agriculture, Faisalabad (n = 7, 1.56%), Tamil Nadu Agricultural University (n = 6, 1.34%), and Lovely Professional University (n = 6, 1.34%). The ten leading institutions with the highest publication output on nutrition and depression are presented in Table 2.

Table 2. Top 10 institutions with the highest publications on research related to herbal-based nutrition for stunting prevention

Ranking	Institution	Country	n	% (of 446)
1st	ICAR - Indian Agricultural Research Institute, New Delhi	India	8	1.79
2nd	University of Agriculture, Faisalabad	Pakistan	7	1.56
3rd	Tamil Nadu Agricultural University	India	6	1.34
4th	Lovely Professional University	India	6	1.34
5th	University of Fort Hare	South Africa	5	1.12
6th	Jiangnan University	China	5	1.12
7th	Universidade do Porto	Portugal	5	1.12
8th	University of Southampton	United Kingdom	5	1.12
9th	Indian Council of Agricultural Research	India	5	1.12
10th	INSERM	France	4	0.89

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Journals

Table 3 lists the top ten journals in this field by productivity. A total of 67 documents were published by the top 10 journals or 12,62% of the total. Most documents were published in Nutriens (n = 16). With 8 publications, Frontiers in Nutrition was the second most productive journal. Trends in Food Science and Technology came in third (n = 7) and were followed by South African Journal of Botany (n = 6) and American Eurasian Journal of Sustainable Agriculture (n = 5).

Table 3. Top 10 journals with the highest publications on research related to herbal-based nutrition for stunting prevention

Ranking	Journal	n	% (of 531)	IF (2024)
1st	Nutrients	16	3.01	5
2nd	Frontiers in Nutrition	8	1.51	5.1
3rd	Trends in Food Science and Technology	7	1.32	15.4
4th	South African Journal of Botany	6	1.13	2.4
5th	American Eurasian Journal of Sustainable Agriculture	5	0.94	2.5
6th	Foods	5	0.94	5.1
7th	Heliyon	5	0.94	3.6
8th	Journal of Ethnobiology and Ethnomedicine	5	0.94	3.7
9th	Journal of Ethnopharmacology	5	0.94	5.4
10th	Molecules	5	0.94	4.6

Authors

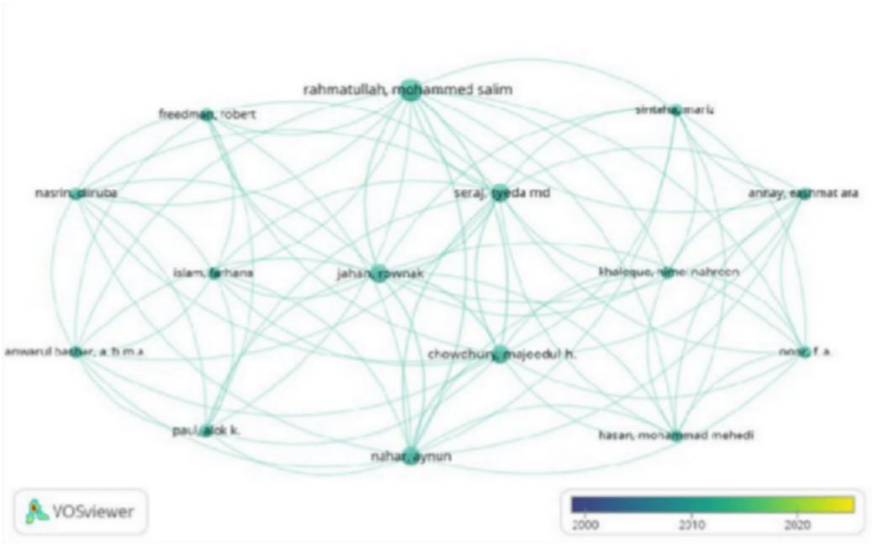
A total of 160 researchers have contributed to the publications in this field, with 95 of them meeting the minimum requirement of at least two articles. Early contributors to this research domain include Rahmatullah, M., who has consistently published in the field, while several authors such as Seraj, Syeda Md. and Hasan, Mohammad Mehedi represent more recent additions to the collaborative network (Figure 3). Notably, half of the ten most productive authors are affiliated with institutions in Bangladesh. Rahmatullah, M. stands out as the leading contributor with six papers, followed by Afolayan, A.J., Chowdhury, M.H., and Jahan, R., each with four publications (Table 3). Although Afolayan, A.J. was not the most frequent publisher, his work achieved the highest citation count, reflecting its strong scientific influence

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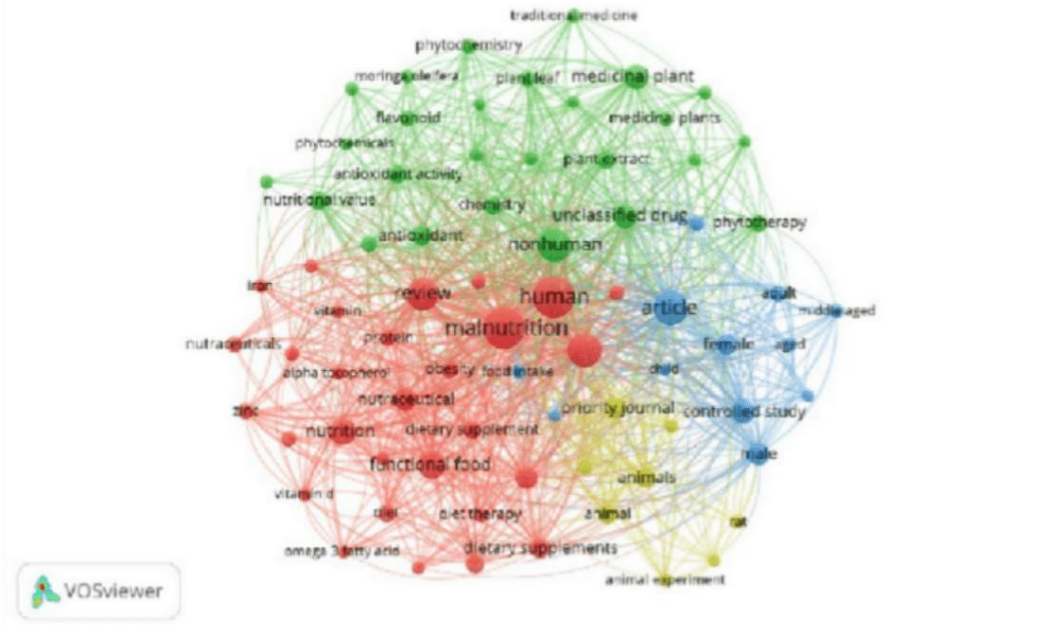
Table 4. Top 10 authors with the highest publications on research related to herbal-based nutrition for stunting prevention

Ranking	Author	Country	Publications	% of (531)	Citations
1st	Rahmatullah, M.	Bangladesh	6	1.13	7435
2nd	Afolayan, A.J.	South Africa	4	0.75	13801
3rd	Chowdhury, M.H.	United States	4	0.75	1444
4th	Jahan, R.	Bangladesh	4	0.75	4197
5th	Nahar, A.	Bangladesh	4	0.75	216
6th	Seraj, S.	Bangladesh	4	0.75	1619
7th	Tanga, C.M.	Bangladesh	3	0.56	5377
8th	Adegboyega, T.T.	East Africa	2	0.38	293
9th	Aggarwal, M.	India	2	0.38	1330
10th	Al-Okbi, S.Y.	Egypt	2	0.38	955

Figure 4. Cluster map based on term co-occurrence analysis in titles and abstracts. The size of each node reflects the frequency of term appearances, while the colors represent distinct thematic clusters. The visualization was generated using VOSviewer software version 1.6.20**.**



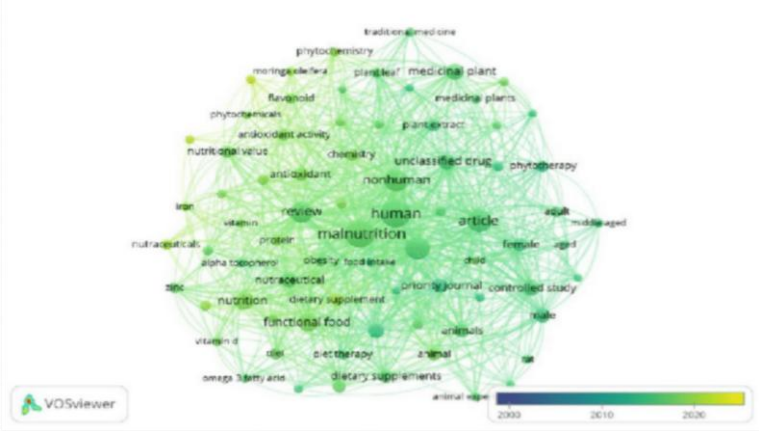
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Future research direction analysis

Figure 5 in VOSviewer illustrates the temporal evolution of term usage, with each term colored according to its average year of appearance across the analyzed publications. Yellow nodes represent terms that have emerged more recently in the literature, whereas blue nodes reflect concepts that appeared earlier. Earlier studies were dominated by themes related to "malnutrition," "nutrition," "dietary supplements," and "functional food," along with foundational concepts such as "human" and "nonhuman." In contrast, more recent developments—appearing after approximately 2018—include terms related to "Moringa oleifera," "flavonoid," "nutraceuticals," and other plant-based or phytochemical topics, indicating a growing research focus on medicinal plants and their nutritional or therapeutic potential.

Figure 5. Network visualization map of term analysis in titles and abstracts based on average publication year. Blue indicates earlier occurrences of the terms, while yellow represents more recent appearances. The visualization was generated using VOSviewer software version 1.6.20.



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DISCUSSION

In this study, we examined the developmental trends, research hotspots, and emerging directions of studies on herbal-based nutrition for stunting prevention using a bibliometric approach based on data retrieved from the Scopus database. Specifically, this analysis covered publications published between 2000 and 2024. A total of 531 documents were successfully identified and analyzed. The results demonstrate a clear and steady growth in scientific output over the past two decades, with a particularly sharp increase observed after 2019. This trend indicates a growing global awareness of stunting as a critical public health problem and reflects increasing interest in plant-based and functional food approaches as complementary strategies to conventional nutritional interventions [12–14]. Given the current emphasis on sustainable and locally available food sources, this upward trend in research productivity is expected to continue in the coming years.

The country-level analysis reveals that research output in this field is dominated by a small number of countries, with India emerging as the most productive contributor. This dominance may be explained by India's high prevalence of stunting, strong agricultural research infrastructure, and long-standing tradition of using medicinal plants and functional foods in nutritional interventions [15–18]. The United States, Italy, and the United Kingdom also ranked among the leading contributors, reflecting their strong research capacity and interest in global nutrition and public health issues. In contrast, although many low- and middle-income countries (LMICs) experience a high burden of stunting, their overall research output remains relatively limited. This imbalance highlights the need for greater research investment and context-specific study designs in LMICs to address local nutritional challenges using indigenous plant resources.

International collaboration analysis further indicates that countries with higher publication output tend to occupy more central positions in the collaboration network [19,20]. India, in particular, demonstrates extensive cross-border research linkages, suggesting that international cooperation plays a key role in advancing knowledge on herbal-based nutrition. However, several countries remain positioned at the periphery of the network, indicating weaker collaborative ties. Strengthening international and regional collaborations may enhance knowledge exchange and promote the development of evidence-based interventions tailored to diverse sociocultural and ecological contexts [21,22].

Analysis of institutional productivity shows that research in this field is distributed across a wide range of institutions, with no single institution dominating publication output. Similar patterns of dispersed institutional contributions have been reported in bibliometric studies of interdisciplinary research areas, where knowledge production spans multiple scientific domains rather than being centralized within a few organizations [20,23]. Leading contributors include agricultural and life science–oriented institutions, such as the ICAR–Indian Agricultural Research Institute and several agricultural universities in South Asia and Africa. This distribution reflects the interdisciplinary nature of herbal-based nutrition research, which integrates agriculture, food science, nutrition, and ethnomedicine [24,25]. The fragmented institutional landscape also suggests opportunities for the establishment of specialized research centers and multicenter collaborations focused on functional foods and plant-based nutritional interventions for child growth.

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Journal analysis reveals that the majority of publications are concentrated in nutrition, food science, and ethnopharmacology journals. Similar distributions have been observed in bibliometric studies of nutrition-related and herbal medicine research, where multidisciplinary topics are typically disseminated across a range of specialized journals rather than confined to a single discipline [26,27]. Journals such as Nutrients, Frontiers in Nutrition, and Trends in Food Science and Technology serve as key outlets for disseminating research findings in this area. The presence of ethnobotany and ethnopharmacology journals further emphasizes the importance of traditional knowledge systems in informing modern nutritional research [28–30]. This diversity of publication venues highlights the multidisciplinary foundation of herbal-based nutrition for stunting prevention.

Author productivity and citation analysis indicate that a relatively small group of researchers contributes consistently to this field. Similar authorship patterns have been widely reported in bibliometric studies, where a limited number of prolific authors often generate a substantial share of publications and citations within a research domain [31,32]. While Rahmatullah, M. emerged as the most prolific author, Afolayan, A.J. recorded the highest citation count, highlighting the well-recognized distinction between publication volume and scientific impact [33]. The co-authorship network further reveals several tightly connected clusters, suggesting that research activities are frequently conducted within established collaborative groups. Expanding collaboration across regions and disciplines may accelerate scientific innovation and enhance the robustness and generalizability of evidence in this field, as emphasized in previous studies on research collaboration and knowledge diffusion [34].

Term co-occurrence and clustering analyses provide valuable insights into the intellectual structure and research hotspots within the field. Such approaches have been widely applied in bibliometric studies to identify thematic patterns and conceptual frameworks within complex research domains [19,23]. In this study, four major thematic clusters were identified. The first cluster centers on core nutritional concepts such as malnutrition, dietary supplements, and functional foods, reflecting the foundational role of nutrition science in stunting prevention research. The second cluster focuses on medicinal plants and phytochemical compounds, including antioxidants and flavonoids, highlighting increasing interest in the bioactive properties of plant-based foods and their potential nutritional benefits [35,36]. The third and fourth clusters encompass human- and animal-based research terms, indicating the coexistence of clinical, epidemiological, and experimental studies aimed at understanding both efficacy and underlying mechanisms [37,38].

Overlay visualization further reveals a clear temporal evolution in research focus. Such overlay analyses have been widely used in bibliometric studies to track thematic shifts and emerging research fronts over time [19,20]. Earlier studies primarily emphasized general nutritional deficiencies and malnutrition, whereas more recent research increasingly targets specific plant species, bioactive compounds, and nutraceutical applications. Notably, Moringa oleifera has emerged as a highly recurrent and recent research topic, reflecting its rich nutrient profile and growing recognition as a functional food with potential benefits for improving child nutritional status [39–41]. In addition, the increasing appearance of terms related to micronutrients, flavonoids, and alternative food sources such as honey and microalgae suggests a broader shift toward innovative and diversified

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strategies for stunting prevention, as highlighted in recent nutrition and functional food studies [42–44].

Overall, this bibliometric analysis demonstrates that research on herbal-based nutrition for stunting prevention is evolving from descriptive nutritional studies toward more targeted, bioactivity-oriented investigations. While progress has been substantial, the findings also reveal gaps in geographical representation and collaborative integration. Future research should prioritize high-quality clinical studies, standardization of herbal formulations, and evaluation of safety and long-term effectiveness. Strengthening collaboration between researchers in high-income countries and LMICs will be essential to translate herbal-based nutritional research into practical, culturally appropriate interventions that support global stunting reduction efforts.

CONCLUSION

This bibliometric analysis provides a comprehensive overview of global research trends on herbal-based nutrition for stunting prevention from 2000 to 2024. The steady growth in publication output, particularly after 2019, indicates increasing scientific attention toward plant-based and functional food approaches as complementary strategies to address chronic undernutrition. Research activity is dominated by a limited number of countries and institutions, with India emerging as a central contributor, while international collaboration networks reveal both strong research hubs and underrepresented regions. The thematic structure of the literature highlights a multidisciplinary foundation, integrating nutrition science, medicinal plants, phytochemistry, and experimental research. Recent shifts in research focus toward specific bioactive compounds, nutraceuticals, and nutrient-rich plants, most notably Moringa oleifera reflect a transition from general nutritional concepts to more targeted, functional, and bioactivity-oriented interventions. Overall, these findings underscore the growing potential of herbal-based nutrition in stunting prevention while also revealing the need for stronger international collaboration, standardized research designs, and translational studies to support evidence-based implementation, particularly in low- and middle-income settings. Malnutrition and severe food insecurity are the underlying causes of stunting, and exacerbating hunger when food is scarce is harmful. Although some herbs can provide micronutrients, without a regular nutrient-rich diet, they are impotent.

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