**Research Article**

GISTU Journal of Health and Biological Sciences

GJOHBS 2026;2(2):61-71. DOI: 10.65308/gjohbs.1909828

# Clinical Outcome Measures Used to Define Surgical Safety in Pediatric Surgery: A Bibliometric Analysis

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**Received Date:** Mar, 2026; **Accepted Date:** May, 2026; **Publication Date:** July, 2026.

## ABSTRACT

**Purpose**: This study was conducted to perform a bibliometric analysis of clinical outcome measures used in defining surgical safety in pediatric surgery.
**Materials and Methods:** The Scopus database was selected for this study. A search using selected keywords, based on the date of February 2026, identified 5,998 publications in the database. 4783 publications that did not meet the inclusion criteria (publication year, study design, language of the study, etc.) were excluded, and 1215 studies that met the inclusion criteria were exported in the appropriate format (.csv). The data were analysed using the Bibliometrix and VOSviewer software via RStudio.
**Results:** The 1215 studies meeting the inclusion criteria were published in a total of 421 academic journals. The annual growth rate of these studies was 17.83%, whilst the average publication age was 4.82 years. The number of keywords assigned by the database (ID) was 8727, whilst the number of keywords specified by the authors (DE) was 2881. The total number of authors contributing to the studies was 10851, whilst the international co-authorship rate was 16.72%. The average number of co-authors per article was 10.5, whilst the number of single-authored articles was 12. It was observed that the highest number of publications occurred in 2025 (n=196), whilst the lowest number occurred in 2015 (n=38). The year with the highest average total number of citations per article was 2015 (33.92), whilst the year with the lowest was 2025 (1.44). The year with the highest annual average total number of citations was again 2016 (3.01), whilst the year with the lowest was again 2025 (0.72).
**Conclusion:** The results of the analysis indicate that the subject retains its strategic importance; particularly when considering the year of publication and the average age of publications, the subject remains relevant, and further research in this area is warranted in the future.

**Keywords:** Surgical safety, Child, Pediatric surgery, Clinical outcome

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## Introduction

The definition of clinical outcome measures in pediatric surgery is a parameter evaluated in terms of patient safety. Although patient safety in pediatric surgery has been systematised within institutions, it is a known fact that problems arise during the reporting and evaluation stages (1). The determination of clinical outcome measures in pediatric surgery is a clear necessity in the literature. For example, it has been stated that studies are needed to evaluate risk factors that may cause complications in the postoperative period in pediatric surgery (2). This situation is confirmed by the prevalence of complications in certain diseases requiring surgical intervention. Indeed, one such disease is hypospadias, and it is noted that the complication rate remains high despite years of surgical procedures (3). In the field of pediatric surgery, clinical outcome measures such as readmission to hospital have been defined; it has been noted that, for certain surgical procedures, children have longer hospital stays and higher rates of early readmission following discharge compared to adults (4). It is evident that certain clinical outcomes are common in the field of pediatric surgery. Indeed, in the United States, where more than 5 million children undergo surgical procedures each year, it is reported that 50-75 per cent of children experience preoperative anxiety (5). However, it should be remembered that certain criteria can lead to different clinical outcome measures among children. For example, it is stated that children living in socially disadvantaged areas are more prone to postoperative complications compared to their peers (6). Another factor in the difference in clinical outcomes is age. For example, children under the age of two who undergo tonsil and adenoid surgery are reported to be more prone to postoperative complications and additional surgical intervention (7). Consequently, the significant differences and variability in surgical clinical outcome measures in children necessitate a review of the existing literature. One method of conducting this review is bibliometric analysis. In other words, it is crucial to sift through the existing information on a subject in the literature—which can otherwise appear as a confusing mass of data—to transform it into a useful resource (8). Bibliometric analysis is a method based on the analysis of researchers' performance and the scientific mapping of data obtained within the scope of the subject (9). This study was conducted to perform a bibliometric analysis of clinical outcome measures used to define surgical safety in pediatric surgery.

## Materials and Methods

### Study Design

This study is a descriptive bibliometric research.

### Study Population and Sample

A database search was conducted in the Scopus database in February 2026. The search string was defined as (TITLE-ABS-KEY ("pediatric surgery") AND TITLE-ABS-KEY ("surgical safety" OR "patient safety" OR "complications" OR "morbidity" OR "adverse events") AND TITLE-ABS-KEY ("length of stay" OR "hospital stay" OR "readmission" OR "reoperation" OR "mortality" OR "postoperative outcomes" OR "clinical outcomes")). The search using the keyword yielded 5,998 publications. A total of 4783 publications that did not meet the inclusion criteria (publication year, study design, language of the study, etc.) were excluded, and 1215 studies that met the inclusion criteria were exported in the appropriate format (.csv).

*Inclusion criteria:*

1. The publication must be indexed in the Scopus database;
2. The publication year must fall between 2015 and 2025;
3. The publication type must be an article;
4. The publication status must be 'final';
5. The publisher type must be a journal;
6. The publication language must be English
7. Being open access

*Exclusion criteria*

1. The publication is not indexed in the Scopus database;
2. The publication year is prior to 2015;
3. The publication type is other than an article (e.g. conference paper);
4. The publication status is 'article in press'
5. The publication type is not a journal (e.g. book)
6. The publication language is not English
7. Lack of open access

The workflow diagram for the database is shown in Figure 1.

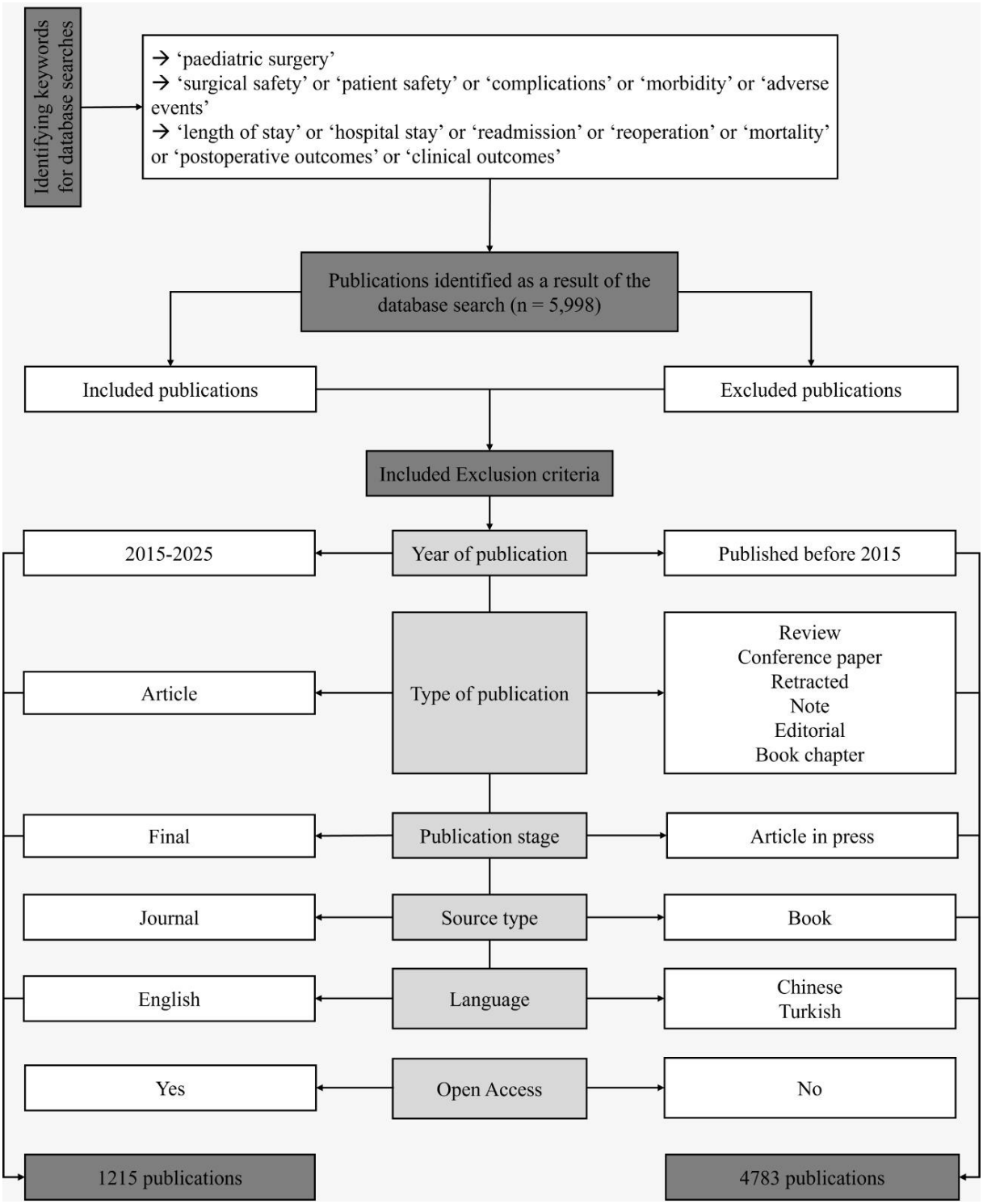


**Figure 1.** Database search PRISMA flowchart

**Study Statistics**

The data set to be analysed was identified using the Scopus database. The statistical analysis of the research was performed using the Biblioshiny software with the VOSviewer and RStudio procedures. Studies relevant to the topic in the literature were screened by selecting appropriate keywords and searching via the Scopus search engine. The VOSviewer and

Biblioshiny software parameters used in the analysis are employed to perform mapping, network visualization, graphical, thematic, and descriptive analyses in bibliometric studies (10, 11). Therefore, VOSviewer was used to map

bibliometric networks, while the Biblioshiny software add-on was used with the R software procedure to perform the relevant thematic and descriptive analyses.

## Results

A literature review identified 1215 studies conducted between 2015 and 2025 that met the inclusion criteria. These studies were published in a total of 421 academic sources. The annual growth rate of these studies was 17.83%, while the average publication age was 4.82 years. The number of keywords assigned by the database (ID) was 8727, while the number of keywords determined by the author (DE) was 2881.

The total number of authors contributing to the studies was 10851, while the international co-authorship rate was 16.72%. The average number of authors per article was 10.5, while the number of articles with a single author was 12. (Table 1).

**Table 1.** General characteristics of searched articles

| **Article Feature** | **n or %** |
|---|---|
| **Timespan** | 2015-2025 |
| **Article** | 1215 |
| **Sources** | 421 |
| **Annual Growth Rate (%)** | 17.83 |
| **Article Average Age** | 4.82 |
| **Keywords Plus (ID)** | 8727 |
| **Author's Keywords (DE)** | 2881 |
| **Authors** | 10851 |
| **Authors of single-authored article** | 12 |
| **Co-Authors per article** | 10.5 |
| **International co-authorships (%)** | 16.72 |

When examining the distribution of scanned studies by year in terms of production and citation counts, it is observed that the highest number of publications was in 2025 (n=196), while the lowest number of publications was in 2015 (n=38). The year with the highest average total number of citations per article was 2015 (33.92), while the year with the lowest was 2025 (1.44). The year with the highest average total number of citations per year was also 2016 (3.01), while the year with the lowest was again 2025 (0.72). The top three most cited studies were Hart et al. (2020), Wellons et al. (2017), and Greenberg et al. (2016) (Table 2) (Figure 2).

**Table 2.** Distribution of studies by year in terms of production and citation counts

| | **Annual Scientific Production** | **Mean Total Citations per Article** | **Mean Total Citations per Year** |
|---|---|---|---|
| **2015** | 38 | 33.92 | 2.83 |
| **2016** | 57 | 33.09 | 3.01 |
| **2017** | 65 | 25.71 | 2.57 |
| **2018** | 86 | 22.67 | 2.52 |
| **2019** | 124 | 18.65 | 2.33 |
| **2020** | 123 | 17.24 | 2.46 |
| **2021** | 125 | 10.74 | 1.79 |
| **2022** | 119 | 9.25 | 1.85 |
| **2023** | 131 | 4.56 | 1.14 |
| **2024** | 150 | 3.95 | 1.32 |
| **2025** | 196 | 1.44 | 0.72 |

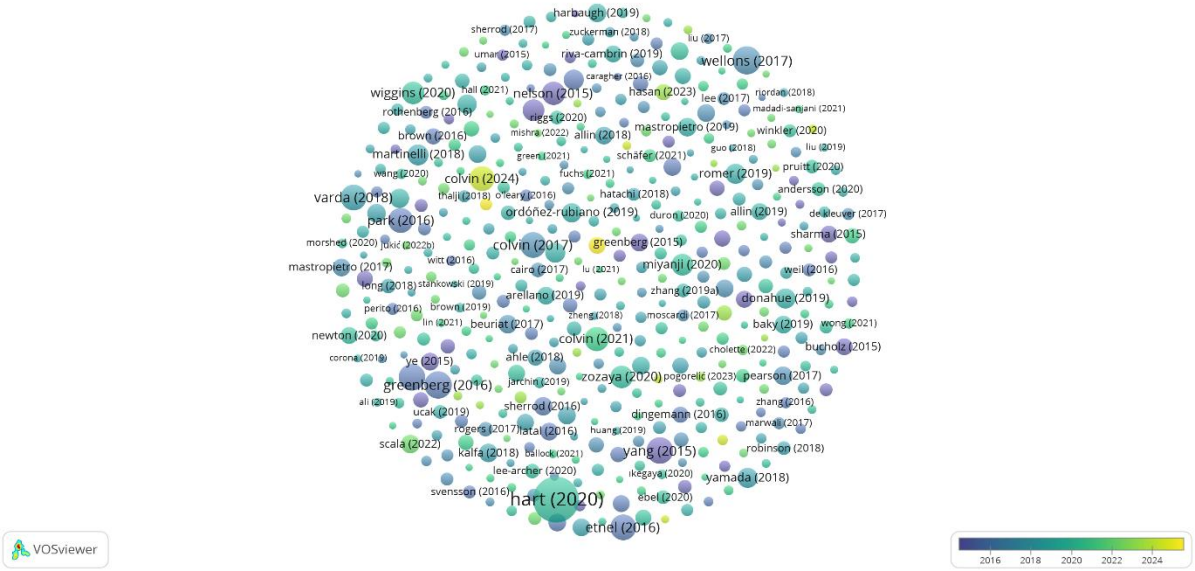


**Figure 2.** Distribution of citations according to authors

When examining the sources in which the studies were published, it is seen that the top three sources with the most publications are Frontiers in Pediatrics (73), Journal of Pediatric Surgery (61), and Journal of Neurosurgery: Pediatrics (32) (Table 3).

**Table 3.** The top 10 sources where the studies were most frequently published

| **Journal Title** | **N** |
|---|---|
| Frontiers in Pediatrics | 73 |
| Journal of Pediatric Surgery | 61 |
| Journal of Neurosurgery: Pediatrics | 32 |
| Journal of Thoracic and Cardiovascular Surgery | 28 |
| American Journal of Transplantation | 25 |
| Medicine (United States) | 25 |
| Pediatric Surgery International | 25 |
| Annals of Thoracic Surgery | 23 |
| Journal of Pediatric Surgery Case Reports | 19 |
| African Journal of Paediatric Surgery | 18 |

An examination of the primary sources in accordance with Bradford's Law reveals that Frontiers in Pediatrics and Journal of Pediatric Surgery represent a significant area (Figure 3).

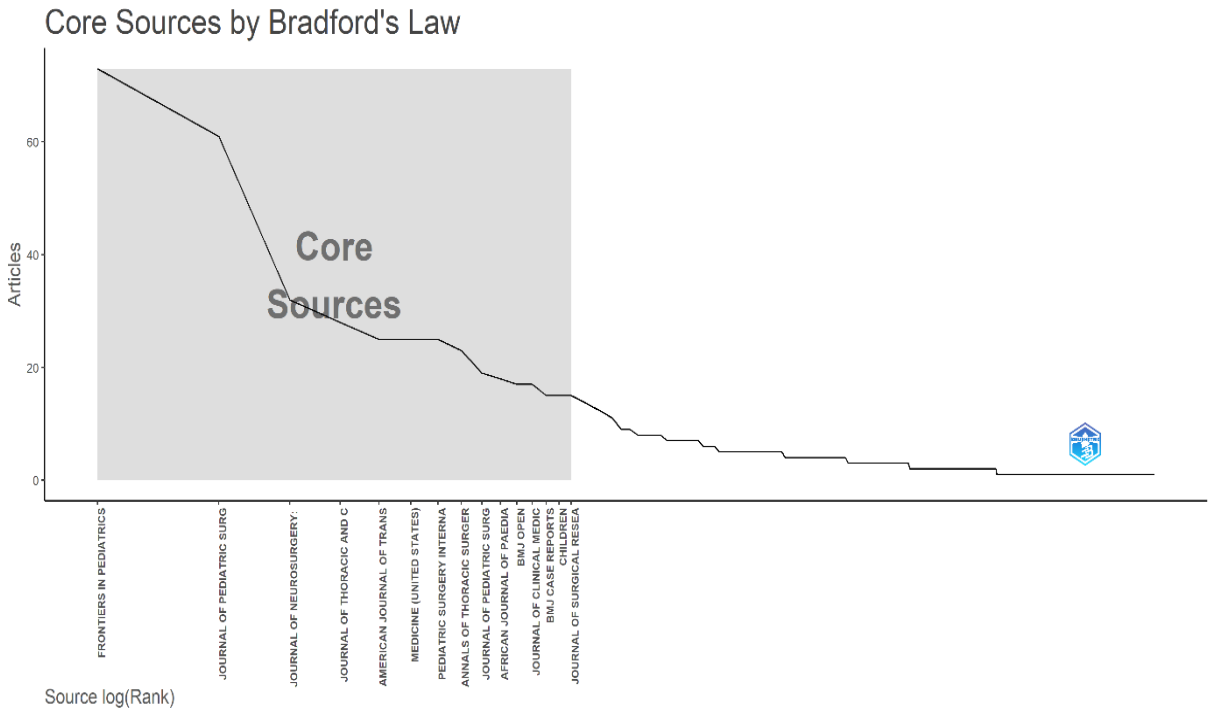


**Figure 3.** Core Sources by Bradford's Law

An examination of the primary sources in accordance with Lotka's Law reveals that the highest number of authors 9,629 contributed to a single publication. The number of authors who contributed to two publications is 894, whilst the number of authors who contributed to three publications is 182. (Figure 4)

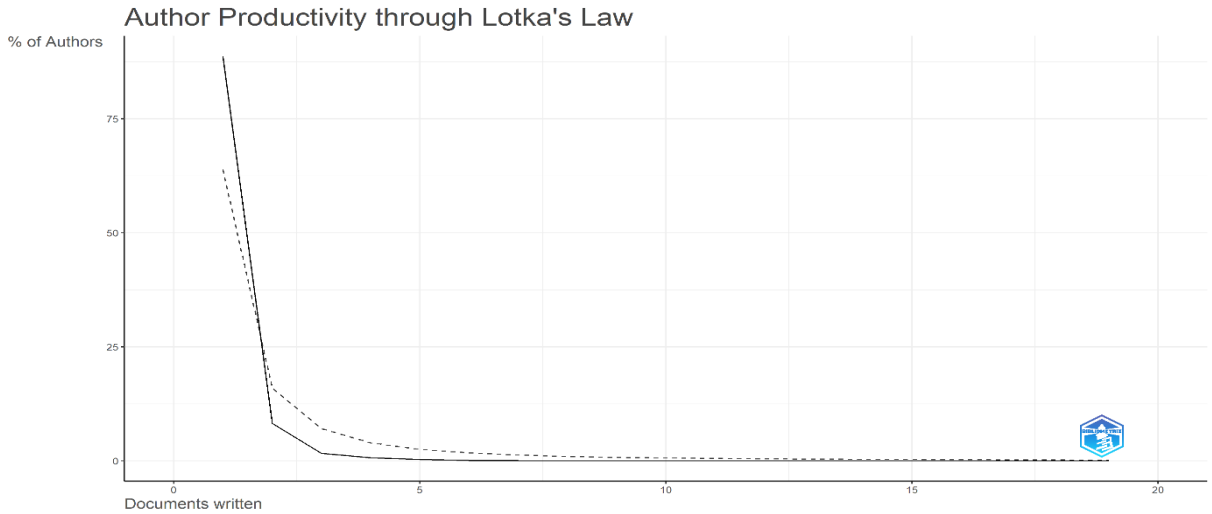


**Figure 4.** Author Productivity through Lotka's Law

When the studies are examined in terms of country characteristics, the top three countries are the United States (n=279, %=23.0), China (n=143, %=11.8) and United Kingdom (n=66, %=5.4). When examining the proportions of studies involving a single country and multiple countries, Canada has the highest proportion among the top 10 countries (48.3%), whilst Türkiye has the lowest proportions, with no studies involving multiple countries. (Table 4) (Figure 5)

**Table 4.** Distribution of countries according to corresponding authors

| Corresponding Author's Countries | Articles (n) | Articles (%) | SCP | MCP | MCP (%) |
|---|---|---|---|---|---|
| United States of America | 279 | 23.0 | 229 | 50 | 17.9 |
| China | 143 | 11.8 | 134 | 9 | 6.3 |
| United Kingdom | 66 | 5.4 | 49 | 17 | 25.8 |
| India | 47 | 3.9 | 45 | 2 | 4.3 |
| Türkiye | 43 | 3.5 | 43 | 0 | 0.0 |
| Germany | 42 | 3.5 | 35 | 7 | 16.7 |
| Italy | 40 | 3.3 | 34 | 6 | 15.0 |
| Canada | 29 | 2.4 | 15 | 14 | 48.3 |
| Japan | 27 | 2.2 | 26 | 1 | 3.7 |
| Egypt | 26 | 2.1 | 23 | 3 | 11.5 |
| France | 25 | 2.1 | 19 | 6 | 24.0 |

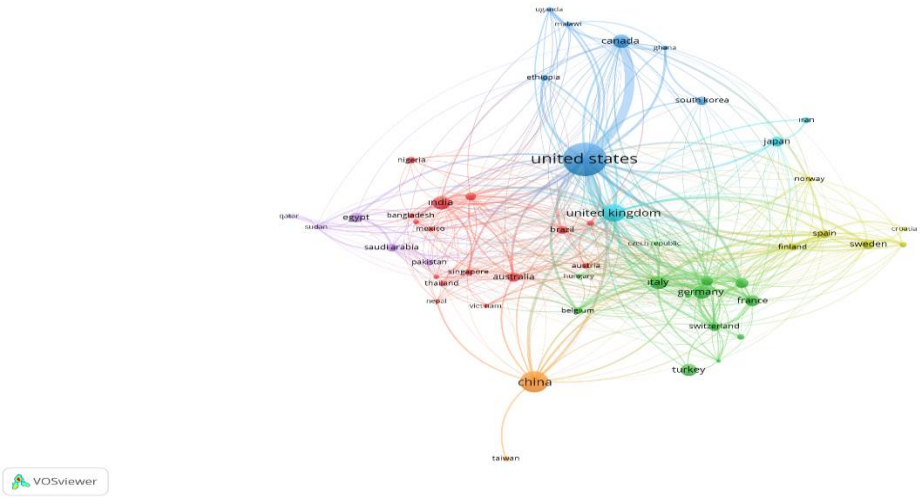


**Figure 5.** Distribution of countries according to co-authorship status

The most frequently used words in the studies included the word "human" (n=1133) in all words, the word "pediatric surgery" (n=132) in the keywords assigned by the author, the word "male" (n=1530) in the database-assigned keywords, and "pediatric" (n=473) in the study title. (Table 5)

**Table 5.** The top 10 most frequently used words in the studies

| All | N | Author Keywords | n | Keywords Plus | n | Title | N |
|---|---|---|---|---|---|---|---|
| Human | 1133 | Pediatric surgery | 132 | Male | 1530 | Pediatric | 473 |
| Article | 1068 | Children | 101 | Child | 1528 | Surgery | 322 |
| Male | 990 | Pediatric | 90 | Female | 1491 | Children | 256 |
| Pediatric surgery | 990 | Pediatrics | 73 | Human | 1133 | Study | 224 |
| Female | 963 | Paediatric surgery | 59 | Article | 1071 | Outcomes | 199 |
| Child | 937 | Laparoscopy | 46 | Pediatric surgery | 919 | Surgical | 142 |
| Humans | 681 | Complications | 40 | Infant | 870 | Patients | 129 |
| Retrospective study | 653 | Surgery | 36 | Adolescent | 812 | Cardiac | 113 |
| Major clinical study | 530 | Cardiac Surgery | 33 | Humans | 773 | Laparoscopic | 100 |
| Postoperative complication | 518 | Outcomes | 32 | Retrospective study | 681 | Experience | 96 |

## Discussion

The ever-increasing volume of information today makes it more difficult to understand the information one wishes to learn; however, analytical methods such as bibliometric analysis, which are employed to resolve this confusion, enable us to grasp the existing information (12). As a result of the database search conducted to achieve this objective, 1215 studies published in 421 different academic sources were identified. This finding demonstrates that the extant literature on clinical outcome measures in pediatric surgery has a wide variety of sources. This bibliometric diversity suggests that the subject is not confined to a particular source option; rather, it demonstrates that the scientific outputs obtained have an effective dissemination process through numerous different source areas. This is of particular importance in terms of demonstrating the potential for high visibility in the relevant global field for the 10851 researchers conducting academic work on the subject, scanned between 2015 and 2025. The year with the highest number of studies conducted between 2015 and 2025 is 2025. However, the average age of the articles is 4.82. Considering that the highest number of studies on the subject in the current literature were conducted a year ago and taking into account the age of the articles, it can be concluded that the subject remains current. Moreover, the finding that the number of single-authored articles is 12 and the average number of authors per article is 10.5 suggests that the number of authors interested in the subject is at a significant level and that it is a potential research topic for multi-authored studies in the field. The fact that the median number of authors per article was found to be 7.0 in the surgery-focused bibliometric study conducted by Li and colleagues confirms this level of interest in surgical research (13). The abundance of studies originating from the United States is a noteworthy and significant situation.

A study conducted by McIntosh and colleagues in 2025 shows that more than 50% of investments in surgical research during the 2016-2020 period were made in North America (14). In another study conducted in the field of surgery, the United States stands out as the country producing the highest number of studies (15). This finding is further supported by a bibliometric analysis of pediatric surgery studies conducted by Zhang and colleagues, which revealed that such studies are prevalent in North America, Europe and East Asia (16). This phenomenon can be considered a factor contributing to the observed distribution of countries active in this field. Another study has noted that in research funded by high-income countries, the likelihood of a first author coming from a low- or middle-income country is low; this finding may also help to shed light on the situation (17).

This database search using keywords revealed that the most frequently cited study was the 2020 article by Hart et al. (18), which examined kidney transplant data from 2018. This was followed by a study conducted by Wellons and colleagues (19) in 2017 on children with hydrocephalus and a study conducted by Greenberg and colleagues (20) in 2016 on renal outcomes in pediatric cardiac surgery. The top three most frequently cited studies appear to reflect the diversity within the field of pediatric surgery. This diversity of topics indicates that the subjects examined in pediatric surgery do not focus on a single systemic area, but are instead assessed across multiple disciplines in the context of postoperative care and surgical techniques. This finding suggests that there is no specific focus on a single area within the subject, and that the topic under investigation may have a more significant impact than a specific topic within the relevant existing literature.

The year with the highest average total number of citations per article was 2015, whilst the year with the lowest was 2025. As for the annual average total number of citations, the highest was recorded in 2016, whilst the lowest was again in 2025. This is attributed to the length of time the article has been in the literature and the impact it has had on related studies. Furthermore, the average publication age of 4.82 years supports this. Another factor to consider here is the citation lag parameter. In a study conducted by Chow et al. in 2023, which analysed 726 articles, the average citation lag was determined to be 7.5 ± 8.4 years (21). Taking this into account, it can be said that the citation potential for this subject continues to present a positive picture.

According to an analysis of the journals that have published the most research in this field, the top three spots are held, in order, by

'Frontiers in Pediatrics', 'Journal of Pediatric Surgery' and 'Journal of Neurosurgery: Pediatrics'. Similarly, in another bibliometric study in the field of pediatric surgery, the 'Journal of Pediatric Surgery' also stands out (22). The journals in which research on this topic has been published have been examined in accordance with Bradford's Law. According to this law, the identification of core journals in a given field is based on the criterion that they account for one-third of the publications in that field (23, 24). When the journals in which studies on this topic have been published are examined within the framework of this legislation, "Frontiers in Pediatrics" and the "Journal of Pediatric Surgery" stand out. It is emphasised that Bradford's Law has not been sufficiently studied in the medical literature (25). For this reason, the analysis of journals in accordance with Bradford's Law is of considerable importance in this study. Another study that examines these works is Lotka's Law. Lotka's Law is a fundamental bibliometric law used to assess scientific productivity (26, 27). Under the law, scientific productivity is measured by the number of articles published by authors (28). In this context, the area of the graph showing the highest concentration consists of authors who have contributed to a single publication. In other words, it was found that the group with the highest number of authors comprises those who have contributed to a single publication, totaling 9,629 individuals. These authors account for approximately 88 per cent of all authors. Given the time it takes for a study to progress from its conceptual stage to publication, it is hardly surprising that a large number of authors contributed to a single publication during the 10-year period between 2015 and 2025.

The unsurprising finding that emerged from this study concerns the most frequently used words and keywords in the studies. As expected, the most frequently used words and keywords in the studies are general terms (e.g. human, child, male, female, etc.) and expressions related to research methodology (e.g. article, retrospective study, major clinical trial, etc.). The fact that similar terms such as 'children' and 'surgery' were found in another study on pediatric surgery serves to support this finding (29). It is therefore to be expected that the most frequently used terms would appear in this way. However, terms relating to clinical outcome measures (outcomes, complications, etc.) and those defining the surgical field (e.g. cardiac surgery, paediatric surgery, laparoscopy, etc.) also play a significant role. This is to be expected and, as with other terms, consists of general expressions rather than specific definitions.

## Conclusion

Bibliometric analysis of clinical outcome measures in pediatric surgery reveals that the intense academic interest observed in the literature indicates that this field retains its strategic importance. The low average publication age of the studies indicates that the literature exhibits a dynamic structure and that current surgical paradigms are undergoing a continuous process of renewal. The size of the network of authors contributing to the literature enhances the scientific impact of this field and provides a solid foundation for future research.

## Limitations of the Study

This study examined only the Scopus database. Furthermore, as the database search for 2026 was conducted in February 2026, data for 2026 could not be included.

## Decleration

### Ethical Approval Statement

Ethics committee approval is not required for this review article as it does not involve human or animal subjects.

### Author Contributions Statement

BÇ: Article concept: Literature review, Data analysis, Preparation of the article, Critical review, Final approval of the version to be published; İD: Article concept, Preparation of the article, Critical review, Final approval of the version to be published; AB: Preparation of the article, Final approval of the version to be published; SMG: Preparation of the article, Final approval of the version to be published

### Fund Statement

No financial support was received for this study.

**Conflict of Interest Statement**

There is no conflict of interest in this study

**Declaration on the Use of AI**

Generative artificial intelligence was not used in this study.

**Acknowledgment:**

None.

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