



Invited Review Article

Bibliometric analysis of the relationship between metabolic study and urolithiasis. A key tool in patient management

**Gabriela Prieto-Angarita¹, Catalina Solano^{2,3}, Manuela Jaramillo-Sierra⁴,
Valentina Melo-Pedroza⁴, Andrea Ascencio-Medina⁵, Olivier Traxer²**

¹Universidad Industrial de Santander, Bucaramanga, Colombia, ²GRC n20, Groupe de Recherche Clinique sur la Lithiase Urinaire, Hôpital Tenon, Sorbonne Université, 75020, Paris, France, ³Uroclin, Medellín, ⁴Universidad de La Sabana, Bogotá, ⁵Universidad El Bosque, Bogotá, Colombia

Keywords:

Urolithiasis, prevention, metabolic evaluation, hypercalciuria

Abstract

Objective: Our objective was doing an analysis of available bibliography to understand tendencies in publications regarding the role of metabolic evaluation in the management of urolithiasis.

Materials and Methods: A retrospective bibliometric analysis of the available medical literature ranging from the year 2001 to 2022 was performed on the Web of Science platform. The graph analysis was done using Microsoft Excel and the bibliographic mapping analysis was done on the VOSviewer software.

Results: A total of 120 references were found in 63 journals, with a decrease in the rate of publications in the last 5 years. The country, journal, and institution with the largest number of manuscripts were the United States, Journal of Urology, and the University of Bonn, respectively. The author with the largest number of publications was Sarica Kemal. The mapping and analysis of the keyword evolution with respect to the timeline centered on the terms: “prevention”, “metabolic risk factors”, “obesity”, “primary hyperoxaluria”, and “medical management”.

Conclusion: Metabolic evaluation is a fundamental tool in the overall approach of these patients. Despite the decrease in the rate of research on the association between metabolic evaluation and urolithiasis in recent years, the importance of a complete assessment of these patients from the first symptomatic episode has been demonstrated, as it helps to determine the risk of recurrence of the disease, and to establish a treatment plan focused on prevention. This first bibliometric analysis on metabolic evaluation and urolithiasis depicts the importance of giving continuity to research on the risk factors of urolithiasis that may be modified and treated.

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Corresponding author: Catalina Solano

Address: Department Endourology, Uroclin; Carrera 50A # 64 – 65; Medellín, Colombia

E-mail: catasolano84@gmail.com

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Introduction

The incidence of urolithiasis has mainly increased in industrialized countries.¹ The ascending tendency in the number of cases is associated with a higher rate of diagnosis (due to the current available technology), but also with geographic and environmental factors, as well as an increase in diseases like obesity and metabolic syndrome.¹⁻³

Despite its relatively low mortality rate, urolithiasis poses significant challenges due to the exponential risk of recurrence, long-term complications such as progressive renal function deterioration³⁻⁵, and the socioeconomic impact it imposes.⁶ Therefore, it is imperative to conduct a comprehensive evaluation of each patient and strive to develop individualized treatment plans with a primary focus on preventive measures. To achieve this, it is crucial to have a thorough understanding of the physiological underpinnings of urolithiasis and the various factors involved in lithogenesis.^{2,3,7} Recent studies have revealed that a considerable number of urolithiasis patients also suffer from concurrent treatable metabolic conditions^{3,5}, further emphasizing the need for a holistic approach to their management.

The metabolic evaluation assesses most metabolic abnormalities through urinary and blood biochemical tests. Depending on the risk of recurrence, either a basic or specific metabolic evaluation is performed. These studies provide enough information to elaborate specific treatment plans for urolithiasis and make it possible to diagnose up to 90% of patients, as well as to reduce the rate of recurrence to less than 25% in the long-term.³

Hence, this study consists of the formulation of a bibliometric analysis that evaluates the contributions, tendencies, and research hot spots associated with the metabolic evaluation and urolithiasis.

Materials and Methods

Database

Initially, we searched for MeSH terms on the PubMed website to ensure a wholesome approach to the topic. “Metabolic evaluation” and “urolithiasis” comprised the subcategories necessary to conduct a literature search. Furthermore, we utilized Clarivate Analytics’ Web of Science Core Collection (WoSCC) in its high impact reviews

section to search for articles and citations associated with metabolic evaluation and urolithiasis.

Search Strategy

A single literature search of publications on metabolic evaluation and urolithiasis was performed to anticipate database updates. The chain search was described as follows: Topic=(metabolic evaluation and urolithiasis) AND Abstract=(metabolic evaluation and urolithiasis). There were no language limitations. The articles included were those with titles and abstracts associated with the topic. Two articles were excluded as the subjects of their studies were animals and another four were excluded as their titles and abstracts did not coincide with the search. The articles’ information concerning titles, keywords, abstracts, authors, institutions, and reference registries was downloaded and stored in Microsoft Excel format for its subsequent analysis and in text format (.txt) to be used in the VOSviewer (version 1.6.16) software.

Data Analysis

The data was downloaded and analyzed by two researchers (G.P., C.S.). Microsoft Excel was used to create the bar graphs and the tables concerning the year of publication, authors, countries, institutions, most productive journals, and most cited publications. Subsequently, the selected files were analyzed. Also, using the platforms Scimago and Journal Citation Reports, a search of measurements such as: H index, impact factor 2021 (IF 2021) and the Journal Citation Reports 2021 (JRC 2021) was performed. These measurements, respectively, made it possible to: analyze the academic productivity level of researchers, countries, and journals; the scientific quality of journals; and to identify the journals’ classification. Lastly, through the VOSviewer software, we obtained the total link strength (TLS), which indicates the strength of association between co-authorship and co-citation and co-occurrence.

Data Visualization

In this study, we used Microsoft Excel 2019 to create bar graphs and tables that summarize the main information included, as well as the VOSviewer (version 1.6.16) software to assess the relationship between: co-authorship of authors, countries, and institutions; of co-citation of

authors and references; and of co-occurrences of keywords. Bibliometric maps were elaborated to illustrate: the collaboration between countries, institutions, and authors; the strength of association between authors according to the number of times that they were cited; and the strength of association between the articles depending on whether they appear together.

Results

A total of 126 documents were found in the search and 120 were included (97 articles, 26 reviews, 8 review reports, 1 editorial material) in accordance with the selection criteria. We excluded animal studies and articles with title and abstract that did not correspond to the subject (Annex 1).

Research on this topic has been conducted globally over the past two decades. Starting from 2010, there has been a notable increase in publications, with an average of more than five articles per year. The peak of research activity

in this area was observed in 2017, followed by a gradual decline in publication output since then. It is noteworthy that the top 10 most cited articles on this subject were published prior to 2015, indicating their enduring significance and impact on the field (Figure 1).

Most Productive Countries Analysis

A total of 34 countries have published articles related to this topic. As shown on table 1, the countries with more than 15 publications are the United States (28%), Turkey (20%) and Germany (14%). Even though 60% of the countries in the top 10 are European, the first two most productive countries are the United States with 34 articles and Turkey with 24 articles. Also, in terms of the H index (307) and total citations (3,702 times), the United States also placed first in comparison to Turkey, which came in second but had significantly lower total citations (436 times). As for the analysis of cooperation between countries, Germany had the largest international

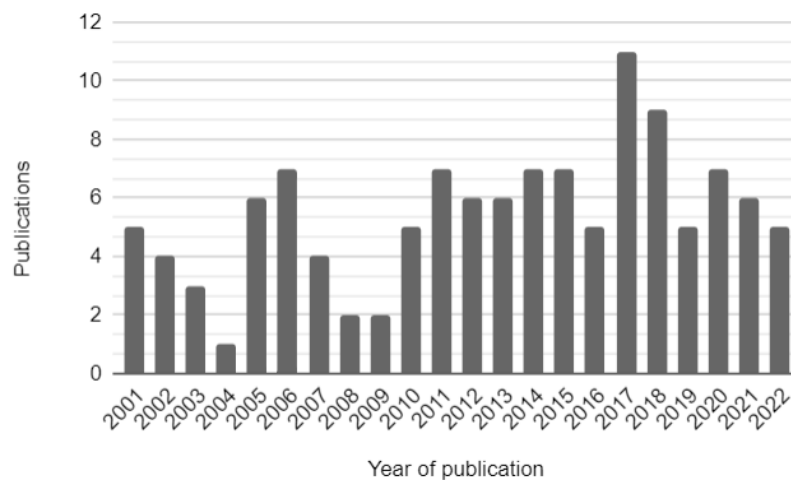


Figure 1. Annual number of publications on metabolic study and urolithiasis research.

Table 1. The 10 most productive countries in relation to metabolic studies and urolithiasis.

Rank	Country	Publication	Percentage (%)	H-index*	Total citations	Average citations per paper
1	United States	34	28	307	3,702	0.78
2	Turkey	24	20	99	436	0.67
3	Germany	17	14	205	1,697	1.42
4	Iran	8	7	59	234	0.6
5	Canada	6	5	170	898	1.07
6	Italy	6	5	190	1,938	1.57
7	France	5	4	174	1,263	1.81
8	England	4	3	202	1,650	1.52
9	Netherlands	4	3	181	1,096	210
10	Poland	4	3	61	83	0.64

* Filtered by area: Medicine, subject: Urology and year 2021

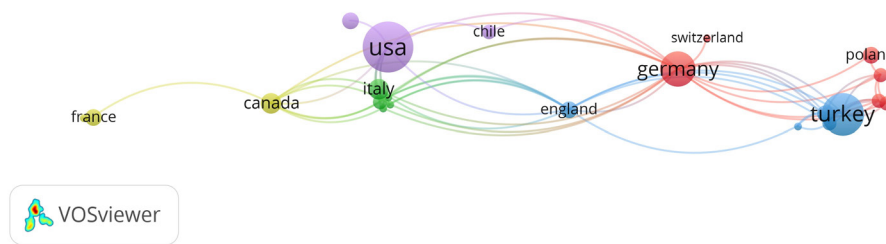


Figure 2. Co-authorship visualization network of countries generated using VOSviewer. The node size is proportional to the number of publications, and the thickness of the connection line indicates the cooperation frequency map.

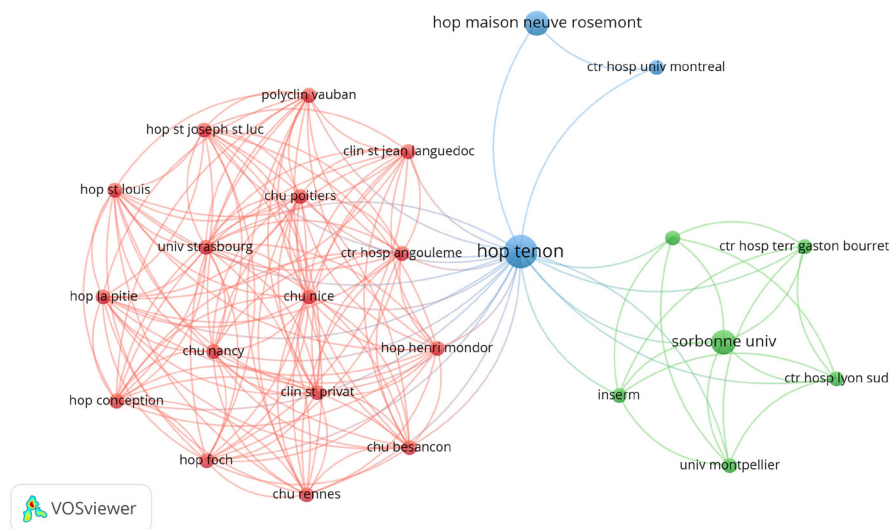


Figure 3. Institution co-authorship visualization network generated using VOSviewer.

cooperation, which included the United States, Turkey, Canada, and Italy (Figure 2). The lines between knots indicate the co-authorship between countries and the thicker the line, the greater the cooperation, referred to as total link strength (TLS). The co-authorship visualization map showed that the top 5 TLS corresponded to Germany (TLS:24), the United States (TLS:14), England (TLS:13), Turkey (12) and Austria. The only Latin American countries that cooperated with the most productive countries were Brazil and Chile, which were co-authors with the United States and Germany.

Main Institutions' Contributions

A total of 24 institutions have participated in the research on metabolic study and urolithiasis. The first three institutions, with the largest contributions, were the University of Bonn in Germany, Public Assistance Hospitals of Paris in France, and the Cincinnati Children's Hospital Medical Center in the United States, with a total of 8, 5, and 5 published articles respectively. The number of French institutions (N=4) that are part of the

top 10 is notable despite France placing seventh in contributions, which suggests cooperation among them (Annex 2).

Figure 3 shows cooperation between institutions. A total of 220 institutions with more than 1 published article were found, of which the first 3 in terms of TLS were the Tenon Hospital in France (TLS=24), Besancon University Hospital in France (TLS=98) and Nancy Regional University Hospital in France (TLS=16). However, most institutions were scattered and those that cooperate limit such efforts to national institutions.

Author Analysis

A total of 497 authors were included. Table 2 shows the top 10 most productive authors. Sarica Kernel, Hoppe Bernd, Laube Nobert took the first three places, with 9, 6, and 5 published articles respectively. A co-authorship web visualization map was created using VOSviewer software and the threshold for the minimum number of documents was set at 3. Finally, 10 authors that reached the threshold were identified and it was demonstrated that Minevich Eugene, Defoor

**Table 2.** Top 10 most productive authors with the most citations

Rank	Author	Country	Publications
1	Sarica Kemal	Turkey	9
2	Hoppe Bernd	Germany	6
3	Laube Norbert	Germany	5
4	Minevich Eugene	United States	5
5	Straub Michael	Germany	5
6	DeFoor William	United States	4
7	Jackson Elizabeth	United States	4
8	Asplin John R	United States	3
9	Hesse Amber	United States	3
10	Preminger Glenn	United States	3

William, Jackson Elizabeth, Asplin John, Sheldon Curtis and Reddy Pamond have cooperated closely (Annex 3). Also, the international cooperation present between them is notable.

Moreover, a co-citation visualization map was generated using VOSviewer software and the threshold for the minimum number of author citations was set at 20. Lastly, 15 authors that met the threshold were found and it was possible to observe that Hoppe B had made significant contributions in the research field of metabolic evaluation and urolithiasis (Annex 4).

Main Journals' Contributions

The articles included were published in a total of 63 journals, including 41 journals with 1 article. According to the results shown on

table 3, the three most productive journals were the Journal of Urology with 11 publications (9,2%), the Journal of Pediatric Urology with 7 (5,8%), and Pediatric Nephrology with 7 (5,8%). Additionally, the total number of citations from Kidney International was 57,360, a much larger number than other journals. In keeping with the Journal Citation Report (JCR) of 2021, among the 10 most cited journals, 4 were found in the Q1 category. Two journals: Urological Research and The Scientific World Journal did not have an updated JCR.

Most Cited Reference Analysis

This study included a total of 120 publications of which 30 articles had been cited at least 30 times. Table 3 numbers the 10 most cited documents, of which Skolarikos et al. placed first with 186 citations, followed by Gambaro et al. and Hoppe et al. with 119 and 108 citations respectively. 80% of the most cited articles belong to American Journals, however, a Dutch article placed first. As for the areas of research: Urology-Nephrology, Pediatrics and Internal Medicine were the first. Nonetheless, the most cited articles were found belonging only in the first few fields (Annex 5).

In total, our study cited a total of 2862 references. Ali Tekin (52) had the largest total citation number, with 20 citations and VanDervoot, K et al. (54) placed second with 19 citations (Annex 6).

Table 3. Top 20 journals related to metabolic study and urolithiasis research

Rank	Journals	Country	Publicaciones	IF (2021)	JCR (2021)	H-index*	Total citations
1	Journal Of Urology	United States	11	7,641	Q1	265	51,677
2	Journal Of Pediatric Urology	England	7	1,921	Q3	49	4,446
3	Pediatric Nephrology	United States	7	3,652	Q1	113	12,251
4	Urology	United States	6	2,633	Q2	182	24,074
5	Journal Of Endourology	United States	5	2,619	Q2	95	8,166
6	Iranian Journal Of Kidney Diseases	Iran	4	1,468	Q4	34	1,027
7	Urological Research	United States	4	1,476	Q3*	-	-
8	World Journal Of Urology	Germany	4	3,661	Q1	88	9,909
9	Current Opinion In Urology	United States	3	2,808	Q3	61	2,310
10	Frontiers In Pediatrics	Switzerland	3	3,569	Q1	48	9,940
11	Urolithiasis	United States	3	2,861	Q2	65	1,600
12	Archivos Espanoles De Urologia	Spain	2	0,43	Q4	25	642
13	BJU International	England	2	5,969	Q1	154	23,142
14	BMC Urology	England	2	2,09	Q3	46	2,421
15	CUAJ - Canadian Urological Association Journal	Canada	2	2,052	Q3	20	2,796
16	Iranian Journal Of Pediatrics	Iran	2	0,62	Q4	28	2,761
17	Kidney International	United States	2	18,998	Q1	288	57,360
18	Pediatric Clinics Of North America	United States	2	3,58	Q1	90	5,332
19	Progres En Urologie	France	2	1,090	Q4	34	1,175
20	The Scientific World Journal	United States	2	1,524	Q1**	103	1,453

*In the year 2014. **In the year 2010

Table 4. The 20 keywords with the highest frequency related to the metabolic study research in urolithiasis

Rank	Keyword	Frequency	TLS	Rank	Keyword	Frequency	TLS
1	Urolithiasis	77	389	11	Epidemiology	13	81
2	Nephrolithiasis	42	241	12	Nephrocalcinosis	13	76
3	Renal Calculus	32	204	13	Excretion	12	75
4	Child	36	200	14	Medical management	10	75
5	Hypercalciuria	20	135	15	Risk Factor	13	75
6	Risk factor	20	126	16	Prevention	11	74
7	Calcium	17	106	17	Metabolic evaluation	16	71
8	Pediatric Urolithiasis	18	102	18	Oxalate	11	68
9	Risk	18	91	19	Shock wave lithotripsy	16	68
10	Prevalence	15	88	20	Stone	14	61

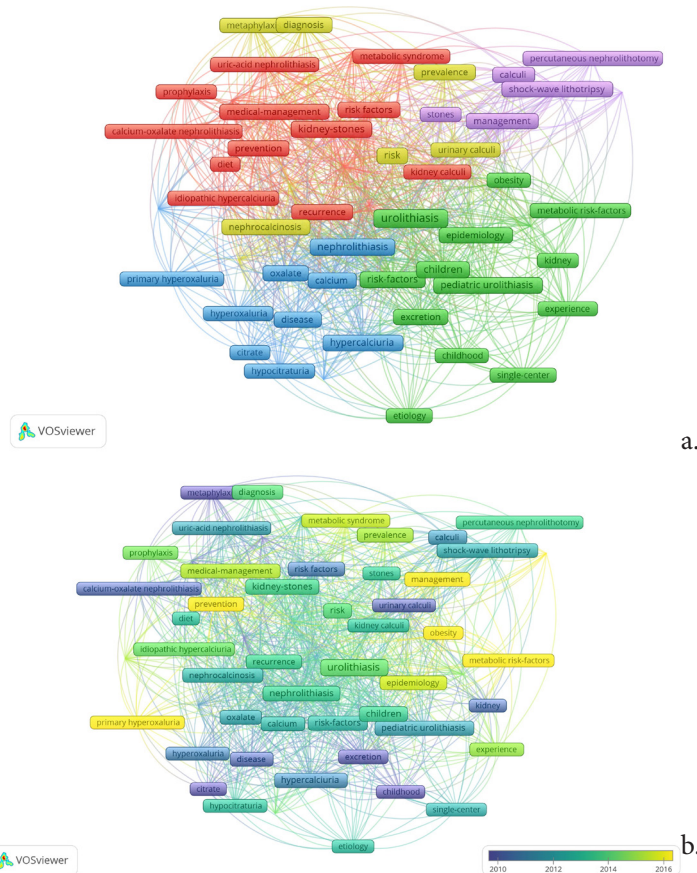


Figure 4. a. Keyword co-occurrence visualization map between metabolic study and urolithiasis, b. Overlay visualization map of keywords over time.

Keyword Co-Occurrence Analysis

Our study included a total of 518 author keywords and 56 keywords had a minimum frequency of at least 5 times. Table 4 showed the 20 keywords with the highest frequency. Among them, urolithiasis placed first (73 times), followed by nephrolithiasis (40 times) and child (36 times).

VOSviewer was used to create a keyword web visualization map and a superposition visualization map that made it possible to analyze and understand the tendencies of the research topics,

as well as to comprehend the changes that they undergo through time. As shown on figure 4a, there are 5 clusters, each one illustrated with a specific color. The red group is composed of words such as: “Medical treatment”, “metabolic evaluation” and “potassium citrate”, which is why it is labeled as #Cluster 1: Medical treatment measures and risk factors. The green group, with its main keywords being “urolithiasis”, “children”, “pediatric urolithiasis”, and “risk factors”, is classified as #Cluster 2: Risk in the pediatric population. The



blue group comprised the key words: “nephrolithiasis”, “hypercalciuria”, “calcium” and “oxalate”, with a particular focus on deposit anomalies that must be studied in the metabolic evaluation, and it is depicted as #Cluster 3: Lithiasic metabolic evaluation abnormalities. The yellow group centered mainly on risk, diagnosis, and prevalence, which is why it can be understood as Cluster #4: Epidemiological and Diagnostic Studies. Lastly, the purple group, with the main keywords “by shock wave lithotripsy” and “percutaneous nephrolithotomy” and “ureteroscopy”, focuses on the surgical treatment of urolithiasis, which is why it can be referred to as #Cluster #5: studies associated with surgical interventions.

Figure 4b is the keyword superposition visualization map that shows the change in keywords through time. The yellow codes represent the most recent keywords that could potentially become crucial topics for current research. It is shown that “prevention”, “metabolic risk factors”, “obesity”, “primary hyperoxaluria” and “management” are keywords that have frequently appeared in the last 7 years, which suggests that future research will focus on the identification of risk factors such as obesity and in developing strategies to elaborate a treatment plan focused on prevention.

Discussion

Conducting a comprehensive metabolic evaluation of urolithiasis patients, starting from the initial episode, enables the identification and treatment of underlying conditions, as well as the implementation of tailored lifestyle modifications to address individual patient needs. This approach plays a crucial role in reducing the recurrence rate and, consequently, minimizing the complications associated with recurrent episodes.⁸⁻¹⁰ Recognizing the significance of this subject matter, it is pertinent to explore the impact, trends, and future directions of research in this field. Understanding these aspects will contribute to advancing knowledge and improving patient outcomes in the management of urolithiasis.

The present study reveals a progressive decline in the number of publications within the past five years. Although no clear trend in the focus of recent research has emerged, there is a consensus on the importance of conducting metabolic evaluations to guide appropriate medical,

surgical, and dietary interventions.¹¹ This tendency may be attributed to information saturation, prompting researchers to explore new fields that complement existing knowledge.⁹

Urolithiasis is a multifactorial disease influenced by environmental factors, regional variations, lifestyle choices, diet, and comorbidities. Industrialized countries exhibit the highest incidence rates¹, which aligns with the findings of this study. Despite publications originating from 82 countries, the top ten most productive countries, except for Iran, predominantly consist of developed nations. Notably, Chile, Brazil, and Argentina, countries with high human development indices in Latin America, also contributed to the research output.

Analyzing productivity, quality, and academic standing, the United States demonstrated a higher H index and total citation count compared to other countries. Turkey ranked second but exhibited a lower index than countries with lesser contributions, indicating a need for improved quality publications despite the increase in article output.

Regarding journals with the highest percentage of publications on the topic, it is worth mentioning that the journal with the highest impact factor in the specialty, *Kidney International*, does not rank among the top ten. Notably, two of the three leading journals in terms of publications are pediatric journals: *The Journal of Pediatric Urology* (5.8%; 7) and *Pediatric Nephrology* (5.8%; 7). This signifies a research interest in pediatric patients, a population group experiencing a rise in urolithiasis cases. Diagnosing pediatric cases can be challenging, often with underlying genetic and metabolic abnormalities.^{1,7} Moreover, the analysis of research areas revealed that 80% of articles were categorized under Urology/Nephrology and Pediatrics.

Sarika Kemal, based in Turkey, emerged as the author with the most publications, considering Turkey an endemic zone for urolithiasis in both pediatric and adult populations.⁵ His 2015 literature review, ranking first among the most cited studies, focused on study approaches and treatment algorithms for low and high-risk urolithiasis recurrence.⁴ In his subsequent publications in 2019 and 2020, he conducted prospective studies to identify new risk and protective factors in urolithiasis, such as obesity¹² and breastfeeding.¹³

On the other hand, the most cited author, Hoppe B, concentrated on research within the pediatric population, driven by the underdiagnosis and potential long-term complications associated with untreated cases.⁷

Through co-occurrence analysis using VOSViewer, five distinct clusters encompassing diagnosis, medical and surgical interventions, and prophylactic treatment in urolithiasis were identified. A specific cluster centered around metabolic evaluation included the most frequently diagnosed metabolic diseases. Furthermore, the visual map highlighted recent studies focused on identifying metabolic risk factors to facilitate appropriate treatment and prevent future urolithiasis episodes. Emerging topics like obesity are just beginning to be incorporated and are expected to be prominent areas of research in the future.

Limitations

There are no other bibliometric studies on this topic to date, which is why it is not possible to compare the obtained results. Additionally, only one database was used for the literature search, which suggests that certain publications on this topic may have been excluded. Moreover, the article selection was done according to title followed by abstract, which may have resulted in publications being included whose main topic may not have been the relationship between urolithiasis and metabolic evaluation.

Conclusions

Metabolic evaluation plays a pivotal role in the management of patients diagnosed with urolithiasis. By employing this approach, healthcare professionals can effectively identify concurrent diseases that significantly impact the patient's risk of recurrence and potential complications. Notably, research in this field is primarily led by developed countries, given the higher prevalence of urolithiasis in these regions. However, it is imperative to foster collaboration and knowledge exchange with developing countries to enhance the global understanding of this condition.

An analysis of research focus reveals an encouraging trend wherein new investigations are exploring additional comorbidities, such as obesity, as potential risk factors for urolithiasis. This development underscores the importance of further studies aimed at adopting a compre-

hensive approach and delivering individualized treatment strategies. By continuing to delve into these areas, the medical community can achieve a more holistic understanding of the disease and improve patient care accordingly.

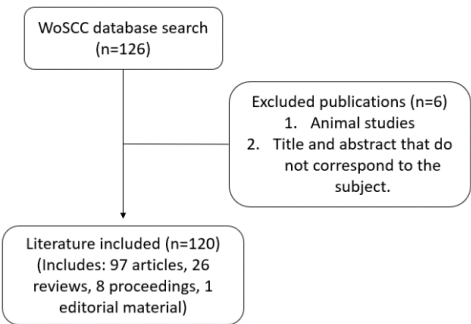
Conflict of Interest

The authors have no conflict of interest to declare.

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Annex 1. Data filtering and publication exclusion treatment flowchart.



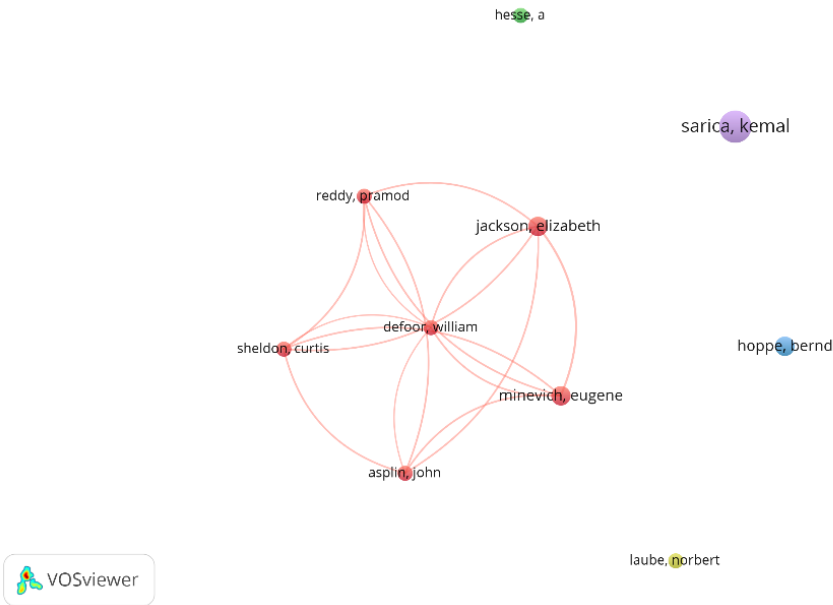
Annex 2. Top 10 institutions with more publications related to metabolic analysis and urolithiasis.

Annex 2. Top 10 institutions with more publications related to metabolic study and urolithiasis

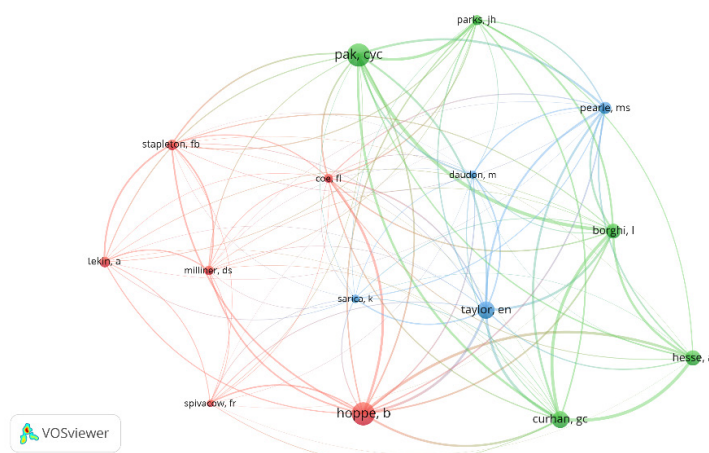
Rank	Institutions	Country	Publications	TLS	Total citations
1	University of Bonn	Germany	8	10	137
2	Public Hospital Assistance Paris - Aphp	France	5	-	-
3	Cincinnati Children's Hospital Medical Center	United States	5	0	0
4	Tenon Ap-Hp University Hospital	France	5	24	22
5	Sorbonne University	France	5	6	0
6	Udice French Research Universities	France	5	-	-
7	Gaziantep University	Turkey	4	1	6
8	University of California	United States	4	0	66
9	University of Chicago	United States	4	6	134
10	University of Cologne	Germany	4	8	209

TLS, Total Link Strength

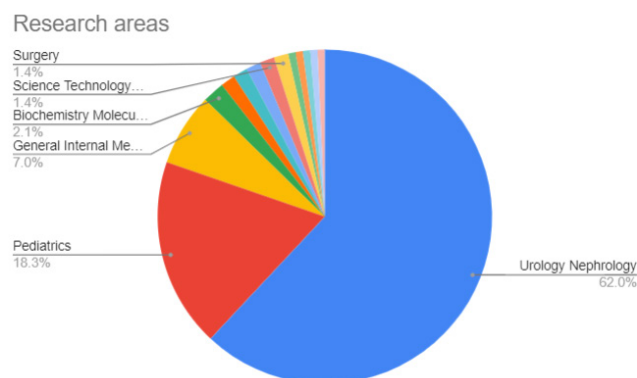
Annex 3. Author co-authorship network visualization map. The size of a circle is proportional to the number of literatures published by the author, and the thickness of the connecting line indicates the frequency of cooperation.



Annex 4. The size of a circle is proportional to the total number of author citations, and the thickness of the connection line indicates the strength of the co-citation link. The size of a circle is proportional to the total number of author citations, and the.



Annex 5. Outline of research Areas



Annex 6. Top 10 most cited articles in the research in metabolic analysis and urolithiasis.

Rank	Title	Author	Year	Journal	Total citations
1	Metabolic Evaluation and Recurrence Prevention for Urinary Stone Patients: EAU Guidelines	Skolarikos, A; Straub, M; et al.	2015	European Urology	186
2	Risk for renal failure in nephrolithiasis	Gambaro, G; Favaro, S; et al.	2001	American Journal Of Kidney Diseases	119
3	Diagnostic examination of the child with urolithiasis or nephrocalcinosis	Hoppe, B; Kemper, MJ	2010	Pediatric Nephrology	109
4	The endourological management of complications associated with horseshoe kidney	Yohannes, P; Smith, AD	2002	Journal Of Urology	108
5	Nephrocalcinosis and urolithiasis in children	Habbig, S; Beck, BB; et al.	2011	Kidney International	88
6	Clinical and metabolic features of urolithiasis and microlithiasis in children	Alpay, H; Ozen, A; et al.	2009	Pediatric Nephrology	87
7	Pediatric urolithiasis - Evaluation of risk factors in 95 children	Erbagci, A; Erbagci, AB; et al.	2003	Scandinavian Journal Of Urology And Nephrology	81
8	Diagnosis and metaphylaxis of stone disease - Consensus concept of the National Working Committee on Stone Disease for the Upcoming German Urolithiasis Guideline	Straub, M; Strohmaier, WL; et al.	2005	World Journal Of Urology	74
9	Pediatric urolithiasis: etiology, specific pathogenesis and medical treatment	Sarica, K	2006	Urological Research	73
10	High kidney stone risk in men working in steel industry at hot temperatures	Atan, L; Andreoni, C; et al.	2005	Urology	72

Annex 7. Top 10 most cited references on metabolic analysis and urolithiasis.

Rank	Title	Author	Year	Journal	Total citations
1	A study of the etiology of idiopathic calcium urolithiasis in children: hypocitruria is the most important risk factor	Ali Tekin; et al.	2000	Journal Of Urology	20
2	Urolithiasis in pediatric patients: A single center study of incidence, clinical presentation and outcome	VanDervoort, K; Wiesen, J; et al.	2007	Journal Of Urology	19
3	Urinary Volume, Water and Recurrences in Idiopathic Calcium Nephrolithiasis: A 5-year Randomized Prospective Study	Loris Borghi; et al.	1996	Journal Of Urology	18
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