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Trends in pediatric kidney stone research between 2004-2023: a bibliometric study

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ABSTRACT

Aims: The purpose of this current investigation is twofold: first, to review the available literature published in the last twenty years on pediatric nephrolithiasis; and second, to evaluate the progression of research on this topic during the indicated period. In this respect, through bibliometric analysis the present study aims to reveal trends, crucial authors, important institutions and outstanding journals of this line of research. It also takes an attempt to compare the increasing trend of publication productivity and citation frequency and the distribution of the research outputs across the countries/regions of the world to map the progress and potential prospects of pediatric kidney stone research.

Methods: The present study aimed to perform a bibliometric analysis of knowledge production. In pediatric kidney stone from 2004 to 2023 using WoS Core Collection. Articles were searched using the term "Kidney Stones in Children" including all articles, reviews and papers indexed, reviews and conference papers. The examination focused on the overall publication output, number of citations received, and journal citation; with methods including keyword frequency, bibliographic coupling, co-citation analysis, and co-authorship networks. Element positions, co-occurrence frequencies, and clusters were developed from the data source by using VOSviewer software. The study covered publication distribution, citation behaviour, keyword frequencies, and collaboration map.

Results: According to the presented research, the level of academic interest in this topic has risen dramatically over the years, and its popularity peaked in 2020. This result is expected because leading academic centres and name-referenced universities like University of Pennsylvania and Children's Hospital of Philadelphia contributed significantly to the current literature. Ten most preferred journals are Journal of Urology, Journal of Pediatric Urology and many more. The findings reveal the overall international cooperation with especial emphasis on relations between institutions in the US and European countries. Carrying out the keyword analysis, authors have determined that "urolithiasis", "nephrolithiasis", and "kidney stones" are the most topical concerns. Aside from general surgery, much of the most frequently cited research is relevant to surgical practices and dietary recommendations. The purpose of this review is to enhance the understanding of the tendencies of the studies the most active contributors and cooperation patterns in the pediatric kidney stones.

Conclusion: This bibliometric analysis reveals a significant rise in pediatric kidney stones research, peaking in 2020. Key contributors include the University of Pennsylvania and the Children's Hospital of Philadelphia, with strong international collaborations. Original research articles and top journals, like the Journal of Urology, remain central. The U.S. leads in contributions, with notable input from Turkish institutions.

Keywords: Pediatric urolithiasis, kidney stones in children, pediatric nephrolithiasis, bibliometric study

INTRODUCTION

Kidney stones, abbreviated as NL, are one of the major non-communicable diseases that have a life time prevalence of 11.0% in males and 5.6 %in females by aged 70 years.[1] Formerly a disease seen as influencing mainly older men, NL incidence has been on the rise among children, especially female children.[2] This demographic change calls for efforts to understand more about NL incidence trends and their predisposing factors as well as endeavours towards finding ways of reversing the observed increase in prevalence of NL in the young population.[3]

NL is not equally distributed throughout the world, and prevalence is higher in areas that are characterized by arid climate.[4,5] Some environmental factors like temperature has been reported to increase the incidence of NL hence the belief that global warming can help to explain the rising incidence of NL across the world.[6] For example, the southeastern region of the United States often called the "stone belt" has twice more frequency of NL than the north western region; this frequency is believed to increase as the climate improvements persist.[7] Likewise, the Afro-Asian stone belt extending from Sudan

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through the Philippines[4] has a high rate of NL attributable to both environmental and dietary influences.[8]

Another risk factor that has been identified is the genetic make-up because it has been clearly seen to have a bearing on NL occurrence. First-degree relatives of patients with kidney stones have 2-16 times higher incidence of NL than other individuals with no such history.[4] A recent study pointed to monogenic causal mutation for NL or nephrocalcinosis (NC) in 106 children without prior known aetiologies in 21%.[9] More than 30 genes have been reported to be associated with NL or NC with features of AD, AR, and X-linked inheritance. Such genetic factors, together with the environments, prove that NL is not easy to explain and has multiple causative factors.[10]

Over the last few decades developed countries have observed a very steep rise in the pediatric NL incidence and this is not associated with either geographical or genetic factors.[4,5] For instance, the incidence rate of this disease in South Carolina increased from 7.9 per one hundred thousand in 1996 to 18.5 per one hundred thousand in 2007, as per the sexually transmitted diseases fact sheet and women were found to have higher rates than men.[5] Similar trend is observed in other cold climate countries such as Iceland where the incidence rose from 3.7 per 100,000 in 1995-1999 to 11.0 per 100,000 in 1999-2004, especially among girls aged between 13-17 years.[11] The causes of increased rate of incidence in females within childhood and adolescence are however not well understood.

Several factors have also been associated with the rising trend of NL and these are; diet, obesity and the environment.[11,12] The cooler temperatures of an office environment may increase the risk of stone formation because these states mean dehydrated bodies leading to concentrated urine. Other non-modifiable risk factors for NL include high sodium and fructose intake as well.[6] Also, metabolic risk factors for stone development have been reported to be associated with increased obesity among children and the adolescents. Knowledge of these risk factors is important to enable the formulation of an appropriate prevention and management model of pediatric NL.[6]

There are metabolic risk factors of pediatric urolithiasis which in turn plays a role in the formation of the kid kidney stones. These metabolic derangements skew urine chemistry and hence encourages formation of stone precipitating compounds. The important risk factors includes hypercalciuria, hypocitraturia, hyperuricosuria, hyperoxaluria and hypomagnesuria. Hypercalciuria that refers to high levels of calcium in urine is one of the most common metabolic derangements associated with stone formation in children. High levels of calcium in the urine can combine with oxalate or phosphate and create stones known as calcium-based stones.[13,14] Moreover, hypocitraturia, which is abnormally low urinary citrate, causes the inability to appropriate calcium binding, and thus enhances the possibility of calcium crystallization and can affect stone formation.[15]

Other metabolic abnormalities include hyperuricosuria, this is elevated levels of uric acid in urine and promotes uric acid as well as calcium oxalate stones formation. There is evidence that calcium oxalate can crystallize on the surface of uric acid crystals; therefore, this is an important factor for paediatric population.[4] First, hyperoxaluria or increased urinary oxalate excretion enhances calcium oxalate crystallization and it is established that stone formation in children is dominated by this constituent.[16] Finally, hypomagnesuria lowers the body's ability to suppress calcium crystal formation because magnesium usually hinders the process of crystallization.[15] The metabolic risks are usually managed through dietary changes and medications to prevent recurrence of the formations in children and youth.[15]

The purpose of the study titled "Trends in pediatric kidney stone research between 2004-2023: a bibliometric study" is to provide an exhaustive synthesis of the development of research in pediatric nephrolithiasis for the last two decades. To achieve these objectives, the present paper employs bibliometric analysis and seeks to uncover trends, authors, institution, and journals with the most impact in this subject area. The study will also look at the increase in publication rate, citation rate and distribution of the research among various countries and regions.

The current research work offers a strategic investigation seeking to address major research voids in the existing literature on pediatric kidney stone. Not only does bibliometric analysis demonstrate the literature's productivity and the involvement of key institutions, but it also describes the development of research topics and indicates what issues future investigations should focus on. This approach can be valuable when assessing international partnerships and the exchange of ideas across borders and provides a global view of scientific progress. Considering the rising occurrence of pediatric kidney stones and the extant literature on surgical options, metabolic disturbances, and dietary management, this review synthesizes fragmented works to lay a substantial groundwork for future studies. The information obtained through the bibliometric analysis, especially when it comes to the identification of the studies in the comparatively understudied fields like minimally invasive methods and genetic profiles, allows to recognize which topics should be paid more attention to by the researchers and other practitioners in the field of medicine. In conclusion, it is not just an atlas of the scientific knowledge distribution but also a helpful guide for any further development of the international cooperation in the field of pediatric kidney stones treatment and prevention.

METHODS

Since this research is a bibliometric study, it did not require ethics committee approval. It is conducted with the institution's permission. All procedures were carried out in accordance with the ethical rules and the principles.

In this study, a bibliometric analysis of research on kidney stones in children conducted between 2004 and 2023 was carried out. Bibliographic data were extracted from the Web of Science (WoS) Core Collection database. In the search section of the website, the term "kidney stone in children" was entered, and a total of 1303 results were obtained. A search was conducted by selecting categories from the Web of Science Categories section such as urology, nephrology, pediatrics, medicine general integral, and clinical nephrology. The

WoS Core Collection is a widely used and reliable database for bibliometric analyses, encompassing over 20,000 peer-reviewed, high-quality journals published globally across various fields.

Articles from 2004 to 2023 were collected using the search term "Kidney Stones in Children" Inclusion criteria for the study encompassed all articles, reviews, editorial materials, books, book chapters, conference papers, and all research indexed on WoS. The research was limited to articles published in English within the specified time frame.

Documents retrieved from the Web of Science database were analyzed based on trends related to the years of publication, citation counts, journals in which they were published, and the most cited authors and citation counts. The analysis included keyword co-occurrence networks, bibliographic coupling of publications, co-citation networks for references, journals, and authors, and co-authorship networks examining collaborations between countries and institutions. Keyword co-occurrence networks measure the most frequently used keywords in documents, bibliographic coupling occurs when two documents cite the same third document, co-citation networks analyze when two documents cite the same third source, and co-authorship networks analyze the volume of publications and how they are connected to each other.[17] For bibliometric analysis, data on article titles, abstracts, publication years, journal names and impact factors, authors, institutions, countries, WoS subject categories, keywords, and citation counts were collected. The annual publication growth, the relative research interest (RRI) in kidney stone research in children, and its percentage within the medical literature were determined.

Distribution of publications by institutions, authors, WoS subject categories, and journals was also analyzed. Network visualization maps were created, and the most-cited articles in research on kidney stones in children were identified using VOSviewer software (Leiden University, Leiden, Netherlands; version 1.6.11). The software uses circles that form a cluster to specify the position of an element, and the size of a circle reflects the total number of co-occurrences, indicating the elements within a clustering technique. Colors reflect the cluster to which an element belongs.[18] The more important an element is, the larger its effect and circle become, and color assignment for elements is determined based on their associated cluster.[18] The total distance between elements provides information about their relationships based on their co-occurrence in documents.[19] Proximity between elements reveals the strength of their relationship, while a larger distance indicates insufficient relationship and similarity. Additionally, a lack of connection strength indicates no relationship between elements. Based on the above, the research questions addressed are as follows:

What is the distribution of articles by year?

What is the distribution of articles by the journals in which they are published?

What are the most cited articles and their citation counts in the study?

What is the most commonly used keyword in the keyword network?

What are the prominent elements in the reference, journal, and author co-citation networks?

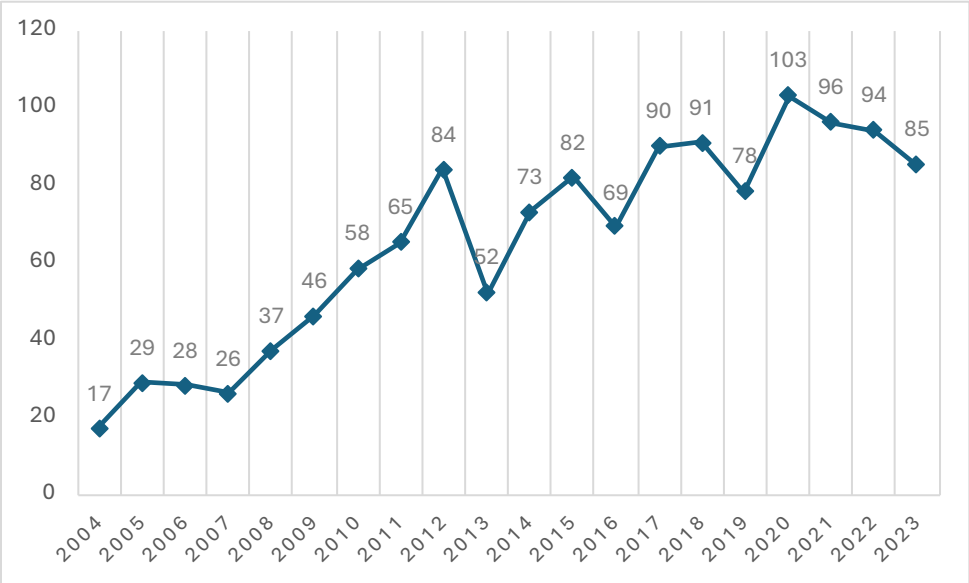
What is the similarity status of articles according to bibliographic coupling analysis?

What is the status of collaboration among universities and countries according to co-authorship analysis?

RESULTS

1-Distribution of Articles Published in WoS by Year

The distribution of articles published in the WoS over the years has been analyzed, and the results of this analysis are presented in Graph 1 below.



Graph 1. Distribution of articles published in WoS by year

When examining the distribution of articles related to kidney stones in children published in the WoS over the years, it is evident that academic interest in this topic has significantly increased over time. Starting with 17 articles in 2004, interest grew steadily. Notably, there was a significant rise in the number of publications starting in 2010, with 58 articles published that year, increasing to 84 articles in 2012. The year 2015 also saw a high number of publications, with 82 articles. However, the highest production of articles in 2020 contributing to the body of knowledge in the management of kidney stones in children was observed. The number remains high in 2021 and 2022 with the publication of 96 and 94 articles. Even in 2023 there was a slight drop with 85 articles but this also shows that there is much academic engagement on the subject.

These data show the increasing trend in the number of academic publications regarding the problem of kidney stones in children with the maximum interest in 2020. This trend might be associated with development in the medical and healthcare fields, higher research and clinical value and the public health relevance of this problem.

Table 1. Distribution of authors with the most publications

Researcher	Number of publications
A1	33
A2	20
A3	16
A4	16
A5	16
A6	14
A7	14
A8	14
A9	11
A10	11
A11	11

2- Distribution of Publications by the Most Prolific Researchers in WoS

The distribution of publications by the most prolific authors in journals indexed in the WoS database has been examined, and the results of this distribution are presented in Table 1 below.

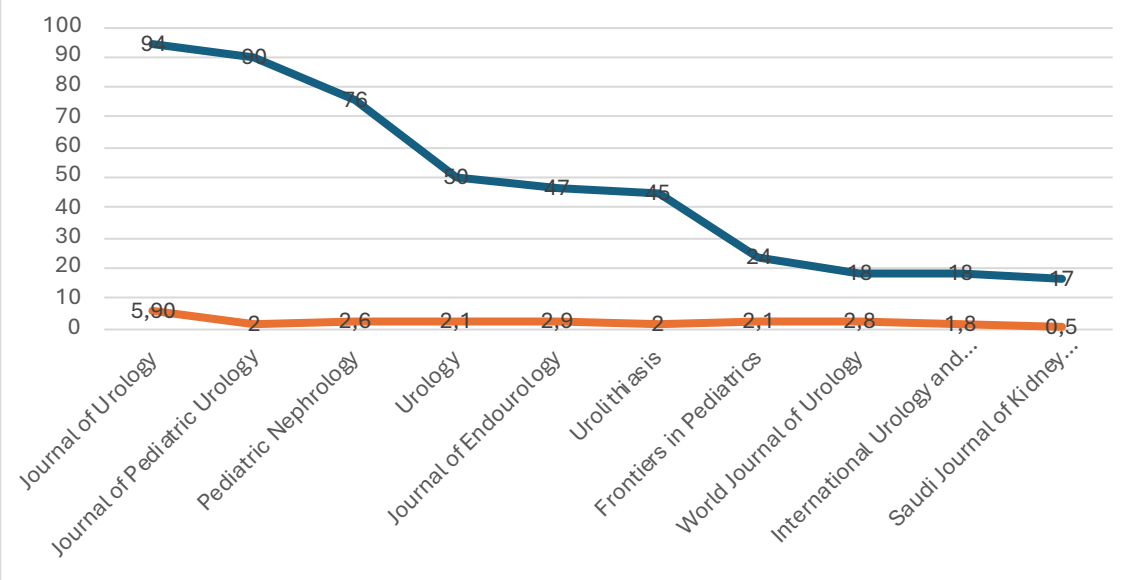
3-Journals with the Most Frequent Publications and Their Impact Factors in WoS

Analyzing the data presented in Graph 2, we can find out the journals most often selected by the researchers studying the problem of childhood kidney stones, according to the WoS database. Furthermore, the journal impact factors are also analysed and discussed in the following section.

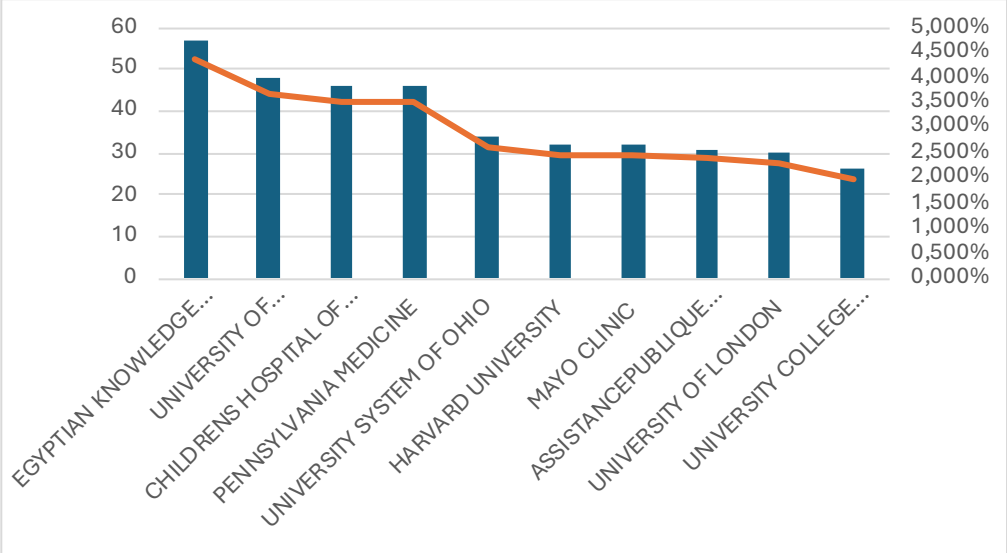
Graph 2 shows the distribution of the selected research articles over the preferred journals among the researchers focusing on pediatric kidney stones and the impact factor of these selected journals. According to the data, the Journal of Urology is the most preferred journal, with 94 publications (WoS Impact Factor: 5.90). Following this, the Journal of Pediatric Urology has 90 publications (WoS Impact Factor: 2.0), Pediatric Nephrology has 76 publications (WoS Impact Factor: 2.6), Urology has 50 publications (WoS Impact Factor: 2.1), Journal of Endourology has 47 publications (WoS Impact Factor: 2.9), Urolithiasis has 45 publications (WoS Impact Factor: 2.0), Frontiers in Pediatrics has 24 publications (WoS Impact Factor: 2.1), World Journal of Urology has 18 publications (WoS Impact Factor: 2.8), International Urology and Nephrology has 18 publications (WoS Impact Factor: 1.8), and the Saudi Journal of Kidney Diseases and Transplantation has 17 publications (WoS Impact Factor: 0.5). These journals are among the most preferred outlets for research on pediatric kidney stones, emphasizing their importance in the field through their impact factors and publication counts.

4- Institutions with the Most Affiliations and Connection Counts in WoS

Graph 3 presents an analysis of the institutions most affiliated with researchers studying pediatric kidney stones as indexed



Graph 2. Most frequent journals for publications and their impact factors



Graph 3. Institutions providing the most support, connection counts, and percentages

in WoS, including the number of connections and their percentages.

Upon examining Graph 3, it is evident that the institution with the most connections in pediatric kidney stone research is the Egyptian Knowledge Bank (EKB), with 57 connections, accounting for 4.375% of the total. The University of Pennsylvania ranks second with 48 connections, representing 3.684%, followed by the Children's Hospital of Philadelphia and Pennsylvania Medicine, both of which have 46 connections, contributing 3.530% each. The University System of Ohio has provided 34 connections, representing 2.609% of the total. Harvard University and Mayo Clinic each have 32 connections, corresponding to 2.456% of the total. Other significant contributing institutions include Assistance Publique Hôpitaux de Paris (APHP), the University of London, and University College London. These data underscore the importance of international collaborations in pediatric kidney stone research and highlight the leading institutions in this field.

Table 2. Institutions with the most publications in WoS

Institution Name	Number of publications (F)	Number of citations
University of Pennsylvania	41	1622
Childrens Hospital of Philadelphia	37	1088
Mayo Clinic	31	1486
Dicle Üniversitesi	20	308
Hacettepe Üniversitesi	17	247
Guangzhou Medical University	15	333
Mansoura University	15	266
Capital Medical University	14	156
Duke University	13	350
Nationwide Children's Hospital	13	319
Cairo University	13	169

5-Author Institutions

Table 2 presents an analysis of the institutions affiliated with the authors of the publications indexed in WoS, along with the collaboration among these institutions.

According to the data presented in Table 2, certain institutions stand out in terms of their collaboration and the number of publications by their affiliated authors in WoS. The University of Pennsylvania leads with 41 publications and 1622 citations, highlighting its significance as a major research center in the field of pediatric kidney stones. Children's Hospital of Philadelphia follows closely with 37 publications and 1088 citations, demonstrating its influence in this area.

Among Turkish universities, Dicle University is noteworthy with 20 publications and 308 citations, followed by Hacettepe University with 17 publications and 247 citations. International institutions like Guangzhou Medical University (15 publications, 333 citations) and Mansoura University (15 publications, 266 citations) have also made significant contributions. These findings indicate that certain institutions have a more substantial impact on pediatric kidney stone research, contributing important scientific knowledge to the field.

Figure 1 illustrates the collaboration network among international institutions involved in pediatric kidney stone research. Each node (dot) represents an institution, while the lines between nodes indicate collaborations between these institutions. The size of the nodes reflects the centrality and intensity of collaboration within the network. The University of Pennsylvania, depicted as a large green node, is at the center of the network, demonstrating strong collaborations with many other institutions and highlighting its central role in pediatric kidney stone research. Mayo Clinic, represented as another prominent blue node, also exhibits a broad network of collaborations. Dicle University, shown as a red node, stands out among Turkish universities, signifying its significant contribution to research on pediatric kidney stones in Turkey.

Colors typically represent different geographical regions or collaboration groups. For instance, the green group includes

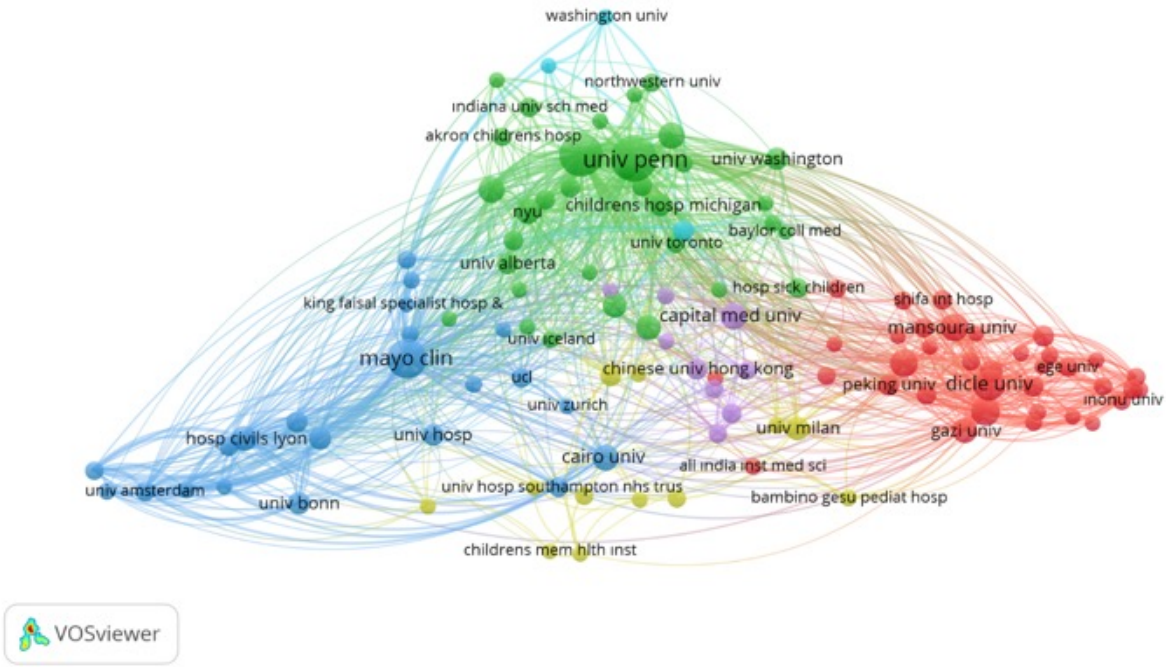


Figure 1. Bibliometric network visualization of institutions (Node size represents the institution with the most publications, colors indicate clusters, and lines show collaborations)

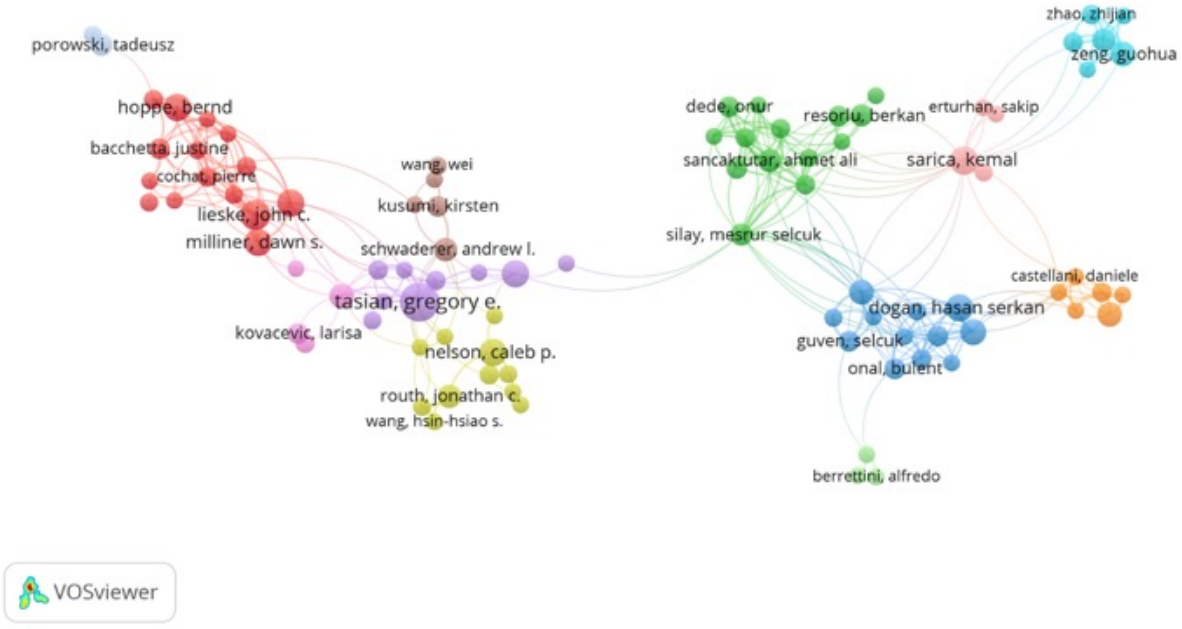


Figure 2. Author collaboration bibliometric network visualization (Node size represents key authors, and lines between nodes indicate collaboration)

North American-based universities, while the red group is composed of Turkish universities. This visualization clearly demonstrates the extent of the international collaboration network and the central roles played by certain institutions within this network.

6- Author Collaboration Network

The network of collaborations among authors of publications indexed in WoS is analyzed and presented in Figure 2.

Figure 2 visualizes the collaboration network among authors involved in pediatric kidney stone research. Each node represents an author, and the lines between nodes indicate collaborations between these authors. The size of the nodes reflects the centrality and intensity of collaboration of the authors within the network. Gregory E. Tasian is at the center of the network and appears to have collaborated with many different authors, indicating his significant role and extensive collaboration in the field. John C. Lieske and Bernd Hoppe are also notable authors with dense collaboration networks. Kemal Sarica and Hasan Serkan Doğan are significant researchers among Turkish authors, highlighted in green and blue clusters, respectively, showing their prominent role in Turkish research on pediatric kidney stones.

Table 3. Most cited source types in WoS

Source type	Number of sources	Percentage
Article	1,033	79.27%
Review article	210	16.11%
Editorial material	28	2.15%
Others	32	2.47%

Colors typically represent specific research groups or geographical regions. This visualization clearly demonstrates the extent of international collaboration in pediatric kidney stone research and the central roles played by certain authors within this network.

7- Distribution of Source Types Cited

The distribution of source types cited in articles published in journals indexed in WoS has been analyzed, and the data is presented in Table 3.

As shown in Table 3, the most cited source type in WoS-indexed journals is "Article," which constitutes 79.27% of the citations with a total of 1,033 citations. The second most cited source type is "Review Article," accounting for 16.11% of the citations with 210 citations. "Editorial Material," with 28 citations and 2.15%, ranks third, while "Others" has 32 citations, representing 2.47% of the total citations. These data indicate that researchers predominantly prefer to cite original articles and review articles.

8- Most Cited Papers

The most cited publications among those listed in WoS journals have been examined, and the data is presented in Table 4.

As indicated in Table 4, some of the most cited articles on kidney stones in children published in journals indexed in WoS have been reviewed. The article title, author name, and citation count are presented in Table 4. These data demonstrate the impact that certain studies have had in the academic community and the influence of their contributions in specific scientific fields.

For example, the article titled "Surgical Management of Stones: American Urological Association/Endourological Society Guideline" by Assimos Dean et al., with 682 citations, highlights its significance as a key reference in the surgical management of stone diseases. Similarly, the article "Lumasiran an RNAi therapeutic for primary hyperoxaluria type 1" by Garrelfs Sander et al., with 261 citations, provides a critical contribution to the treatment of primary hyperoxaluria type 1.

The study by VanDervoort Kristy et al., titled "Urolithiasis in Pediatric Patients: Urinary stone disease in children: a single center study of the incidence, clinical presentation, and outcome has 239 citations and provides a valuable presentation of different clinical features and outcome of urinary stone diseases in children. Meanwhile, the article by Dwyer Moira E. et al., titled "Temporal Trends in Incidence of Kidney Stones Among Children: among them, 'A 25-Year Population-Based Study' got 228 percent with increasing trends in the incidence of kidney stones in children years.

The most cited article, the article: Uric Acid and the Kidney by Fathallah-Shaykh S. A. and Cramer M. T., cited with 177 times, comprehensively present this issue of nephrolithiasis and uric acid. Also, the article "Increasing Incidence of Kidney Stones in Children Evaluated in the Emergency Department" by Sas David J. et al [174 citations] addresses the same issue.

Each of them is crucial to develop both theoretical and practical knowledge contributing to the fields and all of them have become well-represented in the academic literature.

9- Keyword Analysis

A further distribution of the keywords used in articles cited in the WoS database is shown in Figure 3. The above analysis uses Figure 3 to illustrate the most concerning keywords observed in the articles identified by the Web of Science (WoS) database. The keywords in the bibliometric network shown above several keywords that appear too many of times and those that have been more emphasized in the literature.

From these keywords some of the most commonly used terms identified include: urolithiasis, nephrolithiasis, and kidney

Table 4. Most cited papers

Paper Title	Authors	Number of Citations
Surgical management of stones: American urological association/endourological society guideline	Assimos, Dean et al.	682
Lumasiran, an Rnai therapeutic for primary hyperoxaluria type 1	Garrelfs, Sander F. et al.	261
Urolithiasis in pediatric patients: a single center study of incidence, clinical presentation and outcome	VanDervoort, Kristy et al.	239
Temporal trends in incidence of kidney stones among children: a 25-year population based study	Dwyer, Moira E. et al.	228
Uric acid and the kidney	Fathallah-Shaykh, S. A and Cramer, M. T.	177
Increasing incidence of kidney stones in children evaluated in the emergency department	Sas, David J. et al.	175
Rare inherited kidney diseases: challenges, opportunities, and perspectives	Devuyst, O. et al.	164
Hereditary causes of kidney stones and chronic kidney disease	Edvardsson, V.O. et. al.	163
Annual incidence of nephrolithiasis among children and adults in south carolina from 1997 to 2012	Tasian, G. E. et. al.	160
Percutaneous nephrolithotomy for complex pediatric renal calculus disease	Desai, M. R. et. al.	158

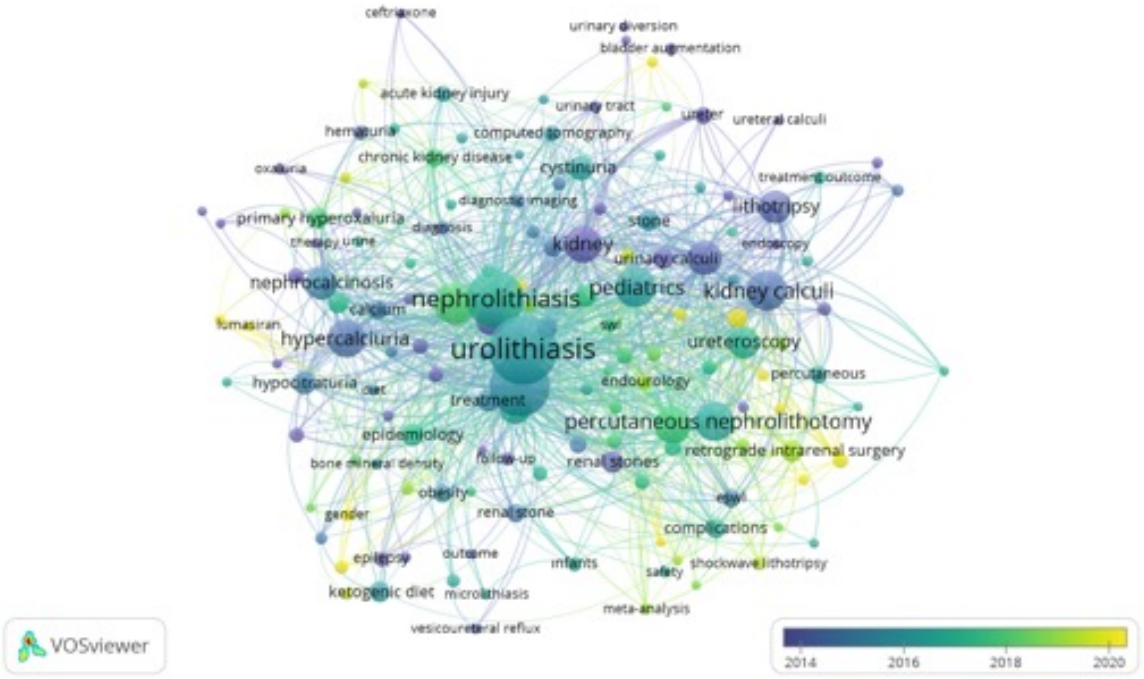


Figure 3. Bibliometric network visualization of keywords (Node size represents the most frequently addressed topics, with yellow areas indicating current topics)

calculi. These terms denote the focal areas of investigation in the field and show how often these topics are discussed in the literature. Keywords in use are a representative of research agendas and topics of interest in the subject area, indicating which areas are positioned as priorities within the academic activity. This analysis is really helpful for the current trends for the researchers while identifying the possible research gaps. It can be stated that distribution of keywords can be viewed as one of the strategic instruments of defining further focuses of an academic study.

10- Distribution of Cited Sources in Publications

In the present paper, we investigated the distribution of citations to sources in articles published in the journals included in the WoS and the results are shown in Figure 4**.** Figure 4 depicts proportions of articles citing sources in the journals from the database of WoS. This analysis helps to identified which studies and source are influential in the academic literature and which sources are cited most often.

Figure 4 can be seen as the citation source map where the citation density is encoded by the blue-yellow color scale with blue color representing works cited less frequently and yellow color representing works cited more frequently. This

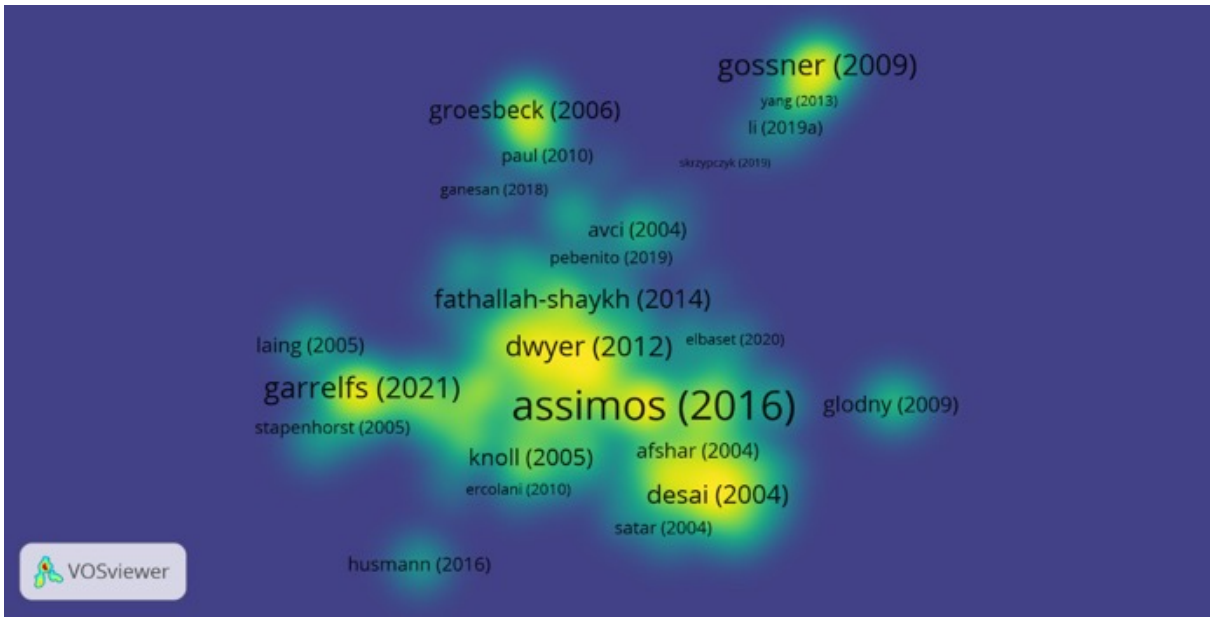


Figure 4. Citation source map (Citation density is represented by a gradient from blue to yellow)

visualization is useful to identify which research contributes more in terms of citations and on the other hand, what research sources are more connected to other studies.

Labels on the map indicate to which extent specific studies are cited in the literature. For instance, the works of "Assimos, 2016" and "Dwyer, 2012" are written in the largest font and bright colors, which mean the sources are frequently cited and occupy the most important position in the reference literature. Other related benchmarks, including "Garrelfs, 2021" is also highlighted in the other areas of the document also they are presented as essential and seminal works within the subject area.

It is very helpful of this kind of analysis to know which sources and studies are treated as the most basic and important in the field. It also has an important function for the researcher in being able to identify essential studies and trends in the literature. All of these pointed out studies identified on this map are well regarded by the scientific community and pieces together as the history of many subsequent works.

11-Distribution of Citations by Country

The distribution has been made according to the citation made by country for articles in the journal indexed in WoS reflected in the Figure 5 below.

Figure 5 analyzes the distribution of citations by country of the articles included in the journals that are presented in the WoS database. This picture depicts the pattern of citations and also depicts the interactions between countries concerning their academic production.

In the figure, circles mean the importance of the countries in the academic databases and the number of citations. For example, the United States and Turkey are shown by larger circles as they are authors involved in scientific production and as recipients of many citations. In this case the lines between circles denote the research cooperation between countries. The nature of dense lines depicts intensity and frequencies of this kind of relationships. For example, one can observe that the relative density of these lines is higher where the cooperation between the United States on the one hand and the European countries on the other hand is stronger.

Above mentioned kind of analysis is quite important in terms of understanding the structural position of the countries in the global academic network and their roles in this network. Moreover, by using this map, evaluation of Turkey situation, as well as Turkish's partnerships in the literature can be made.

DISCUSSION

The present bibliometric analysis of the pediatric kidney stone related research presents some intriguing findings that are consistent with the general trends in three major research areas, namely pediatric nephrology, pediatric urology and related fields. In the last 20 years, research activity in this domain has observed a significant growth, with the highest level of output most recently in 2020. In line with this, the development of the present work reflects the expanding focus on pediatric health care needs as Chen et al.[20] revealed the escalating number of publications on pediatric stone disease indicating its status as a promising line of research. Similarly, Ghidini et al.[21] and Matta et al.[22] observed an expanding focus on pediatric nephrology and pediatric urology, particularly concerning congenital anomalies, metabolic risk factors and surgical techniques, which have been central to the field. Like many researchers, Pedroza et al.[23] also stress on the unexplored association of cardiovascular risk with urolithiasis, although

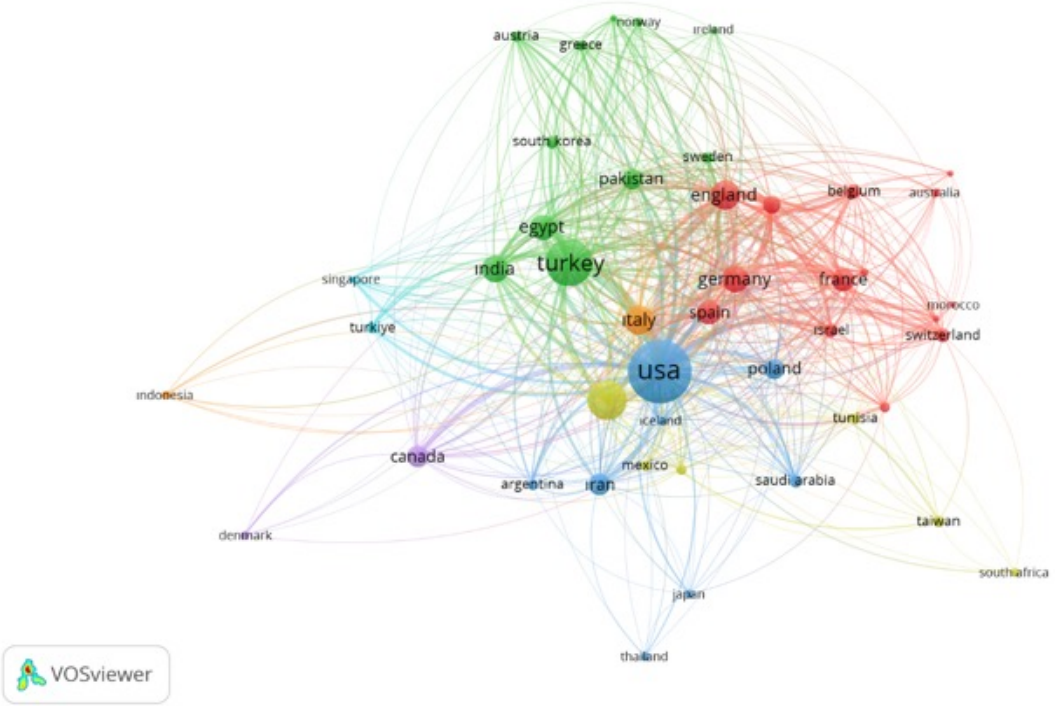


Figure 5. Distribution of citations by country (Circle size represents focal countries; lines between circles represent collaboration)

they have recommended that exploring the underlying system effects of kidney stones, especially in children, may further be explored in research studies in the future. This shows the complexity of the effects of kidney stones which may not be confined to the urinary system only but manifested in several areas of the body; this concept reemphasizes the concept of disease orientation.

The increased publication output in this field reflects the growing recognition of the importance and urgency of the topic. This trend is consistent with the prioritization of pediatric healthcare, which has gained more attention over time. However, the surge in publication numbers does not necessarily reflect uniform quality across studies. Some research has pointed out that while output is increasing, the variability in the depth of analysis and clinical applicability could present challenges for future research to effectively build upon existing studies. These metabolic abnormalities lead to imbalances in the urinary composition, promoting the crystallization and aggregation of stone-forming substances. Recent studies have also emphasized the role of nutrition in pediatric kidney stone formation, suggesting that dietary factors such as increased intake of animal proteins and sodium are contributing to rising cases of urolithiasis in children.[24] This is further supported by Siener and Metzner,[25] who found that dietary interventions focusing on weight management and the reduction of oxalate and sodium intake can significantly reduce the risk of stone formation, underscoring the role of dietary strategies in prevention. As studies increasingly focus on addressing these metabolic risk factors through preventive strategies like dietary modifications and medication, the field has made significant progress in understanding and managing pediatric kidney stone disease.[15] The growth also signifies advancements in medical practices, an increase in clinical research, and the broader public health significance of pediatric kidney stones. Leading researchers and institutions, such as the University of Pennsylvania and the Children's Hospital of Philadelphia, have made substantial contributions to this field, often in collaboration with international partners, particularly between the U.S. and European institutions. Institutional support is crucial in guiding research and ensuring a broad impact, which in turn fosters international collaboration.[26,27] Tan et al.[28] also highlighted the significant rise in urolithiasis cases in China, further emphasizing the global impact of lifestyle changes on pediatric kidney stone formation. Their study points to the need for global collaborations to address this rising trend.[28] Likewise, Nedbal et al.[29] also reported the growing incorporation of modern technologies such as artificial intelligence, machine learning, and virtual reality in the field of urolithiasis suggesting that there is a growing shift towards new diagnostic and interventional technologies that could well revolutionize pediatric care if continued in the next few years.

The analysis further highlights that original research articles are the most frequently cited source type, emphasizing the importance of new findings in the field. This rise, while promising, may also reflect the increasing availability of specialized technologies and diagnostic tools, which could skew the apparent urgency toward certain clinical approaches while underrepresenting others, such as long-term prevention and follow-up care. Leading journals such as the Journal of Urology and the Journal of Pediatric Urology continue to play a central role in disseminating knowledge on pediatric kidney stones. The prestigious status of these journals makes them the preferred platforms for researchers aiming to share their findings with a wider academic audience. This is corroborated by Ghidini et al.[21] who identified the Journal of Urology as the most productive journal for top-cited articles in pediatric urology. Similarly, Fernandez et al.[30] noted that journals like the Journal of Pediatric Urology significantly influence citation counts in the field of pediatric stone disease.[30,31]

However, the citation impact varies across different studies. For example, Matta et al.[22] reported a lower median citation rate per article in pediatric urology compared to other urologic subspecialties. This is a crucial consideration, as it may indicate that while there is a focus on pediatric urology, the depth of research and its translational impact into clinical practice are still in developmental stages, particularly in comparison to adult urology. This suggests that while the research output in pediatric kidney stones is growing, its academic impact may still be developing in certain areas. This could be due to the relatively nascent focus on pediatric urology in comparison to adult urology, where research on urolithiasis has been more robustly established over the years.[32]

Keyword analysis reveals that terms such as "urolithiasis", "nephrolithiasis" and "kidney calculi" are central to the literature, indicating that these are primary research focuses. The most cited papers provide critical insights into surgical management and dietary guidelines, demonstrating their influence on clinical practices. Keywords define the boundaries of the research area and indicate areas where future studies should focus. The field of pediatric kidney stones has primarily concentrated on risk factors, therapeutic approaches, and emerging techniques like mini-percutaneous nephrolithotomy and retrograde intrarenal surgery.[27] Yuvanc et al.[33] has also emphasized the demand for increased treatment options of urinary tract stone disease since medical and complementary therapies have gained popularity over the proceeding years more especially in pediatric patients with recurring conditions. The scope of the research includes both medical and nutritional approaches, such as pharmacotherapy, nutrition therapy, and medical expulsive therapy, presenting a variety of options for the treatment and prevention of kidney stones.[33] Juliebø-Jones et al.[34] also supported this view by stressing the importance of advanced surgical techniques, including minimally invasive methods, which they identified as crucial in improving outcomes for pediatric patients suffering from recurrent kidney stones.The developed scoring system provides an easily completed questionnaire to estimate the risk of recurrence in urinary stone disease. This approach is beneficial in guiding patients toward metabolic testing or suggesting preventive measures, making it both a health-advantageous and cost-effective solution.[35] However, less attention has been given to the psychosocial effects of pediatric kidney stones, an area that could benefit from more focused research as the condition can have long-term impacts on the well-being and quality of life of affected children. These

findings align with those of Ghidini et al.,[21] who identified "congenital anomalies" and robotic-assisted laparoscopic surgery as key areas of interest in pediatric urology. Matta et al.[22] also observed a shift from surgical techniques to exploring disease mechanisms, indicating an evolving focus within the broader field of pediatric urology.

Furthermore, an analysis of pediatric UTI research by Kumar et al.[36] highlighted "vesicoureteric reflux", "management" and "diagnosis" as critical themes, reflecting a similar emphasis on understanding disease mechanisms and improving clinical outcomes. This consistency across different subfields of pediatric nephrology and pediatric urology suggests a broader trend toward addressing specific clinical challenges through focused research efforts.

The distribution of citations by country reveals that the United States is a leading contributor to the field, with strong academic collaborations with European countries, reflecting the global nature of research in pediatric kidney stones. Moreover, recent analyses have shown that China is emerging as a significant contributor to pediatric kidney stone research, with increasing output in both clinical and basic science studies.[31] The rise in China's contribution could be attributed to increasing governmental support for research and development, particularly in the fields of medical technology and pediatric healthcare. Turkish institutions, such as Dicle University and Hacettepe University, also make significant contributions, indicating an active research environment in Turkey. This is consistent with Ramakrishnan et al.[37] findings, which also noted that the United States is the leading contributor to pediatric kidney stones research. Both studies emphasize the role of prominent institutions and countries in advancing the field, highlighting the importance of international collaboration. As more countries continue to invest in pediatric kidney stones research, the global landscape is expected to diversify further, enhancing cross-national collaborations and enriching the field.[27] However, it remains important to ensure that future collaborations also focus on under-researched areas and prioritize not only treatment but also prevention strategies to mitigate the global burden of pediatric kidney stones.

Limitations

This study has several limitations. First, the analysis is based solely on data from the WoS Core Collection, which excludes articles from other major databases such as Scopus, PubMed, and Google Scholar. Second, the study only considers articles published in English, potentially excluding significant research published in other languages, thereby limiting the scope of the analysis. Third, the time frame of the study is restricted to articles published between 2004 and 2023, meaning that earlier or more recent developments in pediatric kidney stone research are not captured in this review.

CONCLUSION

Overall, this analysis underscores the growing importance of pediatric kidney stones as a vital research area, with increasing contributions from a diverse range of researchers and institutions worldwide. This surge in academic interest reflects a broader trend within pediatric nephrology and pediatric urology, where specific clinical challenges, such as rising rates of nephrolithiasis among children, are being addressed through focused, evidence-based research. Key themes emerging from the data include advancements in surgical techniques, risk factor identification, and innovative treatment approaches, all of which are central to improving patient outcomes. The ongoing growth in research output, particularly the identification of new research hotspots like minimally invasive procedures and genetic predispositions, further highlights the dynamic and evolving nature of this field. As research continues to expand, it will be crucial for scholars and institutions to foster international collaboration and maintain a forward-thinking approach to advance pediatric healthcare and enhance the quality of care for children affected by kidney stones.

ETHICAL DECLARATIONS

Ethics Committee Approval

Since this research is a bibliometric study, it did not require ethics committee approval. It is conducted with the institution's permission.

Informed Consent

Since this research is a bibliometric study, it did not require informed consents.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

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Author Contributions

All authors declare that they participated in the design, execution, and analysis of the study and have approved the final version.

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