

Global Research Output (2016 - 2026) in Surgical Oncology: A scientometric analysis of research trends and its impact

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ABSTRACT

Purpose: The aim of the study is to analyze the scientific publications indexed in the Scopus database for the period 2016–2026 to study the world trends of research in surgical oncology. It aims to find out the trends in growth of publications, major contributors, collaboration networks, citation impact and emerging thematic areas in the domain. The purpose of this study is also to identify conceptual structures and to highlight directions of research that impact on surgical oncology.

Methodology: The research design was scientometric, with bibliographic data extracted from the Scopus database. The search was conducted using the keyword “surgical oncology” and restricted to articles in the medical subject area published between 2016 and 2026. 13,525 records were exported in BibTeX format and analyzed using Biblioshiny, the web interface of the Bibliometrix package in RStudio. The study examined the annual scientific output, most productive authors, affiliations and countries, citation patterns, collaboration indicators, keyword co-occurrence and mapping of the conceptual structure.

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Findings: The analysis revealed a consistent increase in the number of publications during the study period with the peak productivity achieved in 2025. Strong collaboration patterns were observed as indicated by a high average number of co-authors per document. The United States was the largest contributor in terms of number of publications and citation impact, followed by major European countries and China. Prominent institutions included Memorial Sloan Kettering Cancer Center, Mayo Clinic and Harvard Medical School. Citation analysis was used to identify high impact publications that influence clinical practice. The keyword analysis showed a recent focus on clinical studies, surgical procedures, treatment outcomes and survival analysis. Clusters were identified by conceptual structure mapping related to clinical-demographic studies, treatment approaches and outcome-based research. Implications: The study provides valuable insights into global research productivity, collaboration trends, and emerging themes in surgical oncology. These findings may assist researchers, clinicians, and policymakers in identifying influential contributors, potential collaboration opportunities, and future research directions within the field.	
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Keywords: Surgical Oncology; Global research output; Scientometric Analysis; Scopus Database; Biblioshiny; Research Trend

1. INTRODUCTION

Surgical oncology is indispensable to the comprehensive management of cancer, a role that has only grown more critical as global incidence continues to rise. In response, research in the field has expanded rapidly, encompassing diagnostic innovations, novel therapeutic strategies, minimally invasive techniques, and long-term survival outcomes. However, this proliferation of literature has also made it increasingly difficult for clinicians and researchers to systematically track progress, identify influential contributions, or recognize emerging themes without the aid of quantitative analytical tools.

Scientometric analysis offers precisely such a framework, providing a data-driven approach to evaluate scientific output, pinpoint leading authors and institutions, and map global patterns of collaboration. Advanced bibliometric platforms like Bibliometrix and its web-based interface, Biblioshiny, enable comprehensive landscape mapping by analyzing publication trends, citation impact, and the underlying conceptual structure of a discipline. Given that cancer management is inherently multidisciplinary—requiring seamless coordination among surgeons, oncologists, radiologists, and pathologists—understanding global productivity and international collaboration becomes not just informative but essential for advancing patient care.

This study applies these scientometric methods to surgical oncology research, using data from the Scopus database covering the period 2016–2026. We evaluate publication trajectories, authorship patterns, institutional and country-level productivity, and citation impact. To

capture the most current research interests and nascent directions, a focused keyword analysis of 2026 publications is also conducted. Through this integrated approach, the study offers broad, evidence-based insights into the present state of the field while highlighting where surgical oncology research is likely heading next.

1.1. Objectives

- 1) To analyze the annual scientific production and growth trends of research publications in the field of surgical oncology during the period 2016–2026.
- 2) To identify the most productive authors, affiliations and countries in surgical oncology research and explore their scientific impact using citation-based indicators.
- 3) To evaluate patterns of collaboration in the field by authorship analysis, countries of corresponding authors and trends of international co-authorship.
- 4) To identify the intellectual and conceptual structure of recent research in surgical oncology by co-occurrence network analysis and keyword-based mapping.
- 5) To identify emerging research themes and current focus areas in surgical oncology based on 2026 publications using word cloud and most relevant word analysis.

2. REVIEW OF LITERATURE

Surgical oncology has evolved significantly over the past century, transitioning from a discipline rooted in general surgery to a formally recognized subspecialty with distinct training and certification pathways. Copeland (1999) highlighted the historical development of surgical oncology, tracing its roots to pioneers such as James Ewing and Murray Copeland, and emphasized the importance of multimodality treatment and fellowship training in shaping the specialty. His presidential address underscored the role of surgical oncologists as coordinators of cancer care, while also noting challenges in maintaining their central role amid the rise of other oncology disciplines. Klimberg and Balch (2014) expanded on the global perspective, particularly in the context of China, stressing the dual role of surgical oncologists as both surgeons and oncologists. They argued that specialization improves outcomes, especially in high-volume cancer centers, and outlined the training paradigm for complex general surgical oncology. Their work emphasized the necessity of multidisciplinary collaboration and the integration of surgical oncologists into long-term cancer management and research. Chandrashekar (2024) examined recent advances in surgical oncology techniques, particularly minimally invasive and robotic-assisted surgeries, intraoperative imaging, and multimodal approaches. The study demonstrated how technological innovations have improved precision, reduced complications, and enhanced patient recovery. Importantly, Chandrashekar highlighted the growing role of personalized medicine in tailoring surgical interventions to individual genetic profiles. Whalen (2016) provided a comprehensive overview of the principles of surgical oncology, categorizing cancer surgeries into diagnostic, curative, metastatic, palliative, and reconstructive. He emphasized the importance of achieving R0 resections and discussed the evolving role of lymphadenectomy and metastasectomy. His work reinforced the multidisciplinary nature of surgical oncology and the intellectual value of subspecialty training beyond technical expertise. Tomas (2022) discussed the role of surgery within oncology, outlining various surgical approaches including open, laparoscopic, robotic, and laser techniques. He emphasized the integration of surgery with other modalities such as chemotherapy and radiation therapy, and highlighted the importance of supportive and palliative procedures in improving patient quality of life. Michelassi (2026) provided a detailed account of the process that led to the formal recognition of Complex General Surgical Oncology (CGSO) by the American Board of Surgery. He traced the debates over certification,

training standards, and concerns about fragmentation of general surgery, ultimately concluding that CGSO certification strengthened the discipline by ensuring rigorous training and assessment for complex cancer care. Finally, Andrews (2022) reinforced the importance of surgical oncology as a cornerstone of cancer treatment, describing techniques such as cryosurgery, radiofrequency ablation, and minimally invasive procedures. He emphasized the preventive, diagnostic, curative, supportive, and palliative roles of surgical oncology, aligning with broader trends in multimodal and patient-centered cancer care.

2.1 Research Gap

The literature reviewed above demonstrates the established clinical importance and continuing technological development of surgical oncology, including advances in minimally invasive and robotic surgery, multimodal treatment, specialist training, and multidisciplinary cancer care. However, the reviewed studies are predominantly clinical, historical, or practice-oriented and do not provide a comprehensive scientometric mapping of the global research landscape in surgical oncology across a defined recent period. In particular, there is limited evidence in the reviewed literature that simultaneously examines publication growth, author and institutional productivity, country-level contribution, citation patterns, collaboration structures, author productivity patterns, and the conceptual and emerging thematic structure of surgical oncology research using a large Scopus-indexed corpus. This gap is important because the rapid expansion and multidisciplinary character of the field make it difficult to identify the development of research activity and emerging directions through narrative literature alone. The present study addresses this gap by applying a scientometric approach to Scopus-indexed research published from 2016 to 2026, with particular attention to publication trends, influential contributors, geographical and institutional patterns, collaboration, citation impact, and the research themes evident in publications indexed through April 2026. The study therefore complements clinically oriented literature by providing a quantitative map of the research structure and recent thematic direction of the field.

3. METHODOLOGY

This study analyses the research trends in surgical oncology by using a scientometric approach. Data were extracted from the Scopus database using the search query TITLE-ABS-KEY (surgical oncology) AND PUBYEAR > 2015 AND PUBYEAR < 2027 AND (LIMIT-TO (SUBJAREA, "MEDI")) AND (LIMIT-TO (DOCTYPE, "ar")) and restricted to articles published in the medical subject area between 2016 and 2026. The 2026 data include publications indexed through April 2026. The records retrieved were exported in BibTex format and analyzed with Biblioshiny, the web interface of the Bibliometrix package in RStudio. Descriptive scientometric indicators were analyzed. These indicators were annual scientific production, most relevant authors, affiliations, country scientific production, citation analysis and authors' impact indices (h-index, g-index and m-index). Conceptual structure analysis was also done using co-occurrence network, word cloud and most relevant word analysis. For the keyword-based analysis, only 2026 publications were used to identify the recent and emerging research trends. To understand the publication patterns, important contributors, collaboration structure and current research trends in surgical oncology, results were analyzed using standard scientometric indicators.

3.1 Inclusion and Exclusion Criteria

Inclusion criteria were defined according to the scope and bibliometric objectives of the study. Records were included when they (i) were indexed in Scopus, (ii) were published between 2016 and 2026, (iii) were classified as research articles (document type: article), (iv) were indexed under the Medicine subject area, and (v) contained the term “surgical oncology” in the title, abstract, or keywords through the Scopus TITLE-ABS-KEY field. The 2026 records were limited to publications indexed through April 2026.

Records were excluded when they fell outside the 2016–2026 publication period, were not classified as articles, were not within the Medicine subject-area restriction, or did not contain “surgical oncology” in the title, abstract, or keywords. Accordingly, reviews, conference papers, editorials, letters, book chapters, notes, and other non-article records were outside the analytical corpus. Because this is a database-based scientometric study rather than a systematic review of individual clinical studies, records were not excluded on the basis of clinical findings, sample size, treatment outcomes, or study design.

4. DATA ANALYSIS AND INTERPRETATION

In the present study, we have analyzed the research trends in surgical oncology through scientometric techniques on basis of literature review and adopted methodology. To map the research landscape, we utilized Biblioshiny to perform a quantitative analysis of publications retrieved from the Scopus database (2016–2026). The analysis focused on publication trends, influential authors and institutions, global geographical contributions, and citation impact. Additionally, the field's conceptual framework and emerging themes were mapped via keyword analysis of 2026 publications. The findings are then detailed in the results and discussion section, which examines publication output, cross-border collaborations, and future directions in surgical oncology.

4.1. Bibliometric Profile of Surgical Oncology Research (2016 – 2026)

Table 1: Bibliometric Profile of Surgical Oncology Research (2016 – 2026)

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2016:2026
Sources (Journals, Books, etc)	2225
Documents	13525
Annual Growth Rate %	-0.06
Document Average Age	4.42
Average citations per doc	14.53
References	0
DOCUMENT CONTENTS	
Keywords Plus (ID)	29290
Author's Keywords (DE)	20152
AUTHORS	
Authors	84947
Authors of single-authored docs	230
AUTHORS COLLABORATION	
Single-authored docs	243
Co-Authors per Doc	10.1
International co-authorships %	16.48
DOCUMENT TYPES	
article	13525

Table 1 presents the Bibliometric Profile of Surgical Oncology Research (2016 – 2026) of the dataset used for the scientometric analysis. Data covers the period 2016-2026, with a total of 13,525 documents published in 2,225 different sources. This suggests that a wide range of journals and scholarly outlets are contributing to the research area. The annual growth rate is -0.06% , which shows that the publication output was relatively stable in the study period with only a small fluctuation of the number of publications. Age of the documents is 4.42 years on average indicating that the dataset contains mainly recent publications. The average citations per document is 14.53 which shows moderate citation impact and that the documents have received reasonable scholarly attention. The dataset includes 29,290 Keywords Plus and 20,152 author keywords, capturing a broad spectrum of themes and offering complete coverage of research topics in the field. The authorship analysis shows that 84,947 authors contributed to the 13,525 documents, thus highlighting the large research community in this domain. Single authored documents are 243 while only 230 authors contributed in single authored documents. It means single author publications are very limited. The average number of co-authors per document is 10.1, indicating high collaboration among researchers. The international co-authorship rate is 16.48% and suggests a moderate level of global collaboration between countries. That means that, although collaboration is common, a sizable share of research still happens within national borders. The analysis of document type shows that all 13,525 records are articles. Hence, the dataset is only research articles and there is consistency in document type for analysis.

4.2. Annual Scientific production

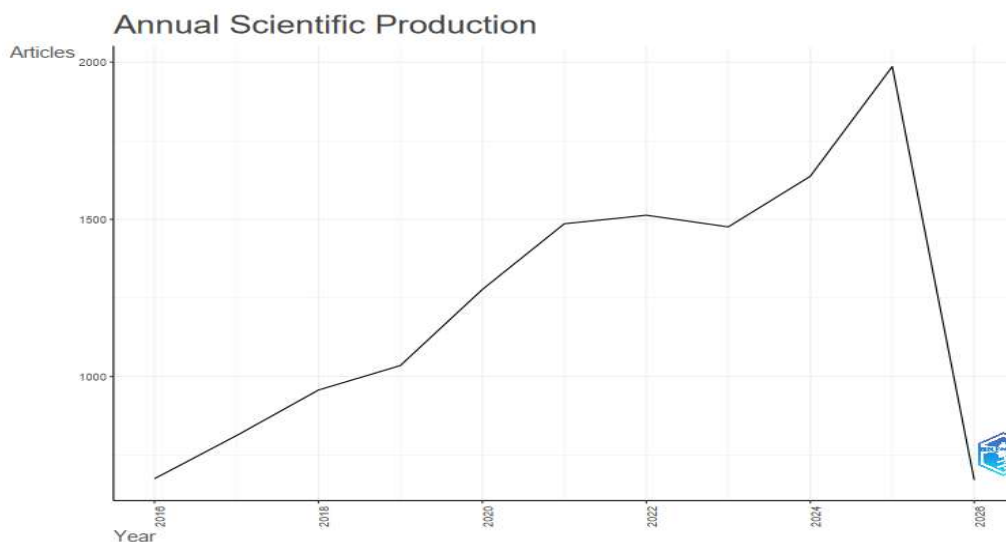


Figure 1: Annual Scientific Production

The annual scientific production in the figure 1 illustrates the publication trend in the research domain during the period 2016–2026. The results show a general increasing trend in the number of publications, suggesting an increasing research interest and scholarly output over time. The number of publications increased steadily from 675 articles in 2016 to 812 in 2017 and 957 in 2018. In 2019, the gradual increase continued, with 1,035 publications and a more significant increase in 2020 (1,277 articles). The upward trend continued in 2021 with 1,486 publications, and increased slightly in 2022 to 1,513 articles. In 2023 there is a slight drop (1,476 articles), which may be temporary fluctuations rather than a long run reduction. The research output increased again in 2024 with 1,637 publications and reached its peak in 2025

with 1,986 articles, which was the highest number of research activity within the duration of the study. The number of publications for 2026, however, appears rather low (671 articles). It should be noted that the lower value does not reflect a decrease in research productivity, as the data for 2026 represent only partial records up to April 2026. Thus, the overall number of publications for 2026 is likely to grow as the year progresses. The scientific output per year shows a stable increasing trend from 2016 to 2025, indicating an increasing research interest and growing scholarly contributions in the field. The temporary drop in 2026 is caused by incomplete yearly data, not by an actual decrease in research output.

4.3. Average Citations per year

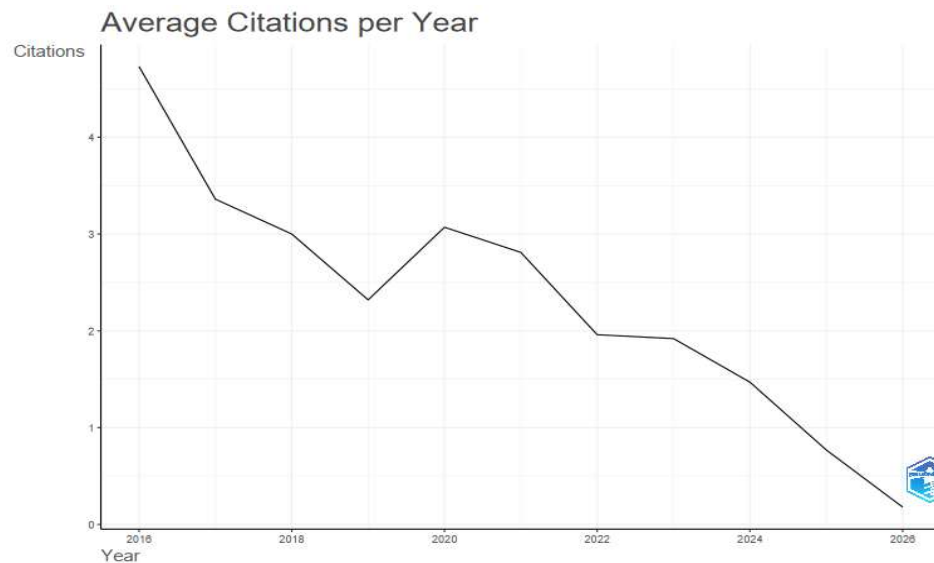


Figure 2: Average citations per year

The average citations per year in Figure 2 show the citation impact of publications during the study period from 2016 to April 2026. Indicators are mean total citations per article, mean citations per year and citable years, which jointly reflect the variation of citation impact with publication age. The findings imply that older publications are, on average, more cited as they have been around longer. Articles published in 2016 have the highest mean citations per article (52) and mean citations per year (4.73), with 11 citable years. Similarly, the 2017 publications have a high citation impact with 33.64 mean citations per article and 3.36 citations per year. The higher values are due to the fact that older publications had more time to accumulate citations. In the subsequent years a slow decline in the average number of citations can be seen. The mean number of citations per article for publications in 2018 and 2019 are 27.02 and 18.57 respectively. Interestingly, the mean citation per article (21.47) and mean citations per year (3.07) of the publications in 2020 are slightly higher, which indicates a relatively strong influence compared with the years around it. From 2021 onwards, the citation averages are declining gradually, with 2021 having 16.87 average citations per article, followed by 9.8 in 2022 and 7.66 in 2023. This trend continues in recent years, with 4.42 citations per article in 2024 and 1.54 in 2025. The lowest values are observed for 2026, with a mean of 0.18 citations per article and 0.18 citations per year. However, the low citation values for 2025 and 2026 should be interpreted with caution, as the dataset is only up to April 2026 in terms of publication. The average number of citations is lower the more recent the date of publication

of the publications. Thus, the downward trend in recent years does not reflect a lower research impact but is rather an expression of the shorter citation window for recently published documents. Average citation per year analysis indicates that citation impact grows with publication age, and the perceived recent decrease is a consequence of incomplete citation accumulation, especially for publications from 2025 and early 2026.

4.4. Most relevant author

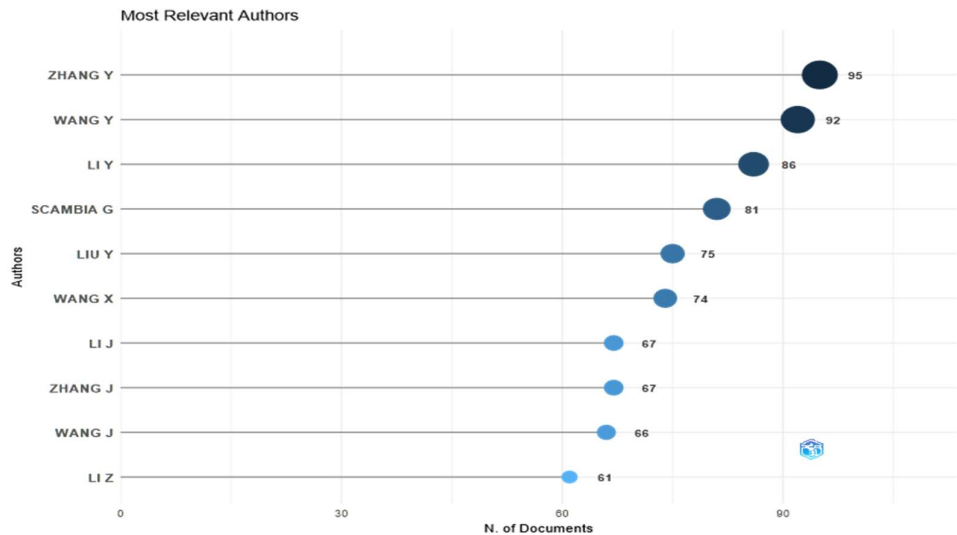


Figure 3: Most relevant author

The analysis of the most relevant authors is shown in Figure 3, which identifies the main contributors in the research domain by the number of publications and fractionalized counts of articles. The fractionalized count is the proportionate contribution of each author accounting for the co-authorship and is a more precise measure of the individual involvement in the research. The author that has published the most with 95 publications and a fractionalized contribution of 12.34 is Zhang Y, indicating a considerable involvement in collaborative research. Wang Y has published 92 papers and has a fractionalized count of 11.38, indicating steady research activity and a prominent position in multi-author publications. Similarly, Li Y ranks third with 86 publications and a fractionalized value of 11.32, indicating high research productivity and involvement in collaborations. Another prolific author is Scambia G with 81 articles. The fractionalized count (6.95) is relatively lower than the three most prolific authors indicating more co-authorship in publications. Next is Liu Y with 75 publications and a fractionalized value of 10.35, which represents both productivity and a meaningful individual contribution. Other prominent authors are Wang X (74 publications; fractionalized 9.89), Li J (67 publications; fractionalized 7.55), Zhang J (67 publications; fractionalized 7.71) and Wang J (66 publications; fractionalized 6.98). These authors show consistent research productivity and active collaboration in the field. Li Z also contributes a lot with 61 publications and a fractional value of 8.18. The dominant authors are Chinese researchers, which shows a high research activity from Chinese institutions. The comparison of fractionalized articles to total articles shows that the field is very collaborative with many authors working together on individual articles. The results reveal that Zhang Y, Wang Y, and Li Y are the most influential and productive contributors in the research field.

4.5. Lotka's Law

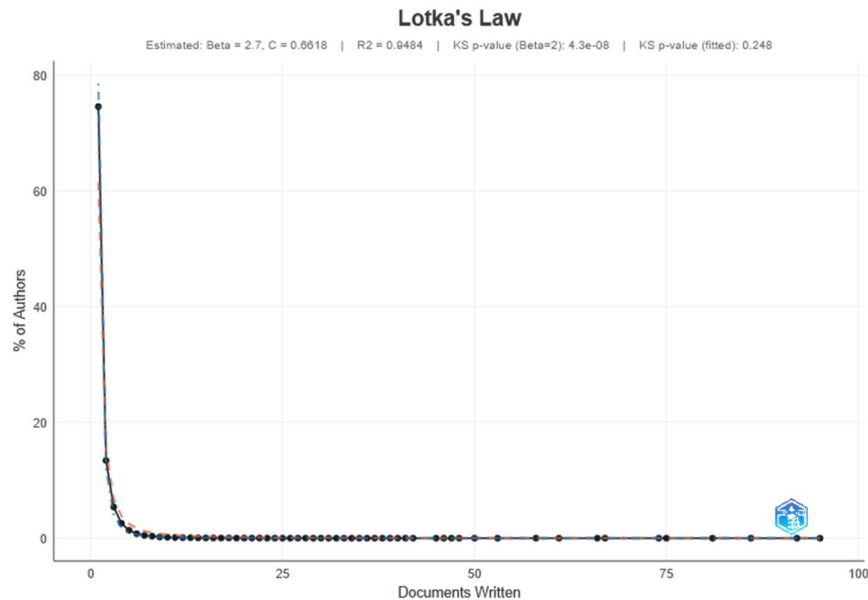


Figure 4: Lotka's Law

Figure 4 shows an application of Lotka's Law, which studies the frequency distribution of the productivity of authors, by analyzing the number of documents written by authors in the dataset. Lotka's Law suggests that a large proportion of authors have only one publication, and a small number of authors have multiple publications. The present findings provide strong support for this pattern of author productivity. The results indicated that 63,365 authors wrote only one document, which accounted for 74.59% of the total authors. This indicates that most researchers in the field are occasional contributors. Authors with two publications are 11,411 (13.43%). Authors with three publications are 4,587 authors (5.40%). The number of publications increases fast with the number of authors and the decrease of the number of authors is rapid, in agreement with the inverse square relation proposed by Lotka's Law. Further analysis shows that only 2,182 authors (2.57%) submitted four documents, 1,166 authors (1.37%) submitted five documents, and 655 authors (0.77%) published six documents. Above this level the proportion of authors falls off rapidly, suggesting that a small core of researchers contributes a large proportion to the field. The authors with 10 or more publications are only a very small portion, each accounting for less than 0.2% of the total. The distribution exhibits a long tail of highly productive authors, where a few individuals have more than 50 publications, and the highest productivity of a single author is 95 documents. These prolific authors, however, make up a very small percentage of the entire population of authors. The distribution closely fits Lotka's Law, which shows that the research area is characterized by many low productive authors and few high productive ones. This pattern is typical of scientometric authorship, where knowledge production is concentrated in a small core of active researchers, with most contributors participating sporadically.

4.6. Author's local impact

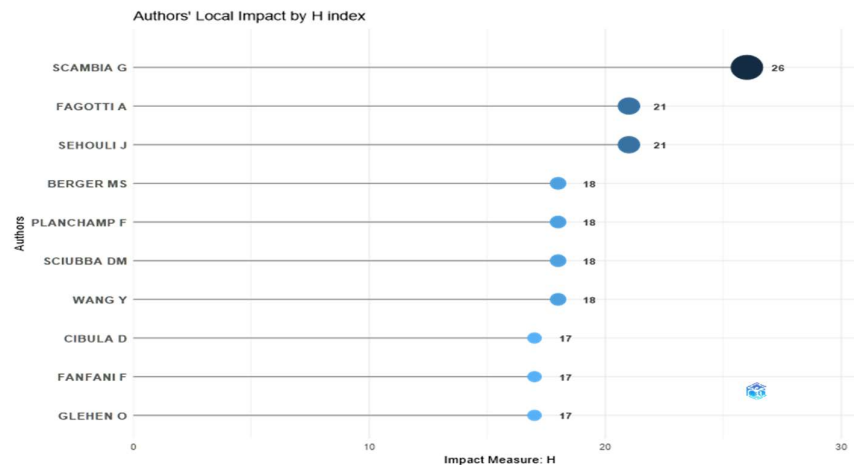


Figure 5: Author's local impact by h-index

The h-index-based analysis of authors' local impact shown in Figure 5 identifies the most influential authors in the research domain with consideration of both productivity and citation impact. The h-index is the number of publications (h) that have been cited at least h times. The g-index is biased towards highly cited articles. The m-index is the career impact normalized to academic age. Total citations (TC) and number of publications (NP) can also support the assessment of author influence. Scambia G has the highest h-index (26), g-index (46), and m-index (2.36), which makes him the most influential author. Since 2016, the author has published 81 papers with 2,364 total citations, indicating both high productivity and strong citation impact. This indicates that Scambia G is a pioneer actor in defining the research field. Fagotti A and Schouli J share second position with h-index 21. Fagotti A has 50 publications and 1,633 total citations while Schouli J has 42 publications and 1,929 total citations. Comparable h-index values suggest similar academic influence, albeit slightly higher citation impact for Schouli J. Berger MS, Planchamp F, Sciubba DM, and Wang Y all have an h-index of 18, reflecting solid, but somewhat less impact than the leading authors. Planchamp F is one of the top authors with 2,149 total citations, but less publication (23) which shows a high citation rate per article. In contrast, Wang Y had the highest productivity in this group with the highest number of publications (92). Cibula D and Fanfani F have an h-index of 17, 36 and 34 publications, respectively. Cibula D has a higher citation impact with 1,969 total citations compared to Fanfani F (740 citations). Glehen O also has a strong research influence, with an h-index of 17, g-index of 28 and 1,264 citations since 2017. Local impact analysis showed that the author with the highest influence was Scambia G, followed by Fagotti A and Schouli J. These authors have a high h-index, g-index and citation counts, suggesting that they are highly productive and have a high scholarly impact. The results also reveal that some authors have a high impact with highly cited publications, whereas others have an influence through ongoing research productivity.

4.7. Most relevant affiliations

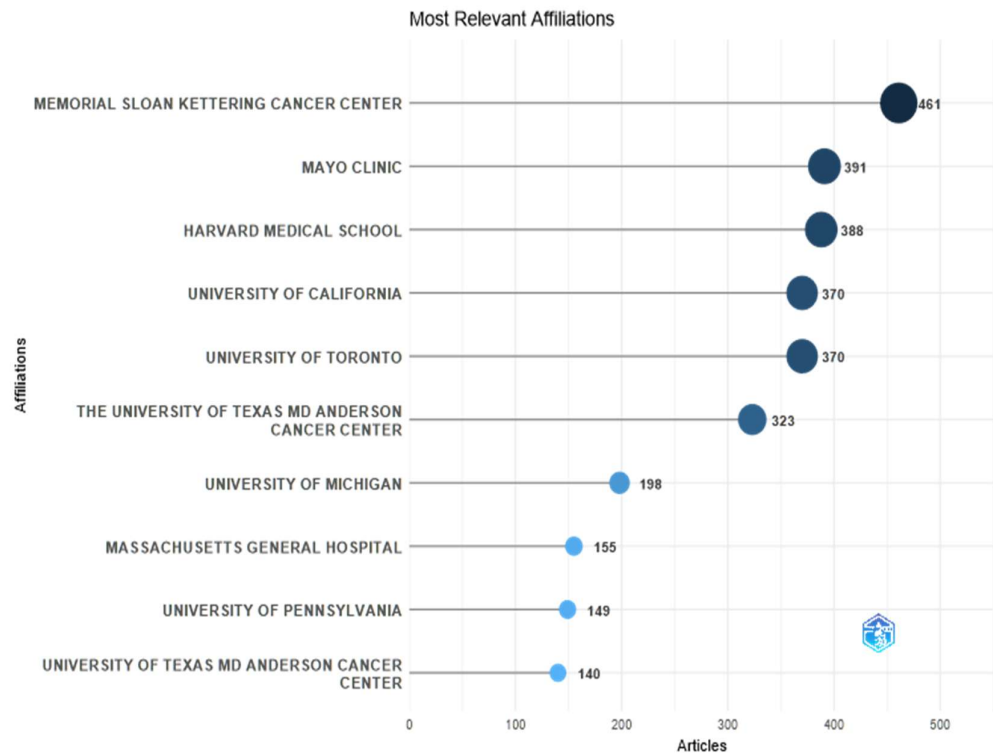


Figure 6: Most relevant affiliation

Figure 6 presents the analysis of the most relevant affiliations and indicates the top institutions involved in the research field based on the total number of publications. The results indicate that major medical universities and specialized cancer research centers are ahead, consistent with the clinical and oncology orientation of the literature. Memorial Sloan Kettering Cancer Center is the most productive affiliation with 461 publications, reflecting their leading role in promoting the research in the domain. It has a strong focus on clinical oncology, multidisciplinary research and wide collaborations, and this is reflected in its high output. Mayo Clinic was the second most productive institution with 391 publications, a major contribution to clinical research, treatment appraisal, and patient-centered studies. Mayo Clinic is second with 390 publications and Harvard Medical School is third with 388. High publication rates reflect high research activity and interdepartmental collaboration, especially in medicine and cancer research. University of California and University of Toronto follow with 370 publications each, indicating a similar research output and international collaboration in the area. The University of Texas MD Anderson Cancer Center has a large research presence, with 323 publications, and demonstrates the importance of specialized cancer research centers in the field. Other important contributors are University of Michigan (198 publications), Massachusetts General Hospital (155 publications) and University of Pennsylvania (149 publications) with moderate but significant contributions. The majority of the key affiliations are leading medical schools, cancer centers and research hospitals. In the research space you have Memorial Sloan Kettering Cancer Center, Mayo Clinic, Harvard Medical School. The research landscape is characterized by high impact clinical institutions with a strong focus on oncology related research, clinical trials and patient outcome studies.

4.8. Affiliations productivity over time

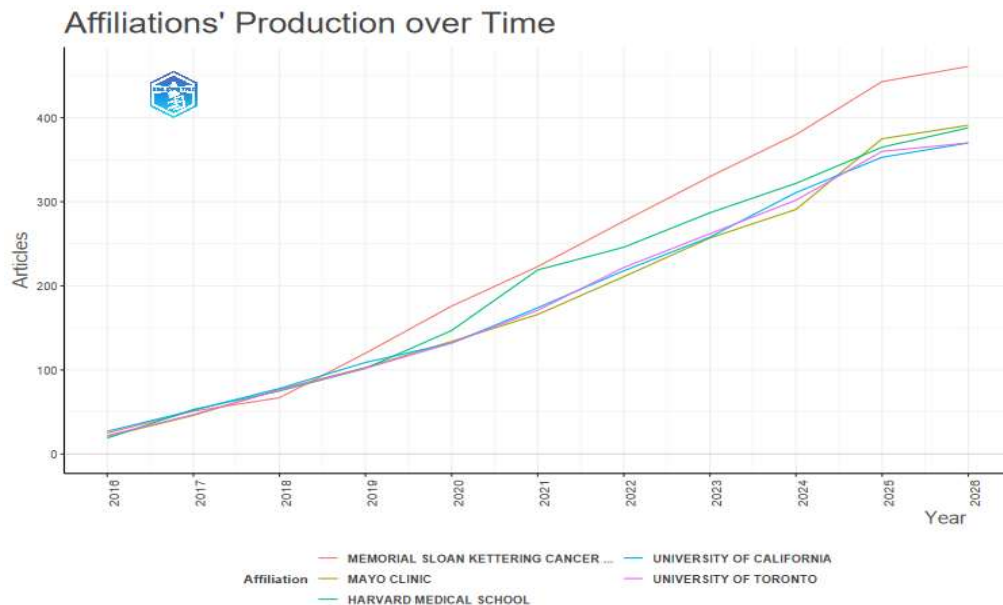


Figure 7: Affiliation's production over time

The productivity of the affiliations over time is presented in Figure 7. The research output of the leading institutions has shown a steady and significant increase during the study period (2016–2026). Our results indicate that the most prominent medical schools and cancer research organizations have experienced a steady growth of their academic production, reflecting an increase of research efforts and collaborations in this field. Harvard Medical School's publication output has a very good upward trend from 19 articles in 2016 to 388 articles in 2026. The upward trend is more evident after 2019, with the number of publications increasing rapidly from 102 in 2019 to 219 in 2021 and 365 in 2025. Such continuous growth is a reflection of ongoing research activities and growing institutional focus in the field. We also find that the research productivity of the Mayo Clinic increases significantly with time. (2016: 21, 2026: 391) Publications went from 21 in 2016 to 391 in 2026. The steady increase in the post-2020 with a strong acceleration suggests more research investment and collaborative clinical studies over the years. The increase from 291 articles in 2024 to 375 articles in 2025 further illustrates the growing research output. During the later period of study, Memorial Sloan Kettering Cancer Center was the most prolific institution. The publication output has increased from 25 articles in 2016 to 461 articles in 2026, the highest cumulative growth among all affiliations. The number of publications has sharply increased from 2019, from 120 in 2019 to 330 in 2023 and 461 in 2026. This trend reflects the leading position of the institution in the research development in the domain. The University of California also shows a constant growth trend in productivity from 27 publications in 2016 to 370 publications in 2026. The trend indicates a steady and continuous growth throughout the whole period, especially after 2021. This pattern reflects sustained institutional engagement and a long-term research commitment. The University of Toronto also follows the similar growth curve with 22 publications in 2016 growing to 370 publications in 2026. The institution is growing at a steady rate each year, and especially from 2020 to 2025, with the increasing number of collaborations and multidisciplinary research. The productivity analysis by affiliation shows that all five

institutions have a steady and significant increase in their research output during the study period. Memorial Sloan Kettering Cancer Center has the highest productivity in the later years, with Mayo Clinic and Harvard Medical School next. The overall upward trend for all affiliations indicates the increasing interest in the field in terms of research, collaboration, and academic contribution.

4.9. Corresponding author's countries

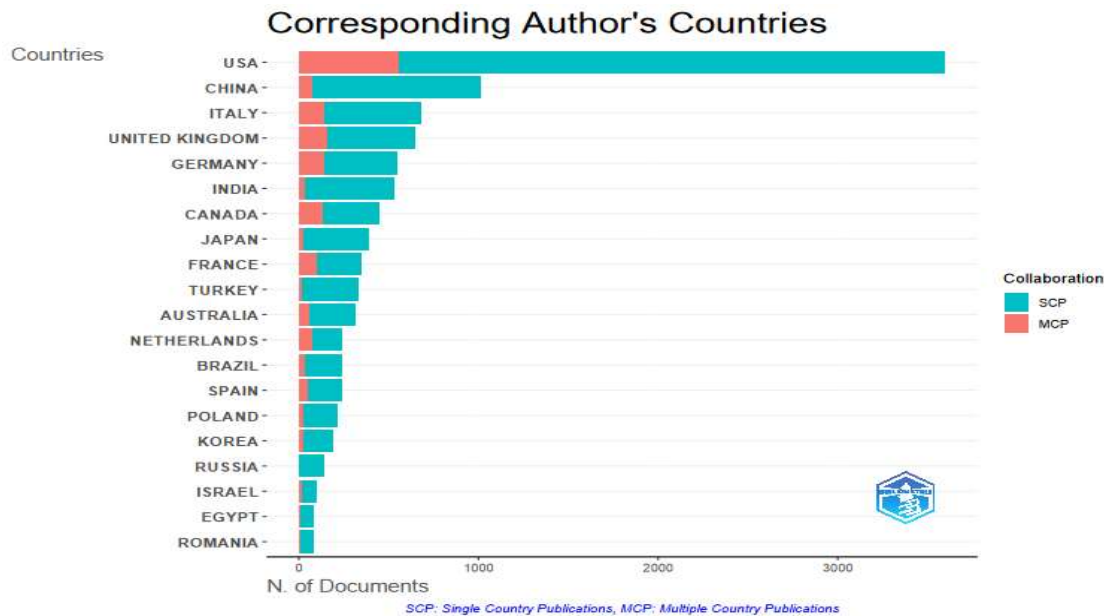


Figure 8: Corresponding author's countries

The analysis of the countries of the corresponding authors (Figure 8) provides insights into the geographical distribution of research output in the field and patterns of international collaboration. The results show that the research productivity is concentrated in few developed countries with significant contributions from North America, Europe and Asia. The United States leads the research field with 3,599 publications, making up 26.61% of the total output. The country also has the highest single country publications (SCP = 3,046) and 553 multi-country publications (MCP), indicating a strong domestic research capacity and a significant international collaboration. However, the percentage of MCP (15.37%) shows that a large part of the research is carried out in national institutions. The second position was occupied by China with 1,011 publications (7.48%), which indicates high research productivity. The country has a high number of single country publications (940) and relatively lower multi country collaborations (71) with an MCP percentage of 7.02%. This shows that research in the field is mainly domestically driven with low international collaboration in China. Italy (684 publications, 5.06%) and the United Kingdom (651 publications, 4.81%) are the most important European contributors. The MCP percentages of both countries are relatively high, i.e., 21.20% and 24.42%, respectively, which indicates there are stronger international collaborative networks than USA and China. Germany also contributes 545 publications (4.03%) with MCP percentage of 26.61% indicating a high level of multinational research collaboration. India is also a major contributor with 532 publications (3.93%). However, the percentage of MCP is relatively low (6.77%), with 496 single-country publications and only

36 multiple-country collaborations. This means that even though India produces a lot of research, international collaboration is still limited. Canada has 452 publications (3.34%), and a high MCP percentage (30.31%), showing high international collaboration. France shows a high MCP percentage of 27.84% with 352 publications and the Netherlands with 243 publications shows a high MCP percentage of 29.63% reflecting collaborative research networks across the countries. Japan (391 publications) and Turkey (329 publications) have relatively low percentages of MCP, 7.42% and 4.56%, respectively, suggesting that their research is mostly confined within their national boundaries. On the other hand, a high percentage of MCP is seen in Switzerland (54.43%), followed by Sweden (51.79%) and Belgium (40%), suggesting the active engagement of the international collaboration despite the relatively less number of publications. The analysis of the countries of the corresponding authors shows that the United States has a higher research output than China and other major European countries. Countries like the USA, China and India show high publication productivity but European countries and Canada show higher levels of international collaboration. The results indicate that the research domain is globally distributed with an upward trend in multinational collaboration, particularly between European countries and developed research economies.

4.10. Countries scientific production

Country Scientific Production

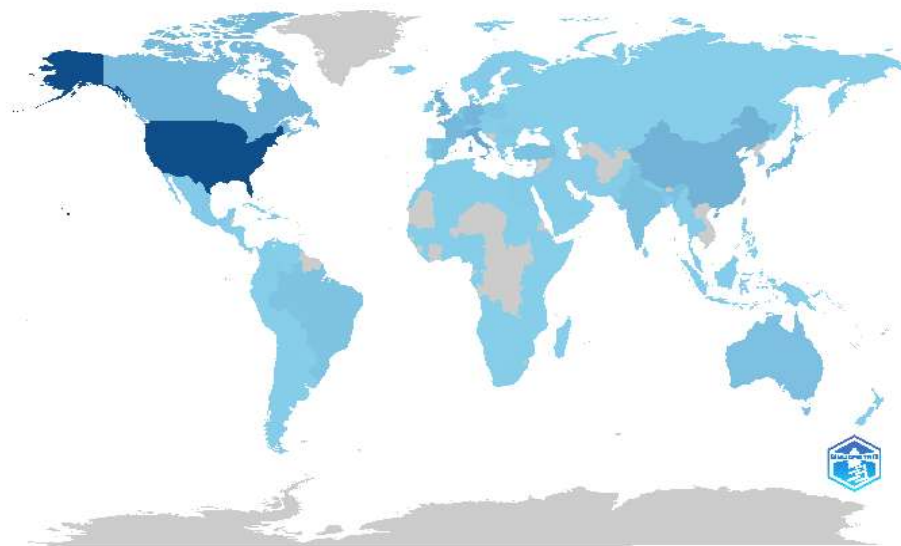


Figure 9: Country Scientific Production

The country scientific production analysis, as illustrated in Figure 9, presents the country-wise distribution of research output based on the authors' country affiliations. In this analysis, each country is counted by its appearance in the author affiliation, meaning that one article with authors from different countries contributes to the frequencies of all the countries involved. That is why the total frequency is often greater than the total number of documents. The United States leads the world in scientific output with 17,956 publications, a number that dwarfs the output of all other countries. This speaks to the robust research infrastructure, funding support and institutional collaboration the country has. Italy ranks second with 4,792 publications, followed by the United Kingdom (3,693), China (3,566) and Germany (3,152).

Together, these countries are the main contributors to the research area and indicate a strong dominance of Europe and North America. Asian countries also make a significant contribution, with Japan (2,706), India (1,607), South Korea (982) and Turkey (1,424) leading the way. This indicates India is producing more research, although it still lags behind the leading Western countries. The fact that India is among the top contributors shows that. China also has a strong research output reflecting increasing investment in scientific research. Other important contributors with a stable research activity are France (2,704), Canada (2,568), the Netherlands (1,855), Spain (1,854) and Australia (1,794). Emerging contributors such as Brazil (1,285) and Poland (1,050) are increasing their participation in the field. Moderate levels of scientific production are observed from Switzerland, Belgium, Sweden, Portugal, Austria, Israel and Greece indicating active, but relatively smaller research communities. There is an increasing global participation with a number of developing countries like Pakistan, Malaysia, Nigeria, Egypt and South Africa contributing to the literature. Analysis of scientific production in the country shows that the research output is mainly concentrated in the United States and European countries followed by contributions from Asia-Pacific regions. The broad distribution of countries in the dataset indicates the global research interest, while the dominance of a few countries suggests the scientific production in the field is mainly driven by developed research economies with good institutional support and collaborative networks.

4.11. Countries production over time

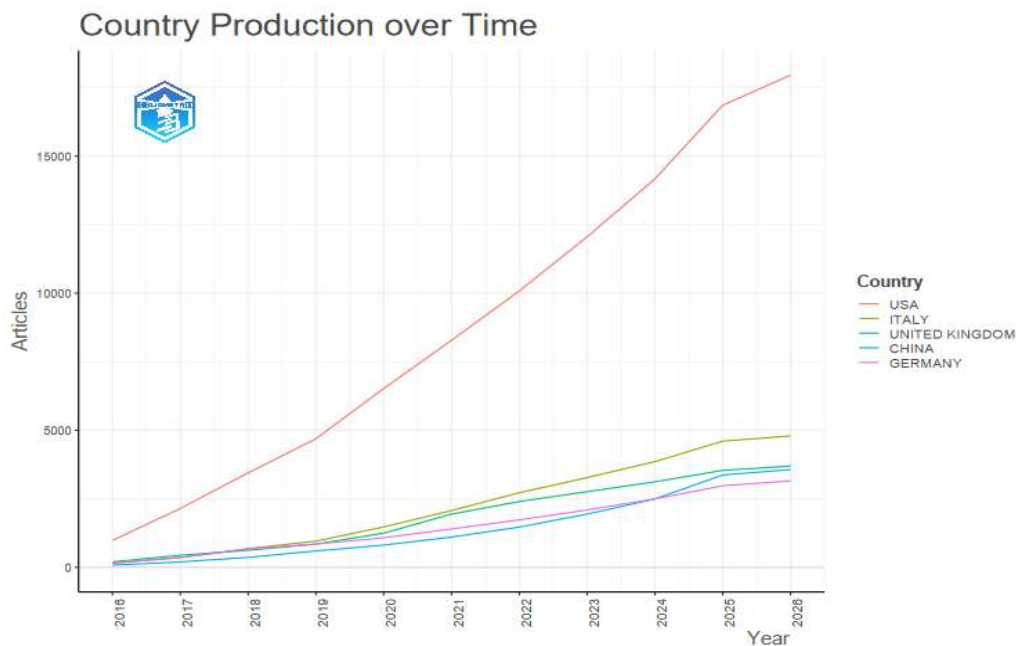


Figure 10: Country Production over time

The country production over time analysis (Figure 10) shows the growth in research output among the leading contributing countries during the study period from 2016 to 2026. The results show an overall and significant increase in publications in all the major countries indicating an increasing interest in research globally and increasing scholarly activity in the field. The United States shows the highest research productivity in the study period. The number of publications increased dramatically, from 981 in 2016 to 17,956 in 2026. A clear and steep increasing pattern is observed particularly after 2019 with the publications increasing from 4690 in 2019 to 10084 in 2022 and further to 17956 by 2026. The continuous growth is

a confirmation of the dominant role of the United States in the research field, manifested in a strong institutional support and collaborative networks. Italy is the second most productive country over time, with a remarkable increase from 150 publications in 2016 to 4792 publications in 2026. Between 2020 and 2025 a significant increase can be observed, pointing to an increasing research engagement and collaboration within European Institutions. Likewise, the United Kingdom shows consistent growth from 201 publications in 2016 to 3,693 publications in 2026, reflecting increasing research contributions and international collaborations. Germany also exhibits steady growth in scientific output, rising from 158 publications in 2016 to 3,152 publications in 2026. The trend shows a slow and steady increase in research activity. China has one of the fastest growth trajectories with publications increasing from 81 in 2016 to 3,566 in 2026. The rapid rise, especially post-2020, signals growth in research funding and global engagement. The country production analysis over time shows a strong upward trend in research output in all leading countries. The United States is dominant throughout the period, while Italy, the United Kingdom, Germany and China show considerable growth. The results show that international research activity, collaboration networks and global interest in the subject area are increasing over time.

4.12. Most cited countries

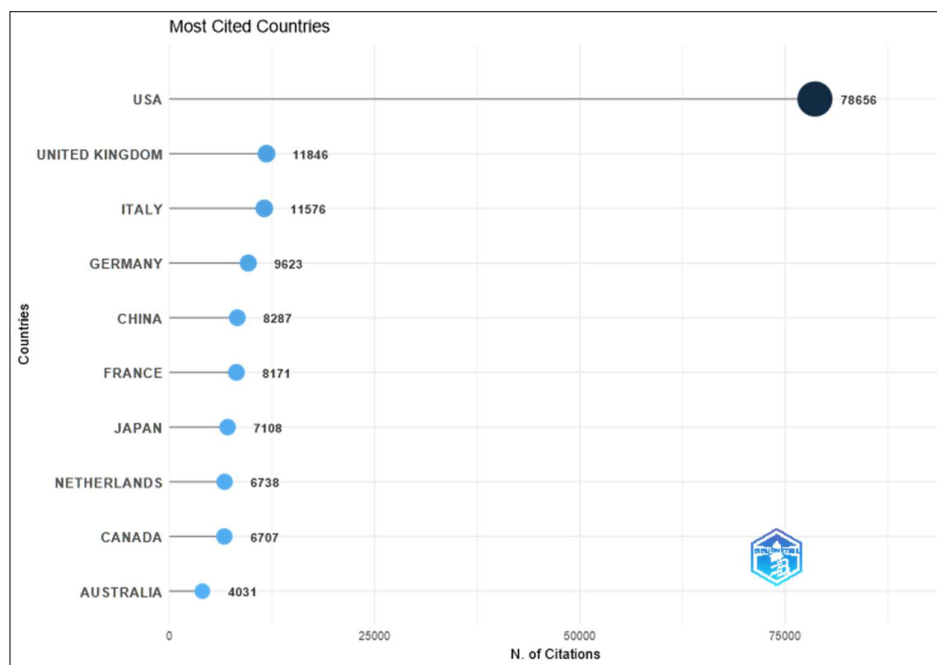


Figure 11: Most cited countries

The analysis of the most cited countries is shown in Figure 11. The scientific impact of countries is estimated based on the total citations (TC) received and the average citations per article. Total citations show the overall impact and average article citations show the quality and impact of publications of each country. Total citations = the total number of citations of the documents in the database. Average citations Average impact of citations per paper in scientometric analysis. The results show that the United States is ranked first, with 78,656 total citations and an average of 21.9 citations per article, indicating both high productivity and high global research influence. The United Kingdom (11,846 citations; 18.2 average citations) and Italy (11,576 citations; 16.9 average citations) are next with a great research impact. Germany

also exhibits good citation performance with 9.623 total citations and an average of 17.7 citations/article, which suggests a consistent quality of research. China has a total of 8287 citations but the average number of citations per publication is lower at 8.2 which indicates a large volume of publication with moderate citation impact. By contrast, France shows a strong research impact with a total number of citations of 8,171 and a higher average citation rate of 23.2. Japan has also made its presence felt with 7,108 citations and an average of 18.2 citations per article, suggesting a consistent scholarly impact. The Netherlands is one of the most influential countries in terms of citation quality, with a total of 6,738 citations and an average of 27.7 citations per article. For Belgium the total number of citations is lower but the average number of citations is even higher (29.4). This means that the publications are highly cited. Finland (20.6), Austria (19.9) and the Czech Republic (19.9) also show a high citation impact relative to their publication volume. Canada (6,707 citations; 14.8 average) and Australia (4,031 citations; 12.7 average) show a moderate, but steady, citation impact. Moderate total citations and average citation values ranging from 13 to 14 are also observed for similar citation patterns in Spain, Korea and Israel. India has a total of 2,746 citations with an average of 5.2 citations per article, showing increased participation but relatively lower citation impact. Similarly, Turkey (4.8), Brazil (5.4) and Poland (5.3) show moderate citation influence. A few countries with low publication numbers have very high average citation impact, such as Chad (41 average citations), Belgium (29.4) and the Netherlands (27.7). Such high averages are usually the result of a few highly cited publications which have a large effect on the overall citation impact. In general, analyzing the most cited countries, the United States is the leader in total citation impact, and European countries such as the Netherlands, Belgium, France and Finland have high average citation influence. The results suggest that some countries lead in the number of publications, while others have a greater impact with highly cited publications, indicating differences in research quality, collaboration and visibility of publications.

4.13. Most global cited document

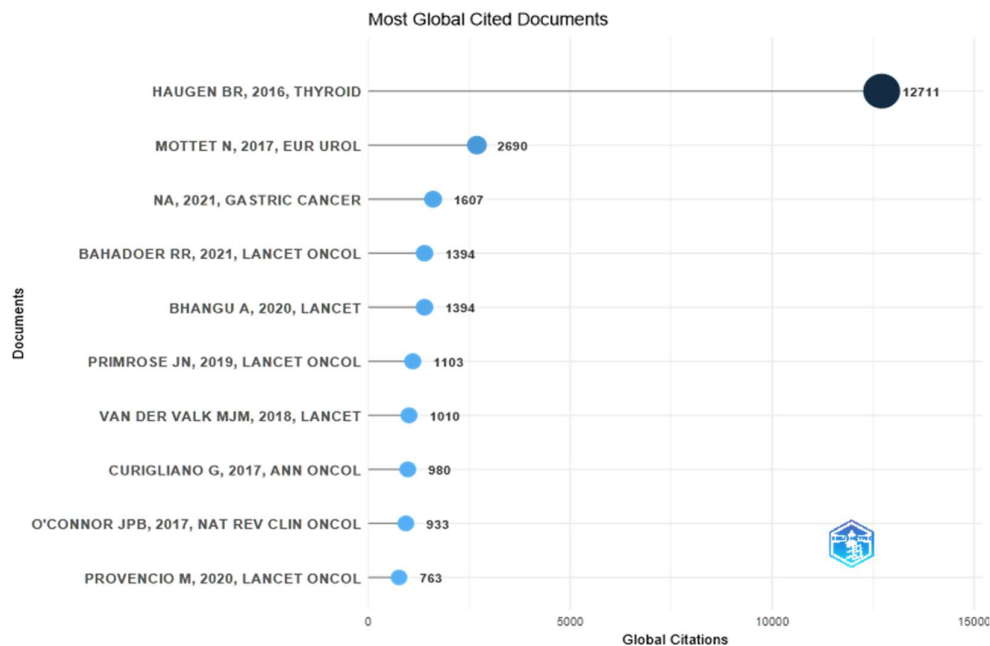


Figure 12: Most global cited document

The analysis of the most globally cited documents in Figure 12 shows the publications that have exerted the greatest scholarly impact in the research domain. Citation-based indicators, such as total citations (TC), citations per year and normalized citations, are useful in assessing the long-term impact as well as the recent importance of highly cited works. Haugen BR (2016) Thyroid 12,711 Total Citations: Highest among all documents The article by Haugen BR (2016) in Thyroid is the most cited paper. The paper also has 1,155.5 citations per year and a normalized citation score of 244.43, which indicates its outstanding global impact and enduring relevance over time. It seems to be a very general guideline/reference document, which is used as a reference in many subsequent publications. The second most cited document is the Mottet N (2017) European Urology with a total of 2,690 citations and 269 citations per year. The normalized citation score of 79.97 reflects a strong impact and continued relevance. Similarly, the 2021 article published in Gastric Cancer has 1,607 citations and a high citation rate of 267.8 per year, which shows rapid and recent scholarly influence. The article by Bahadoer RR (2021) published in Lancet Oncology has received 1,394 citations, with 232.3 citations per year and a normalized citation value of 82.61, indicating significant impact in a short time span. Another highly cited study by Bhangu A (2020) in The Lancet got 1394 citations, with 199.1 citations per year, indicating strong global recognition. Other highly cited documents are Primrose JN (2019) in Lancet Oncology with 1103 citations, Van der Valk MJM (2018) in The Lancet with 1010 citations and Curigliano G (2017) in Annals of Oncology with 980 citations. These publications have similar citation performance and are important for the development of the field. Other highly cited global documents include the works by O'Connor JPB (2017) in Nature Reviews Clinical Oncology (n=933) and Provencio M (2020) in Lancet Oncology (n=763). The high citations/year indicate that they are still relevant and influential in recent research. The most cited documents worldwide are mainly published in high-impact journals, including the Lancet, Lancet Oncology, European Urology, Annals of Oncology, and Nature Reviews Clinical Oncology. The prominence of these journals suggests that clinical guidelines, multicentre trials and large-scale oncology studies are the major drivers of highly cited research in the field. These high citation values normalized also show that these documents are important references that have an impact on later research in the field.

4.14. Most frequent words

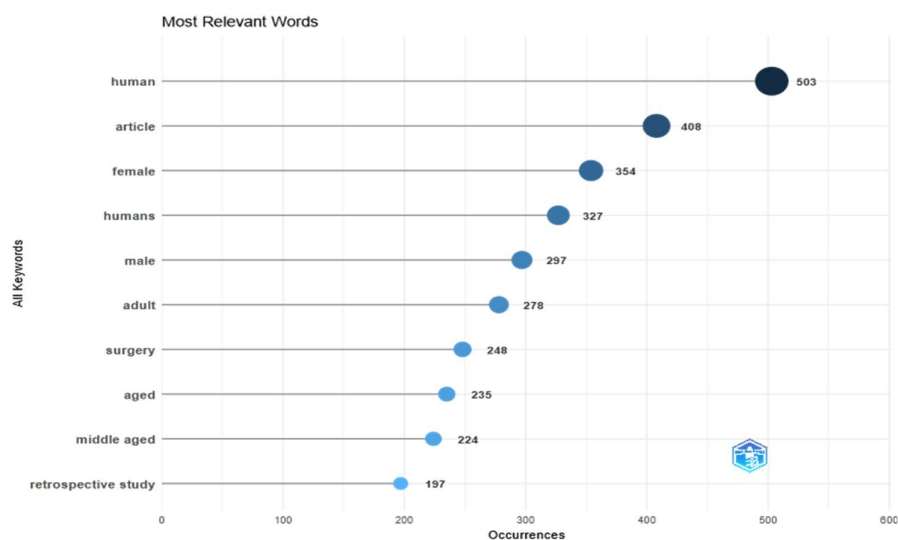


Figure 13: Most relevant words

To identify the latest research trends in the domain, the analysis in figure 13 represented the most relevant words was performed on publications from 2026 (up to April). Restricting the data set to 2026 will enable us to see the emerging topics and the current focus of recent studies, not the thematic patterns in the long term. The results indicate that the most frequent word is “human” (503 times), then “article” (408), “female” (354) and “humans” (327). The importance of this term means that the emphasis on human-based clinical investigations still exists in recent research in 2026. The high frequency of demographic descriptors such as “male” (297), “adult” (278), “aged” (235) and “middle aged” (224) suggests that current research is largely focused on adult and aging populations. The presence of clinical and methodological terms such as “surgery” (248 occurrences) and “retrospective study” (197 occurrences) further highlights the focus of the present research. The high frequency of “surgery” suggests that surgical interventions are still an important subject in recent publications, while the presence of “retrospective study” indicates that retrospective clinical analysis is often applied in current research. As the analysis is based solely on 2026 publications, the identified words are indicative of the recent research focus, emerging themes, and current keyword trends rather than the overall thematic structure of the entire study period (2016–2026). This approach allows to capture the latest trend of research activity in the field.

4.15. Wordcloud



Figure 14: Wordcloud

To identify the latest and emerging research themes in the domain, the word cloud analysis was generated using publications from 2026 (up to April) (Figure 14). The word cloud shows the current research focus as the dataset is limited to 2026 and not long-term trends over the whole study period. The largest words in the word cloud are “human” (503 times), “article” (408), “female” (354), “humans” (327), and “male” (297). This indicates that recent publications are mostly about human-based clinical research with demographic considerations. Age-related descriptors such as “adult” (278), “aged” (235) and “middle aged” (224) support the fact that the majority of studies conducted to date are in adult and elderly populations. The current focus of research is on surgical procedures, clinical assessment and retrospective studies as indicated by the terms 'surgery' (248), 'retrospective study' (197), 'major clinical study' (179), 'pathology' (161) and 'procedures' (153). The presence of “cohort analysis” (137), “controlled study” (136) and “clinical trial” (52) indicates the use of different clinical research designs in active publications. The focus of recent research is clearly on cancer-related investigations as indicated by oncology-related terms such as “oncology” (132), “surgical oncology” (132), “cancer surgery” (88), “cancer staging” (82), and “cancer patient” (51). Keywords related to

outcomes such as “overall survival” (86), “treatment outcome” (80), “clinical outcome” (77), “mortality” (97), and “survival rate” (49) suggest a focus on prognosis and treatment efficacy. Diagnostic and imaging-related terms such as “nuclear magnetic resonance imaging” (75), “histopathology” (67), “computer assisted tomography” (58), and “diagnostic imaging” (50) indicate the importance of diagnostic procedures in current studies. Also, treatment-related terms such as “therapy” (80), “drug therapy” (48), “antineoplastic agent” (51), and “postoperative complication” (75) suggest a focus on therapeutic interventions and patient management. The identified terms in the word cloud reflect current research focus, emerging topics, and recent keyword trends, as the word cloud is based on only 2026 publications. The results presented here are indicative of the recent direction of research activity, not the general thematic structure of the entire study period (2016–2026).

4.16. Co-occurrence network

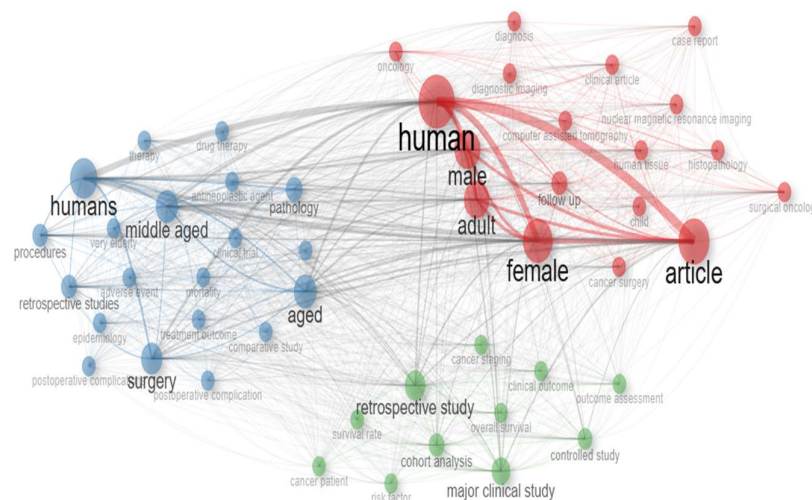


Figure 15: Co-occurrence network

Figure 15 shows the co-occurrence network generated through the Biblioshiny conceptual structure (network approach) was constructed using publications from 2026 (up to April) to identify the latest conceptual structure and emerging research themes in the domain. By limiting the analysis to 2026 data, the network reflects current research focus rather than long-term thematic patterns across the entire study period. The analysis produced three major clusters, indicating that recent literature in 2026 is organized around clinical-demographic characteristics, treatment and procedural aspects, and outcome-based clinical research.

Cluster 1 represents the largest and most central thematic group, dominated by terms such as “human,” “article,” “female,” “male,” and “adult,” which show high centrality values. These keywords indicate that recent research primarily focuses on human-based clinical studies with demographic segmentation. Other terms such as “oncology,” “surgical oncology,” “histopathology,” “diagnostic imaging,” and “cancer surgery” suggest that today studies are more often in the realm of diagnostic and clinical investigation of cancer-related conditions. The presence of imaging-related terms such as “nuclear magnetic resonance imaging” and “computer assisted tomography” also highlights the importance of diagnostic technologies in recent publications.

Cluster 2 is linked to recent studies on treatment procedures and patient management. Current research is focused on therapeutic approaches, as shown by the keywords: surgery, therapy,

drug therapy, antineoplastic agent and treatment outcome. The demographic descriptors “aged,” “middle aged,” and “very elderly” imply that recent research has investigated the efficacy of treatment across various age groups. Other terms such as “postoperative complication”, “mortality” and “adverse event” were also present, indicating that recent publications are aimed at evaluating the safety of treatments and clinical outcomes.

Cluster 3 consists of outcome-oriented and survival-oriented research topics and contains 2026 publications. The keywords used in research designs are “retrospective study,” “cohort analysis,” “controlled study,” and “major clinical study.” Terms related to “overall survival”, “survival rate”, “clinical outcome” and “risk factor” suggest that prognosis and treatment efficacy have been the focus of recent research. The terms “cancer staging” and “cancer patient” also imply an emphasis on disease progression and survival analysis.

Overall, the co-occurrence network based on 2026 publications reveals that current research is structured around three interconnected themes: clinical-demographic characterization and diagnostic approaches, treatment and procedural interventions, and outcome-based clinical evaluation. Since the analysis uses only 2026 data, these clusters represent recent conceptual trends and emerging research directions rather than the overall conceptual structure of the entire study period.

4.17 Data Validation and Interpretation Note

The bibliometric outputs were interpreted according to the counting conventions used by Biblioshiny. Corresponding-author country statistics and country scientific production represent different counting approaches. Corresponding-author analysis assigns a publication according to the country of the corresponding author, whereas country scientific production counts the appearance of countries in author affiliations; therefore, a single publication may contribute to more than one country in the latter analysis and country frequencies can exceed the total number of documents. Affiliation counts should likewise be interpreted as database-derived publication frequencies rather than mutually exclusive institutional totals. Citation indicators are sensitive to publication age, so recent publications, especially those from 2025 and 2026, should not be compared directly with older publications without considering their shorter citation windows.

5. FINDINGS AND SUGGESTIONS

A quantitative analysis of the surgical oncology literature spanning the 2016–2026 period identified 13,525 research articles, distributed across 2,225 distinct sources. This corpus serves as the primary dataset for our longitudinal analysis of publication trends and scientific impact. This means that the research was widely published across the medical field. The annual scientific production showed a general increase, from 675 publications in 2016 to a maximum of 1986 articles in 2025. Note that the relatively low number of publications in 2026 (671 articles) is due to the incompleteness of data only available until April 2026. The average number of citations per document was 14.53 and the average document age was 4.42 years, indicating a moderate citation impact. The analysis of authorship shows a strong collaborative nature, with 84,947 authors contributing to the dataset and an average of 10.1 co-authors per document; single-authored publications are rare.

The most productive authors in the field were Zhang Y, Wang Y, Li Y, Scambia G, and Liu Y, according to the number of publications. Scambia G achieved the highest h-index, with Fagotti A and Schouli J following, indicating the greatest academic influence within this field. Lotka's Law was also used in the analysis of author productivity, where most authors published one

paper, and a small group of researchers published multiple papers, indicating a core group of highly active authors.

Institutional analysis indicated that Memorial Sloan Kettering Cancer Center was the most productive affiliation, followed by Mayo Clinic, Harvard Medical School, University of California, and University of Toronto. These are all top cancer research centers and medical universities and emphasize the dominance of the specialized oncology institutions in the field. The country-wise analysis showed that the United States was the most productive in terms of scientific output and citation impact, followed by Italy, the United Kingdom, China, and Germany. The country production over time analysis also showed a steady growth in publications from these leading countries, indicating an increasing global contribution. The country analysis of the corresponding authors also showed that while the United States dominated research output, several European countries had higher international collaboration rates.

The citation analysis showed that the most cited document in the world was Haugen BR (2016) followed by Mottet N (2017) and Bahadoer RR (2021). The highly cited papers were mainly clinical guidelines and large-scale oncology studies. Country citation impact showed that the United States had the highest total citations, and countries such as the Netherlands, Belgium and France had high average citations per article, indicating strong research influence. In the recent research trends in surgical oncology were identified by the keyword analysis of 2026 publications. The most important words were human, female, male, adult and surgery, indicating that the focus was on human clinical studies. Word cloud analysis showed the most common themes were related to oncology, surgical procedures, survival and treatment outcomes. The co-occurrence network analysis revealed three major thematic clusters representing clinical-demographic studies, treatment and surgical interventions and outcome-based survival analysis. The results indicate that recent research in surgical oncology is predominantly related to clinical management, diagnostic evaluation and patient outcome assessment.

5.1. Suggestions

- 1) International collaboration in surgical oncology research should be strengthened, particularly involving developing countries, to promote multicenter clinical studies and improve the global applicability of research findings.
- 2) Greater interdisciplinary collaboration among surgeons, oncologists, radiologists, and pathologists is recommended to enhance research on diagnostic techniques, treatment outcomes, and survival analysis.
- 3) Institutions with lower research output may improve productivity through collaborative partnerships with leading cancer research centers and participation in large-scale clinical trials.
- 4) Future research should focus more on prospective studies, randomized clinical trials, and long-term survival analysis to strengthen evidence-based practices in surgical oncology.
- 5) Further studies may incorporate multiple databases and extended time periods to provide a more comprehensive understanding of evolving research trends in surgical oncology.

5.2. Limitations of the Study

This study has several limitations. First, the analysis is based exclusively on Scopus records and therefore does not capture publications indexed only in other databases such as Web of Science, PubMed, or Dimensions. Second, the search was based on the term “surgical oncology” in the TITLE-ABS-KEY field and may omit relevant studies that address surgical cancer care without using this specific expression. Third, the 2026 dataset is incomplete because it includes records indexed only through April 2026; consequently, annual publication and citation figures for 2026 should not be interpreted as a full-year estimate. Fourth, citation-based indicators are influenced by publication age, field practices, database coverage, and highly cited individual documents. Fifth, country and affiliation measures depend on the counting conventions used by the bibliometric software, and multi-country or multi-affiliation publications may contribute to several categories. Finally, keyword and co-occurrence analyses identify patterns in indexed terminology and should be interpreted as representations of the research corpus rather than direct measures of clinical importance or research quality.

6. CONCLUSION

The present scientometric study was conducted to analyze the research landscape of surgical oncology in the period 2016–2026 based on the data extracted from the Scopus database and analyzed with Biblioshiny in RStudio. The results show a constant growth of the scientific production, which indicates an increasing interest of the investigators in this area. Highly collaborative authorship patterns were also found, with contributions mostly from leading cancer research institutions and developed countries, notably the United States and major European countries. Through citation analysis, the most influential publications that have shaped clinical practice and research directions in surgical oncology were identified. The data of 2026 keyword analyses showed the recent research focus on human clinical studies, surgical procedures, diagnostic imaging and survival outcomes. The conceptual structure also showed that the present research is predominantly focused on treatment strategies, clinical evaluation and outcome-based investigations. In summary, the study provides a comprehensive overview of the publication trends, major contributors and emerging themes, offering useful insights into the evolving research directions in surgical oncology.

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