Turkish Journal of Diabetes and Obesity / *Türkiye Diyabet ve Obezite Dergisi*
Review / Derleme

Mapping Research on School Nutrition and School Meals: A Bibliometric Analysis (2000–2025)

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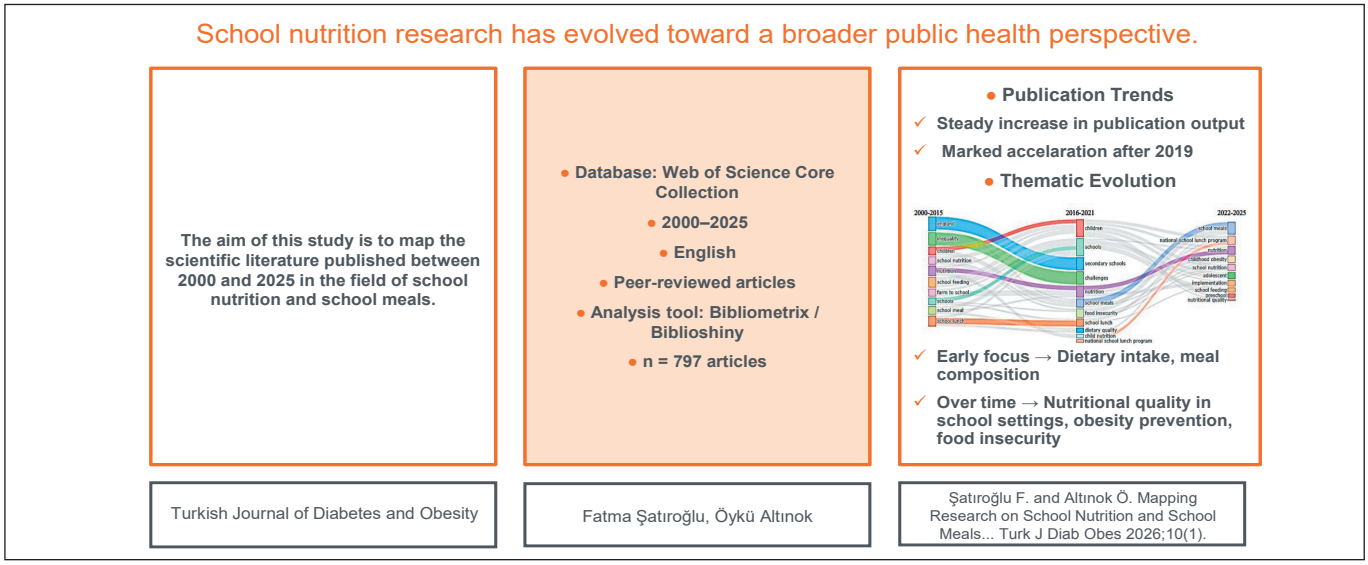
Cite this article as: Şatıroğlu F and Altınok Ö. Mapping research on school nutrition and school meals: a bibliometric analysis (2000–2025). Turk J Diab Obes 2026; 10(1): 81-93.

GRAPHICAL ABSTRACT



ABSTRACT

This study aims to map the scientific literature the scientific literature published between 2000 and 2025 on school nutrition and school meals using bibliometric methods. A comprehensive search was conducted in the Web of Science Core Collection database, and peer-reviewed articles published in English between 2000 and 2025 were included in the study. After applying predefined inclusion and exclusion criteria, a total of 797 articles were analysed. The analyses were conducted using the Bibliometrix/Biblioshiny software. The findings indicated a steady increase in publication output in the field, with a marked acceleration after 2019. Thematic analyses showed that the concepts of "school meals" and "nutrition" consistently maintained central positions, while themes such as "food insecurity," "universal school meals," "implementation," and "childhood obesity" have become more prominent in recent years. The findings also demonstrated that early studies focused on dietary intake and meal composition, whereas over time the field has shifted toward a broader public health perspective encompassing nutritional quality in school settings, obesity prevention, and food insecurity. This bibliometric study indicates that school nutrition should be addressed as a public health intervention in the context of nutritional quality, childhood obesity, and food insecurity; additionally, it highlights the need to implement evidence-based approaches that focus on how school nutrition programs are implemented in practice and, consequently, to strengthen efforts to reduce the policy–practice gap, thereby enhancing program effectiveness.

Keywords: *Bibliometrics, Nutrition policy, Pediatric obesity, Public health, Schools, School health services*

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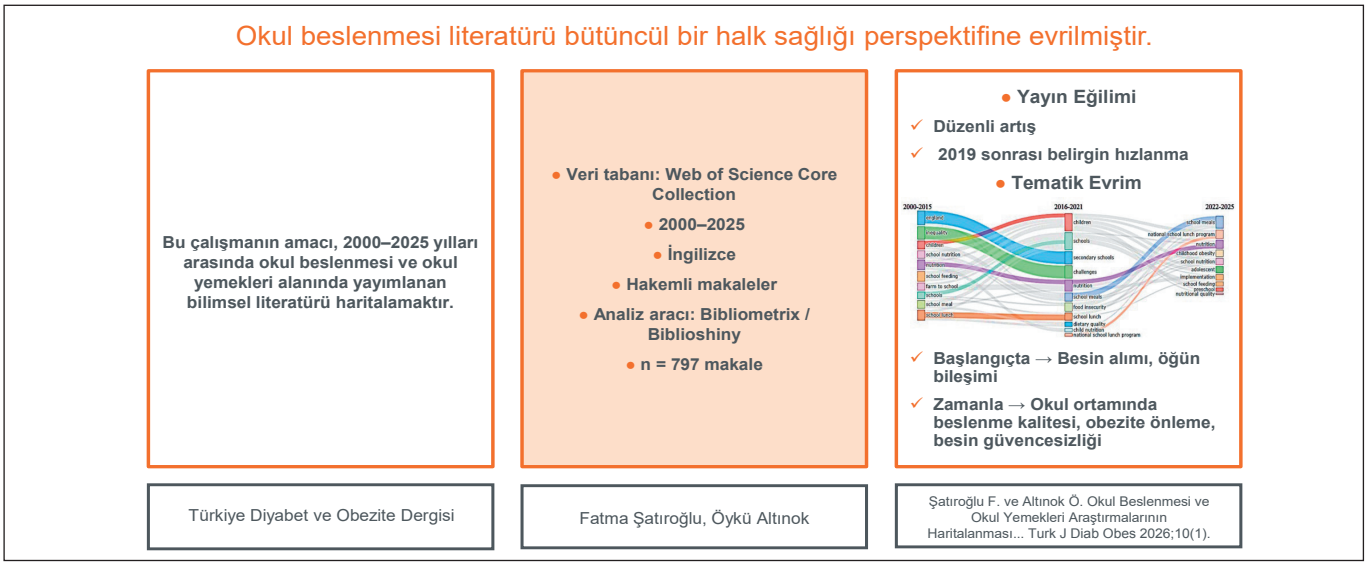
DOI: 10.25048/tudod.1897791

Received / *Geliş tarihi* : 25.02.2026
Revision / *Revizyon tarihi* : 11.04.2026
Accepted / *Kabul tarihi* : 14.04.2026

Okul Beslenmesi ve Okul Yemekleri Araştırmalarının Haritalanması: Bibliyometrik Bir Analiz (2000–2025)

GRAFİKSEL ÖZET



ÖZ

Bu çalışmanın amacı, 2000–2025 yılları arasında okul beslenmesi ve okul yemekleri alanında yayımlanan bilimsel literatürü bibliyometrik yöntemler kullanarak haritalamaktır. Web of Science Core Collection veri tabanında kapsamlı bir tarama yürütülmüş ve bu kapsamda 2000–2025 yılları arasında yayımlanmış, hakemli ve İngilizce dilindeki makaleler çalışmaya dâhil edilmiştir. Önceden belirlenen dâhil etme ve dışlama kriterlerinin uygulanmasının ardından toplam 797 makale analiz edilmiştir. Analizlerde, Bibliometrix/Biblioshiny yazılımı kullanılmıştır. Bulgular, alanda istikrarlı bir yayın artışı olduğunu ve 2019 yılından sonra belirgin bir hızlanma yaşandığını göstermiştir. Tematik analizler, "okul yemekleri" ve "beslenme" kavramlarının sürekli olarak merkezî konumlarını koruduğunu; bununla birlikte "gıda güvencesizliği", "evrensel okul yemekleri", "uygulama" ve "çocukluk çağı obezitesi" temalarının ise son yıllarda daha belirgin hâle geldiğini ortaya koymuştur. Bulgular ayrıca, erken dönem çalışmaların besin alımı ve öğün içeriğine odaklandığını; zamanla okul ortamında beslenme kalitesi, obezite önleme ve gıda güvencesi konularını içeren daha geniş bir halk sağlığı perspektifine yönelim olduğunu göstermektedir. Bu bibliyometrik çalışma, okul beslenmesinin beslenme kalitesi, çocukluk çağı obezitesi ve gıda güvencesi bağlamında ele alınması gereken bir halk sağlığı müdahalesi olduğunu; aynı zamanda, okul beslenme programlarının etkinliğini artırmak için programların sahada nasıl yürütüldüğüne odaklanan kanıta dayalı yaklaşımların hayata geçirilmesi ve buna bağlı olarak politika-uygulama boşluğunu azaltmaya yönelik çabaların güçlendirilmesi gerektiğini ortaya koymaktadır.

Anahtar Sözcükler: *Bibliyometri, Beslenme politikası, Pediatrik obezite, Halk sağlığı, Okullar, Okul sağlık hizmetleri*

INTRODUCTION

Nutrition plays a crucial role in health throughout the life course. It is also essential to the prevention of malnutrition and reducing the risks of non-communicable diseases such as cardiovascular diseases, diabetes, and certain types of cancer (1). Adequate, balanced nutrition contributes to healthy physical growth and development, as well as cognitive and emotional development (2). Dietary behaviors established during early life serve as the basis for habits that persist throughout the lifespan (3). In recent years, an increasing global prevalence of unhealthy dietary habits has been identified, leading to concerns about the nutritional status of children and adolescents and the associated health outcomes. This is currently recognized as a major public health challenge (4).

Malnutrition among school-aged children is a major international health concern. Chronic malnutrition during childhood is associated with low body weight, stunting, increased susceptibility to infections, and cognitive and behavioral impairments (5). These issues are more pronounced among socioeconomically disadvantaged populations and are a core component of health inequalities that begin in early life and continue throughout adulthood (6). On the other hand, overnutrition and childhood obesity have reached

historically high levels worldwide, with approximately 8% of school-aged children now classed as overweight or obese (7). Obesity is associated with adverse health outcomes, including cardiovascular diseases, diabetes, certain cancers, and chronic respiratory diseases. As such, it also constitutes a substantial economic burden (8). Therefore, strengthening scientific research into child and adolescent nutrition is a critical priority (9). In parallel with global trends, obesity and chronic disease management among school-aged children have become a significant public health concern in Türkiye. A large-scale study conducted in Zonguldak province with 16.880 students revealed that 15.1% of middle school children were obese, while 22.8% were at risk of overweight (10). Moreover, another study conducted in Türkiye among children with Type 1 diabetes reported that glycemic control was directly associated with academic performance and school absenteeism rates (11). Collectively, these data indicate that school nutrition should not be considered merely a dietary issue, but rather a health intervention intrinsically linked to educational outcomes and overall quality of school life.

Schools are environments in which children meet a substantial portion of their daily energy intake and where dietary behaviors are shaped (12,13). School nutrition programs are interventions in which students are supported with meals/snacks within the school setting and/or provided with take-home food rations (14). These programs have been shown to have positive effects not only on improving nutritional status but also on school attendance and academic achievement (13,15). Before the COVID-19 pandemic, school nutrition programs have become one of the largest social protection networks worldwide (16). In 2022, 418 million children received free or subsidized school meals (17). Research has demonstrated benefits that include improved dietary intake, support for healthy weight maintenance, enhanced nutrition-related behaviors, and strengthened social support. Nevertheless, the heterogeneity of program designs between countries complicates overarching evaluations of school nutrition initiatives (13). Consequently, further research is needed to strengthen the generalizability of findings and address outstanding questions regarding program effectiveness across diverse socioeconomic contexts, cost-benefit considerations, and long-term health outcomes (18,19).

Several bibliometric studies have examined child nutrition in the past. However, these studies have not considered school nutrition and school meals as an integrated public health domain. In addition, the existing literature includes systematic reviews and meta-analyses that primarily focus on specific interventions (20,21), As such, these studies appear limited in their ability to comprehensively reflect the growing volume of the literature and its thematic evolution. To address this gap, the present study aims to map the scientific literature on school nutrition and school meals published between 2000 and 2025 using bibliometric methods. In this context, it seeks to identify publication trends, delineate the conceptual structure of the field, and evaluate its thematic development. The study is expected to contribute to identifying future research priorities in the area of school nutrition and school meal programs.

MATERIAL and METHODS

In this study, we adopted the bibliometric framework developed by Donthu et al. Bibliometric analysis is a systematic means of evaluating the development, dissemination, and impact of scientific knowledge over time through the analysis of large-scale datasets (22). Accordingly, performance analysis (e.g., annual scientific production, authorship patterns, and selected citation-based indicators) and science mapping techniques were used to examine the structural and thematic characteristics of the field, including conceptual structures and thematic evolution.

Data Source and Study Selection

The data for this study were obtained from the Web of Science Core Collection (WoSCC) database. The search was conducted on December 22, 2025, using the query ((TS = "school meals") OR (TS = "school nutrition")) in the topic field. The search terms were selected to capture the core concepts most commonly used in the school nutrition literature. The initial search yielded a total of 2505 records. At this stage, the retrieved records were exported to the Bibliometrix/Biblioshiny software to undergo detailed data cleaning and preprocessing.

The inclusion criteria were as follows: (i) Studies addressing topics related to school nutrition, school meals, and the nutritional status of students; (ii) Studies that examine school nutrition within the context of public health, nutrition, health promotion, or education, and link it to health-related outcomes; (iii) Articles published in peer-reviewed academic journals indexed in the WoSCC database; (iv) Publications classified by document type as articles; (v) Studies published in the English language; and (vi) Studies published between 2000 and 2025.

The exclusion criteria were as follows: (i) Publications that are not peer-reviewed original research articles, including reviews, conference proceedings, early access publications, books, book chapters, editorial materials, corrections, and notes; (ii) Studies published in languages other than English; (iii) Clinical health sciences publications focusing on clinical nutrition and hospital-based interventions that are not linked to the school context and do not offer an interdis-

ciplinary school health or public health perspective; and (iv) Gray literature, including reports, policy documents, and institutional technical documents. In line with these criteria, we specifically targeted scientific trends in school nutrition research at the intersection of health and education, while clinical and non-school-based literature was deliberately excluded from the scope of our analysis. In addition, WoSCC subject category filters were applied to further refine the dataset. Only articles indexed under Nutrition Dietetics, Public Environmental Occupational Health, Education Educational Research, and Social Sciences Interdisciplinary were retained.

Bibliometric Analysis

Following the initial screening, the retrieved records underwent preprocessing to construct a consistent dataset suitable for bibliometric analysis. Duplicate records were removed, and studies that did not meet the inclusion criteria were excluded from the dataset. Spelling variations in author names and keywords were corrected, and synonymous or conceptually similar terms were standardized. These data cleaning and harmonization procedures were performed using Microsoft Excel software (version 2511) and Bibliometrix R package (version 4.5.2). After this process, the final dataset comprised 797 articles.

All bibliometric analyses in this study were conducted using the Bibliometrix R package (23) and its web-based interface, Biblioshiny. Bibliographic records downloaded from the WoSCC database using the "full record and cited references" option were merged in txt format and then imported into the Biblioshiny interface within R Studio. Descriptive tables related to WoSCC subject categories and selected summary statistics were prepared using Microsoft Excel.

Using Biblioshiny, we calculated descriptive indicators related to publication output and thematic structures. Conceptual relationships within the literature were examined through keyword-based analyses, including trend topic analysis to explore the evolution of prominent themes over time. For this, we used author keywords as the field, with the parameters set to a minimum word frequency of five and three words per year. This enabled examination of the temporal distribution of key concepts within the literature for each year between 2000 and 2025. Conceptual structures were further explored through a keyword co-occurrence network analysis based on author keywords. We used the Fruchterman and Reingold layout algorithm for network visualization, and applied the association normalization method with the Louvain clustering algorithm (24). The network was restricted to 30 nodes, and isolated nodes were excluded to enhance interpretability.

To assess the strategic positioning of thematic clusters, a thematic map analysis was performed using author keywords, with parameters set to the top 250 most frequent terms and a minimum cluster frequency threshold of five per 1000 documents. The centrality and density levels of the themes were comparatively assessed using the Louvain clustering algorithm. Finally, thematic evolution analysis was conducted to examine the development of conceptual structures over time. Author keywords were used with the same term selection criteria, and the inclusion index (weighted word occurrence) served as the weighting method. Time slices were constructed using two cut-off points (2015 and 2021). These were automatically determined by Biblioshiny.

RESULTS

In this study, the initial search of the WoSCC yielded 2505 records. After applying the predefined inclusion and exclusion criteria, removing non-eligible document types and subject categories, and completing the data cleaning procedures, a final dataset of 797 articles published between 2000 and 2025 was retained for analysis (Figure 1).

The main characteristics of the dataset are presented in Table 1.

As shown in Table 1, a total of 797 articles published between 2000 and 2025 were produced by 2860 distinct researchers. The average age of the documents was 7.86 years, and the mean number of citations per document was 18.94.

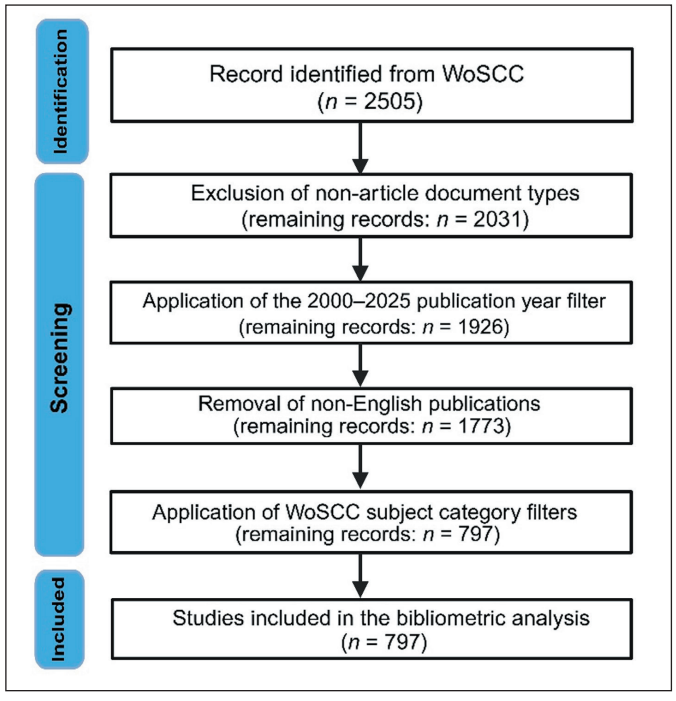


Figure 1: Flow diagram of the study selection process for the bibliometric dataset.

The dataset contained a total of 22,395 references. The annual growth rate in the number of articles was 11.44%. The proportion of papers with international co-authorship was 16.81%. The average number of co-authors per article was 5.01. The dataset included a total of 1.617 author keywords. The annual distribution of scientific publications on school nutrition over the study period is presented in Figure 2.

Figure 2 illustrates that between 2000 and 2025, there was an overall trend toward an increasing number of publications. There was a marked acceleration in annual publication output at several time points, particularly after 2019. The number of publications peaked in 2022. While a slight decline was noted in 2023, publication levels increased again in the subsequent years (2024–2025). These findings indicate sustained growth in research on this topic over time, albeit with some fluctuations. Figure 3 presents the thematic trends that emerged during the study period in the school nutrition literature based on author keywords.

Table 1: Main information from a dataset of articles.

Information	Results
Timespan	2000–2025
Sources	148
Documents	797
Annual growth rate	11.44%
Authors	2,860
Single-authored documents	60
International co-authorship	16.81%
Co-authors per document	5.01
Author keywords	1,617
References	22,395
Average document age	7.86
Average number of citations per document	18.94

As illustrated in Figure 3, in the 2009–2014 period, "packed lunches," "vegetables," "food choice," and "primary schools" were particularly prominent keywords. During the 2015–2020 period, the terms "school nutrition," "nutrition policy," "free school meals," and "school health" were more frequent. These concepts showed noticeable concentrations within specific time intervals. After 2021, use of the keywords "food insecurity," "national school lunch program," "child nutrition," and "universal school meals" increased. The terms "implementation" and "adolescent nutrition" were also frequently given as keywords during this period. Overall, the figure demonstrates diversification of the key concepts in the school nutrition literature over time, with different prominent themes across distinct periods. Figure 4 illustrates the co-occurrence relationships between author keywords in the school nutrition literature.

When Figure 4 is examined, within the network structure, the terms "school meals," "children," and "nutrition" were the nodes with the most connections to other concepts. Examination of the network indicates a cluster of concepts organized around school-based and policy-related terms such as "school nutrition," "nutrition policy," "public policy," and "school feeding." Another cluster is composed of health- and behavior-related terms, including "obesity," "childhood obesity," "physical activity," and "health promotion." The keywords "food insecurity," "national school lunch program," and "food policy" commonly co-occur with "school meals" and are directly connected within the network. Overall, the co-occurrence network demonstrates the coexistence of multiple conceptual clusters within the school nutrition literature and shows the relationships between these concepts across the network. Figure 5 presents the thematic structure

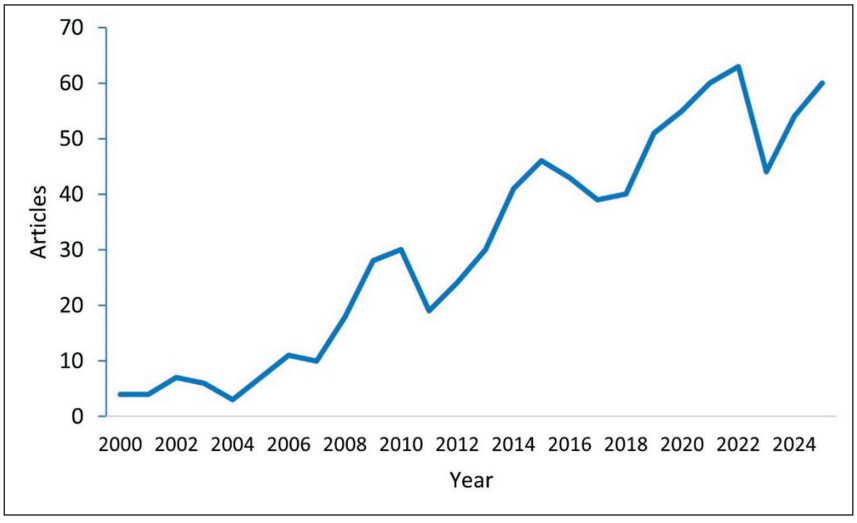


Figure 2: Annual publications on school nutrition.

of the key concepts in the school nutrition literature according to their centrality and density.

As shown in Figure 5, the themes in the upper right quadrant —"school meals," "nutrition," and "school"— are motor themes, characterized by high centrality and density. In the lower-right quadrant are the basic themes, "schools," "obesity," and "school feeding." They have high centrality but relatively lower density. The upper-left quadrant includes the niche themes "children," "nutrition education," and "implementation." These have high density and comparatively lower centrality. The lower-left quadrant contains emerging and declining themes, which have low centrality and density. These are "school lunch," "diet," and "school meal." Overall, the thematic map demonstrates that the key themes in the

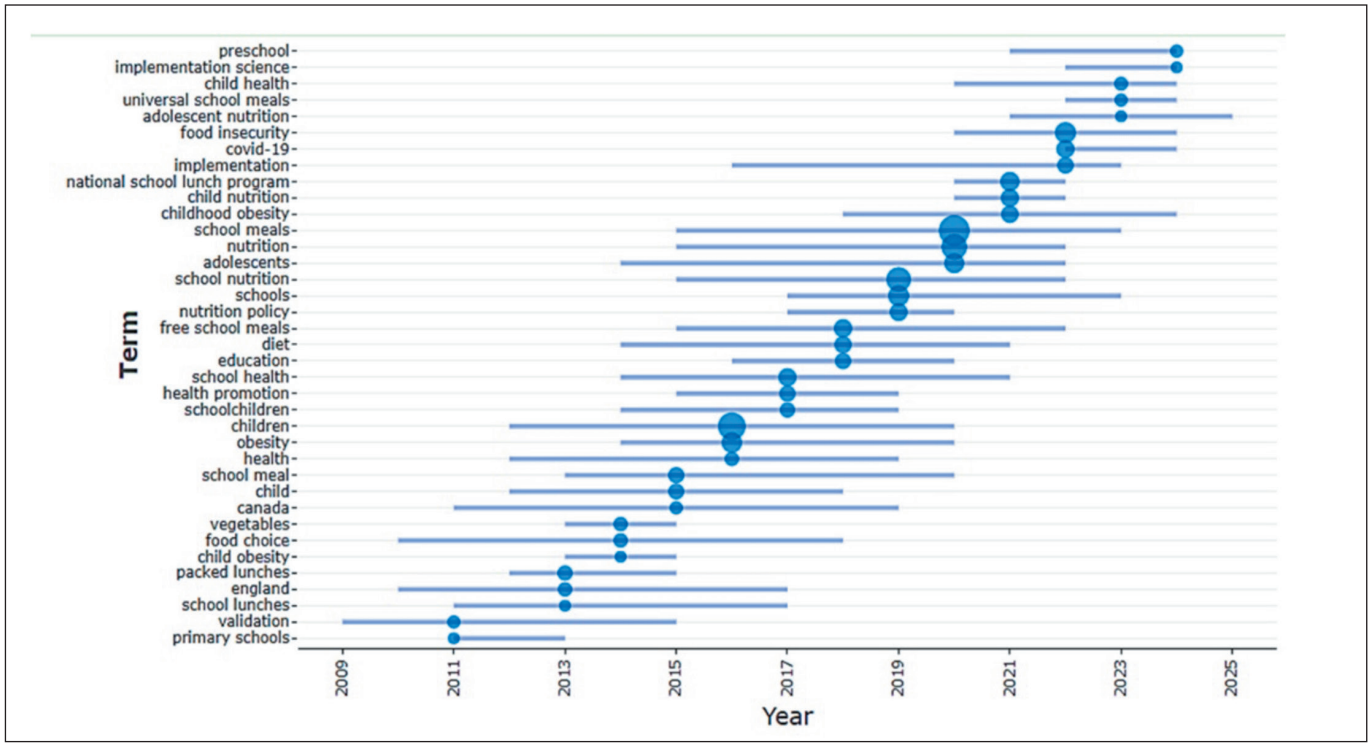


Figure 3: Thematic trends in school nutrition based on author keywords.

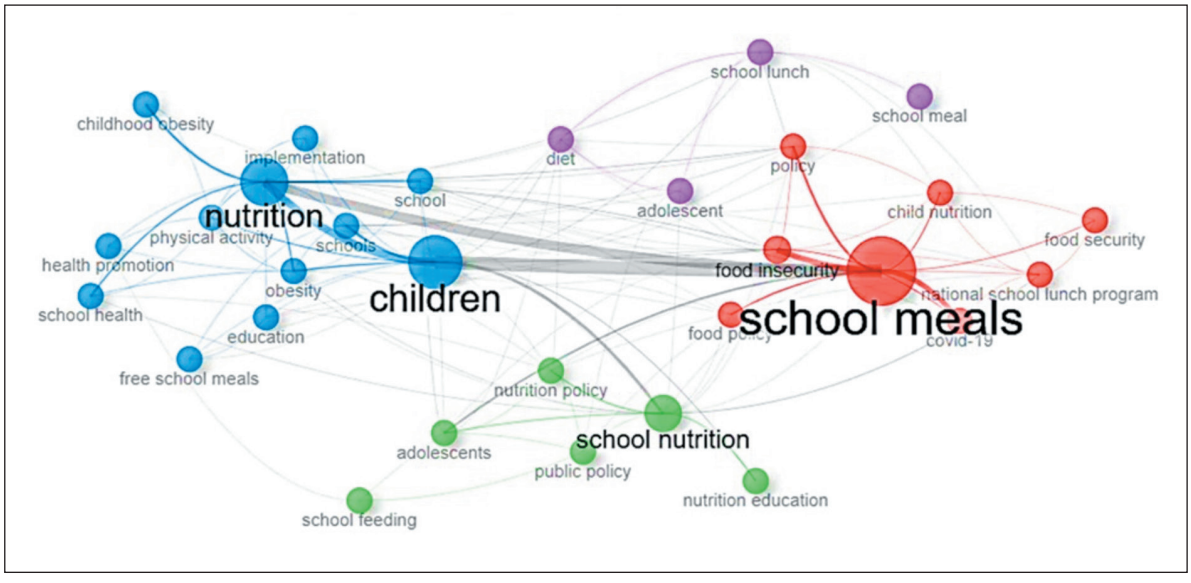


Figure 4: Keyword co-occurrence network in school nutrition research.

school nutrition literature were distributed across distinct categories based on their centrality and density. Figure 6 presents the evolution of the key themes in the school nutrition literature across three time periods (2000–2015, 2016–2021, and 2022–2025).

As shown in Figure 6, in the first period (2000–2015), the themes "children," "nutrition," "school nutrition," "school feeding," and "school lunch" were prominent. The concepts "inequality" and "farm to school" were also observed within the thematic flow. In the second period (2016–2021), several themes from the previous period continued to appear, including "children," "nutrition," "school meals," and "school lunch." In addition, the themes "food insecurity," "dietary quality," "child nutrition," and "national school lunch program" began to emerge. In the third period (2022–2025), the themes "school meals" and "nutrition" continued to maintain prominence, while additional themes, including "childhood obesity," "school nutrition," "adolescent," "implementation," and "nutritional quality," were incorporated into the thematic structure. Overall, the thematic evolution map illustrates the core themes that have persisted throughout the study period, and those that have emerged and developed over time.

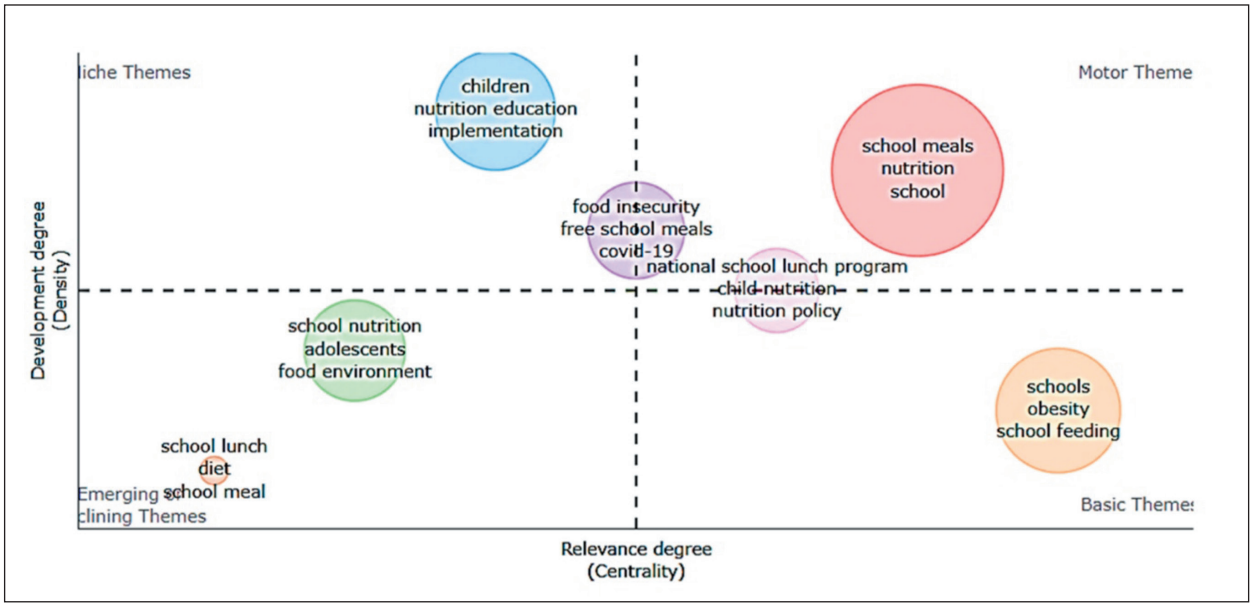


Figure 5: Thematic map of school nutrition research.

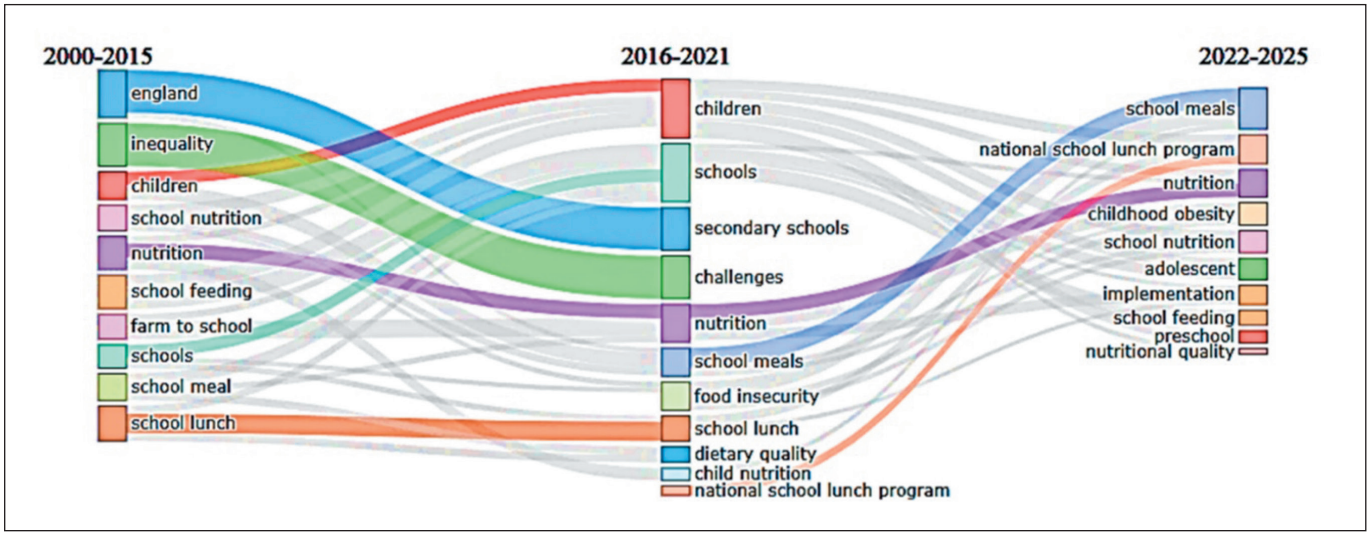


Figure 6: Thematic evolution of school nutrition research.

DISCUSSION

School nutrition is a central public health strategy on the global policy agenda due to its associations with child health, well-being, and educational outcomes (13). We examined the field of school nutrition and school meals in depth using 797 original research articles published between 2000 and 2025 and obtained from the WoSCC database. This bibliometric analysis maps the temporal development and thematic evolution of school nutrition research, highlighting annual publication output and growth patterns as well as the conceptual structures within the field.

We found an average annual growth rate in school nutrition publications of 11.4%. The proportion of the included articles with international co-authorship was 16.81%. While the field of school nutrition is inherently conducive to comparative and multi-contextual evidence generation, this finding suggests relatively limited international research collaboration. It has been reported that countries with higher national research capacity tend to exhibit comparatively lower levels of international co-authorship (25). In low- and middle-income countries, research agendas are frequently determined by international funding bodies. Together with country-specific policies governing school nutrition programs and differences in institutional infrastructures and financing, this can complicate shared data collection and reporting protocols in international projects. It has been suggested that these issues may influence collaboration dynamics in this field (26–28). Nevertheless, if school nutrition research is to develop and evolve, strengthening research networks that support the generation of comparable evidence through international collaborations is critical.

In this study, the annual production of research publications on the topic of school nutrition (Figure 2) exhibited an overall upward trend over time, albeit with periodic fluctuations. After 2019, we observed a pronounced increase in publication output, with the annual publication rate reaching its peak in 2022. This increase may be attributed to increased attention on the role of school nutrition programs in addressing food insecurity during the COVID-19 pandemic (29), as well as growing interest in universal free school meal policies and initiatives such as the Community Eligibility Provision (CEP) (30,31). The widespread school closures during the pandemic disrupted access to regular school meals for millions of children, bringing the social protection and equity dimensions of school nutrition programs to the forefront. This contributed to a rapid increase in research on program accessibility, inclusiveness, and flexibility (32,33). Concurrently, the publication of several global reports provided systematic and comparable data on school nutrition, strengthening academic interest in the field (14,34,35). Despite a relative slowdown in publication rates in 2023, the subsequent increase in 2024 and 2025 indicates sustained evidence-based interest in the relationships between school meals, food insecurity, educational outcomes, and inequalities in the post-pandemic period (14,36,37).

Among the merged keywords, "children," "nutrition," and "school meals" were strongly associated with nearly all source and author nodes, indicating that these concepts constitute the core conceptual backbone of school nutrition research. The terms "breakfast," "lunch," "obesity," "physical activity," "food insecurity," and "childhood obesity" emerged as complementary axes that reflected thematic diversity and the evolving priorities of the subject area. Moreover, the strong connections between the keywords "food insecurity," "policy," and "childhood obesity" and recently active authors suggests that the research trajectories for these themes have gathered momentum in recent years.

The thematic trends (Figures 3 and 6) identified in this study indicate that school nutrition research has evolved from an early descriptive phase concerned with micro-level behavioral foci, such as individual dietary intake, meal composition, and food preferences, through a policy and institutional arrangements phase, to a recent, more focused and mature structure centered on implementation processes and food insecurity. This pattern aligns with cyclical models presented in the literature to describe the interactions between behavior, policy, and practice (38,39). During the early phase, the network connections between concepts were relatively weak, suggesting limited thematic integration at that time.

During the mid-phase, the system- and policy-level concerns that moved to the center of the research agenda included school-based nutrition policies, programs, and institutional arrangements. In this context, policy changes such as the Healthy, Hunger-Free Kids Act (2010), revisions to the National School Lunch Program (NSLP), and the expansion of the CEP program were accompanied by a growing body of research. This increased the prominence of concepts such as "dietary quality" and "food insecurity" (13). At the same time, the subject area was characterized by expansion and diversification, including the rapid growth of established thematic clusters and the formation of new conceptual links (40). A growing number of implementation-focused examinations of how evidence-based programs can be adapted across diverse contexts were published during this period. This was indicative of a shift from the question, "What should be done?" to the question, "How, where, and under what conditions can interventions be effectively implemented?" (41). In the most recent phase, the themes "COVID-19," "food insecurity," "universal school meals," and "implemen-

tation" came to the fore, demonstrating the expansion of the school nutrition literature along the axes of social protection and equality. The rise of the "universal school meals" theme in our analysis reflects a global shift toward inclusive social protection. However, the psychosocial implications of such policies remain complex. Recent evidence from Orta-Aleman et al. suggests that while universal programs effectively reduce social stigma for low-income students, they may induce unexpected emotional responses, such as embarrassment, among higher-income peers. This situation indicates that school feeding programs should aim to understand peer norms and family perceptions in order to ensure equal participation across all socioeconomic groups (42). Joint reports by the United Nations (UN) Children's Fund (UNICEF) and the World Food Program (43), together with the UN Research Roadmap for the COVID-19 Recovery, have emphasized that schools are critical social protection infrastructures that ensure regular access to nutritious food, particularly for disadvantaged children. Similarly, the call by the UN Educational, Scientific, and Cultural Organization for a rethink on school health and nutrition in the context of the pandemic has underscored the potential of school-based programs to mitigate structural inequalities (44). Consistent with this, we found that the more recent literature showed a stronger orientation toward themes related to structural barriers, food insecurity, and the sustainability of national programs. A growing number of studies are now examining the impact of school nutrition policies in different contexts and the challenges encountered during their implementation (13,30,45–49). The concurrent rise in the themes "childhood obesity" and "food insecurity" in recent years shows an increasing use of approaches that address both the social equality and nutritional outcomes of free school meal programs (30,46,50). The growing visibility of the keywords "child health" and "adolescent nutrition" further indicates an extension of the research focus beyond energy levels and nutrient intake during growth and development to encompass broader health-related effects of school nutrition programs (13). Recent research trajectories indicate that school feeding is increasingly linked to the sustainability of global food systems. The Brazilian PNAE (Programa Nacional de Alimentação Escolar) model, which integrates school menus with local family agriculture, serves as a benchmark for fostering local economic empowerment and food sovereignty (51). Furthermore, the emerging focus on food recovery and waste management reinforces the role of schools as platforms for climate action (52). This bibliometric surge in sustainability-related keywords reflects a transition where school meals are viewed not just as a health intervention, but as a component of resilient local food systems (51).

A four-quadrant thematic map (Figure 5) was developed for this study. In this, the motor theme quadrant comprised a cluster of the themes "school meals," "nutrition," and "school." This quadrant has the highest centrality and density, so forms the structural backbone of the subject area (53). The themes "free school meals," "COVID-19," "food insecurity," "NSLP," "child nutrition," and "nutrition policy" at the boundary of the motor theme quadrant point to a strengthened research trajectory, particularly post-COVID, focused on system-level interventions, structural inequalities, and food security (54,55). The growing prominence of the themes "food insecurity" and "free school meals" indicates that school meals are increasingly being considered in terms of their contribution to equity and social protection, rather than just in relation to nutritional objectives (13,56). This shift reflects alignment of the research agenda with the UN Sustainable Development Goals (SDGs), specifically SDG 2 (zero hunger) and SDG 10 (reduced inequality) (57). We found that the "children," "nutrition education," and "implementation" cluster in the niche themes quadrant represents a conceptually well-developed and internally coherent subfield. However, its relatively limited interaction with broader debates in the field suggests that it would benefit from greater integration with policy- and system-level research (58). Based on this element of our analysis, we believe that the systematic integration of implementation science theories and frameworks into the development of school nutrition interventions is a vital step toward ensuring that programs are realistic, sustainable, and scalable (59). The basic theme quadrant included "schools," "obesity," and "school feeding." These themes were highly visible, but related conceptual frameworks and coherent research streams have not yet fully matured (53). Finally, the emerging/declining themes quadrant incorporated a "school nutrition," "adolescents," "food environment," cluster, and a "school lunch," "diet," and "school meal" cluster. The themes in this quadrant have low levels of integration but the potential to strengthen over time and contribute to more central issues in future research (40). Our mapping identified the "food environment" as a pivotal theme, yet it is often limited to physical availability. According to the framework by Jeong et al., the school food environment comprises four vital dimensions: physical, economic, socio-cultural, and policy (60). Our findings indicate that while most measurement tools focus on the physical environment, economic accessibility and socio-cultural alignment are frequently overlooked. This is evidenced by field data from Türkiye (61) and Brazil (51), which demonstrate that the mere presence of healthy options is insufficient if they conflict with cultural food preferences or if school canteens predominantly promote affordable but less nutritious competitive foods.

Our keyword co-occurrence network (Figure 4) indicated that "children," "nutrition," and "school meals" are the core concepts around which school nutrition research is organized. From these, three dominant conceptual clusters emerged. These included a school policies and practices cluster, a health- and behavior-oriented cluster, and a cluster concerned with school nutrition at the level of food insecurity, national programs, and system-scale responses. Together, these clusters represent the principal thematic axes of the topic, with the third cluster representing a research trajectory that has strengthened markedly in recent years. Reflecting this thematic concentration, our findings suggest that school feeding programs have evolved beyond mere food security to encompass cognitive and cultural dimensions. For instance, a study examining the free nutritious meal program in Indonesia demonstrated that this intervention significantly improved students' concentration levels (62). Similarly, Supnawadi argues that integrating local cuisine into school menus strengthens cultural identity (63). These international examples provide important references for the development of school feeding models in Türkiye. However, the current situation in Türkiye continues to be characterized by a persistent knowledge–behavior gap. For example, field studies conducted in Istanbul revealed that although children were aware of the importance of milk consumption, only 13% reported preferring it, and 46% were found to skip meals (61). These findings directly support the trajectory of the third cluster, paralleling the 46% breakfast and over 40% lunch skipping rates observed among students in Ghana, highlighting that the misalignment between nutritional awareness and actual intake is a universal barrier (64). At this point, the drama-based learning intervention implemented by Eryiğit et al. demonstrated improvements in obesity awareness and body mass index (BMI) values, suggesting that experiential learning models may play a key role in bridging the knowledge–behavior gap (65). Ultimately, as evidenced by the Indonesian national school feeding program (ProGAS—Program Gizi Anak Sekolah), the sustainability of these school-based interventions depends on robust stakeholder participation and the integration of pedagogical depth into nutritional policies (66). Hence, school nutrition is increasingly being discussed within the frameworks of social protection, inequality, and system-level policy approaches. These findings also suggest that school nutrition is an interdisciplinary topic closely linked to curricula, school environments, and learning (34,67). Previous studies have emphasized the need for school nutrition programs to be integrated into the education environment and other school-based interventions to maximize their efficacy (45,68,69). Greater representation of school nutrition research in education-focused journals is likely to support the establishment of an evidence-based bridge between the health and education sectors (45).

While this study provides important insights into the evolution of school nutrition research, several limitations should be considered when interpreting the findings. First, the analysis was confined to bibliometric indicators and did not include in-depth content analysis of the research designs, methodologies, or findings of the included studies. Second, the exclusive use of the WoSCC database may have resulted in the exclusion of relevant studies indexed in other databases, such as Scopus, PubMed, or ERIC. Third, only English-language publications were included, which may have introduced language bias and limited the representation of research produced in non-English-speaking regions. Fourth, the search strategy was based on specific keywords ("school meals" and "school nutrition"), and although carefully selected, it may not have captured all relevant studies using alternative terminology.

CONCLUSION and RECOMMENDATIONS

In this bibliometric analysis, we demonstrate that research on school nutrition and school meals has evolved from an early focus on dietary intake and meal composition toward a more comprehensive public health framework that addresses food insecurity, childhood obesity, and the implementation of national school meal policies. Despite this maturation, important gaps remain that require targeted and coordinated research efforts. The relatively low rate of international collaboration and the limited generation of implementation-focused evidence may hinder the development of scalable, context-sensitive interventions aimed at improving dietary behaviors and reducing nutrition-related inequalities. In this regard, strengthening interdisciplinary integration is essential to ensure that nutritional science is effectively connected with education and social policy domains. The coexistence of health-oriented and policy-oriented clusters underscores the need to integrate nutritional science with education and social policy perspectives, thereby facilitating a more coherent translation of evidence into practice. Adopting implementation science frameworks is essential to reduce the policy–practice gap and to enhance the measurable impact of school nutrition programs on dietary quality and obesity prevention.

When considered within the Türkiye context, school nutrition research should move beyond its predominantly clinical focus and adopt a more system-level perspective, encompassing dietary quality, childhood obesity, and food security (70). As exemplified by Canada's national school food policy, the development of multidimensional assessment tools and the monitoring of long-term intervention outcomes

(60) may contribute to the formulation of evidence-based policies aimed at addressing childhood obesity and nutritional inequalities in Türkiye. Such an approach would enable research to more clearly demonstrate and sustainably strengthen the protective effects of school-based interventions on child and adolescent health.

Acknowledgements
None.

Authorship Contributions
Conceptualization: **Fatma Şatıroğlu, Öykü Altınok,** methodology: **Fatma Şatıroğlu,** formal analysis: **Fatma Şatıroğlu,** investigation: **Fatma Şatıroğlu,** data curation: **Fatma Şatıroğlu, Öykü Altınok,** writing—original draft preparation: **Fatma Şatıroğlu, Öykü Altınok,** writing—review and editing: **Öykü Altınok,** visualization: **Öykü Altınok.** All authors have read and agreed to the published version of the manuscript.

Conflict of Interest
The authors declare no conflict of interest.

Financial Support
The authors received no financial support for this study.

Ethical Approval
As this is a review article, ethical approval was not required.

Peer Review Process
Extremely and externally peer-reviewed.

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