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REVIEW

Robotic surgery across Latin America: a bibliometric analysis of research trends from 2009 to 2022

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Abstract

The rise of robotic surgery throughout the world, particularly in Latin America, justifies an objective evaluation of research in this field. This study aimed to use bibliometric techniques to identify the research trends and patterns of robotic surgery in Latin America. The research strategy used the terms "Robotic," "Surgery," and the name of all the Latin American countries, in all fields and collections of Web of Science database. Only original articles published between 2009 and 2022 were included. The software Rayyan, Bibliometric in the R Studio, and VOSViewer were used to develop the analyses. After screening, 96 articles were included from 60 different journals. There was a 22.51% annual increase in the scientific production of robotic surgery in the period studied. The more frequent topics by specialty were: Urology (35.4%), General Surgery (34.4%), and Obstetrics and Gynecology (12%). International cooperation was observed in 65.62% of the studies. The Latin American institution with the highest production of manuscripts was the Pontificia Universidad Católica de Chile. Mexico, Chile, and Brazil were, in descending order, the nations with the highest number of corresponding authors and total citations. When considering the total number of articles, Brazil ranked ahead of Chile. Scientific production regarding robotic surgery in Latin America has experienced accelerated growth since its beginning, supported by the high degree of collaboration with leading countries in the field.

Keywords Robotic surgery · Bibliometric analysis · Latin America

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Introduction

Robotic surgery (RS) uses specialized technology that enhances the capabilities of the surgeon to perform a minimally invasive procedure with the most resemblance to open techniques but with numerous ergonomic advantages over traditional laparoscopy. It allows surgeons to perform operations in hard-to-reach areas through small incisions beyond laparoscopic surgery. The specialized technology also enables precise movements and enhanced magnification. It facilitates many types of complex procedures with more precision, flexibility and control than conventional techniques [1]. This is possible due to high-definition, magnified, 3D views of the surgical site, and instrument ergonomic. The benefits of robotic surgery include lesser complications, such as surgical site infection, less pain and blood loss, shorter hospital stay and quicker recovery, and smaller, less noticeable scars [2].

The idea of robotics used for surgery emerged more than 50 years ago, but actual use began in the late 1980s with Robodoc (Integrated Surgical Systems, Sacramento, CA), the orthopedic image-guided system, for prosthetic hip replacement. Meanwhile, a urologic robot for prostate surgery was developed. In addition, there were a number of computer-assisted systems being used in neurosurgery (called stereotactic) and otolaryngology. These were procedure-specific, computer-assisted, and image-guided systems proving the potential and value of robotic surgery systems. They also heralded the multipurpose teleoperated robotic systems initially developed by SRI International and the Defense Advanced Research Projects Agency and led to the surgeon-controlled (multifunctional) robotic telepresence surgery systems [3].

The first robotic cholecystectomy worldwide was performed by the Belgian surgeon Jacques Himpens in 1997 [4]. The first laparoscopic cholecystectomy in Latin America was performed in 1990 in Mexico and the da Vinci system was acquired in the region in 2005, at the Clínicas Hospital in Argentina, where a robotic Heller procedure was performed in a patient suffering from achalasia [5].

By 2021, over 50% of RS systems in Latin America were acquired in the previous 5 years, and almost 30% of it in the last year and a half [6]. According to the analysis by Global Health Intelligence: the da Vinci system holds 85% of the market share in Latin America, while Cyberknife and Rosa control 10 and 5%. Over 80% of robotic surgical systems in Latin America belong to the private healthcare sector. In October 2021, the analysis from Global Health Intelligence shows that over 130 medical institutions in Latin America (both private and public) have robotic surgery systems, with over 150 robotic platforms in the region [6].

While the rise of robotic surgery in Latin America is evident, the evaluation and impact assessment of research in this field are equally important. Bibliometric analysis offers a quantitative approach to assess the quality and influence of scholarly research. Various parameter can be measured such as the number of citations, author productivity, and collaborative networks. It provides insights into the impact of publications, authors, and institution. Bibliometric studies in robotic surgery indicate that the USA have the highest number of publications, followed by China, and Italy [7]. Yet, this type of study has not been conducted in Latin America for the specific and relevant topic of robotic surgery in the region. This study aims to use bibliometric techniques to identify local research trends and patterns of robotic surgery in the Latin American countries.

Materials and methods

A bibliometric analysis of original articles published by authors with Latin American affiliation in journals indexed in Web of Science (WOS) was carried out.

Search strategy

The search strategy involved the name of Latin American countries and keywords for robotic surgery in all fields and collections of WOS database (1997), resulting in the following: ALL = ("Latin America" OR "Argentina" OR "Bolivia" OR "Brasil" OR "Chile" OR "Colombia" OR "Costa Rica" OR "Cuba" OR "Ecuador" OR "El Salvador" OR "Guatemala" OR "Haiti" OR "Honduras" OR "Mexico" OR "Nicaragua" OR "Panama" OR "Paraguay" OR "Peru" OR "Puerto Rico" OR "Dominican Republic" OR "Uruguay" OR "Venezuela") AND ALL = (("Robotic" OR "robot") AND ("Surgery" OR "Surgical Procedures")). It aimed to retrieve studies where the patients, institution, or main author were Latin American, and not simply collaborator. It was conducted on August 15, 2023 and the data analysis finished on September 1st, 2023.

Selection of articles

The metadata of the identified records were downloaded as.ciw files. Subsequently, they were imported into the Rayyan web application, for the review process. The titles, abstracts, and authors of each record were examined to determine if they met the inclusion criteria: original articles published between 2009, when the first year's original article with a Latin American affiliation was published, and 2022, as the year 2023 was still ongoing; with at least one author affiliated with a Latin American institution. Any records that did not meet these criteria were excluded. The WOS "Accession Number" was extracted from each excluded record to remove them from the initial search and to set the final records.

Bibliometric analysis

Bibliometric indices were obtained using the Bibliometrix package in the R programming language [8]. Similarly, the VOS viewer software version 1.6.17 from Leiden University in the Netherlands was utilized to develop bibliometric networks based on co-authorship [9]. This analysis involved considering bibliometric indicators such as number of articles and journals, annual growth rate, average number of articles published per year, average number of citations per document, most cited articles, most relevant topics, scientific production by authors, journals and countries, average number of authors per article, international cooperation, affiliations and keywords.

Prior to the network analysis, a manual standardization of the data was conducted for the author, institutional affiliation, and keywords fields. The aim was to eliminate redundancies and inconsistencies by creating thesauruses in.txt format, following the two-column format (label and replace by) as specified in the VOSviewer version 1.6.17 software manual [10]. In addition, Microsoft Excel was employed to create tables and graphs for data presentation.

Papers analyzed were classified according to Bradford's Law. Related zones are indicative of their utility in a certain field. Journals or sources in Zone 1 are associated with the highest productivity within robotic surgery and would represent "the core" of the literature [11].

Statistical analysis

Data were collected and collated on Excel (Microsoft, United States). Statistical analysis was completed using IBM SPSS Statistics (IBM, United States). The R2 value (coefficient of determination) was used to determine how well the data fit the regression model of the growth line in the scientific production.

Results

The search strategy resulted in 390 articles, out of which 96 were included after the screening process from a total of 60 different journals. There was a 22.51% annual increase in the scientific production of RS in Latin America between 2009 and 2022, with an average of 4.82 original articles published per year. The highest production year was 2021, with 20 original articles. Furthermore, a second-degree polynomial trend was observed in the publications between 2009 and 2022, with an R-squared value of 0.68. This indicates a moderate correlation between the year and the number of publications in the field of RS during that time period (Fig. 1), with an estimation of 24 original articles published in 2027.

The predominant language of publications was English (90.6%) compared to Spanish. The average number of citations per document was 25.73. The most cited article was a clinical trial conducted by Ramirez et al., published in the New England Journal of Medicine in 2018. The article, titled "Minimally Invasive versus Abdominal Radical Hysterectomy for Cervical Cancer" received a total of 1002 citations and 167 citations per year at the moment of research. A detailed list of the top 10 most cited articles can be found in Table 1.

The most relevant topics within the articles analyzed are presented in Table 2.

The journal Actas Urológicas Españolas had the highest number of articles published by Latin American authors in the last 13 years, with a total of 7 publications. The International Brazilian Journal of Urology was the first Latin American journal with 3 publications. Overall, 57.3% of the articles were published in journals originating from the USA, with the United Kingdom accounting for 11.5%. In contrast, a mere 7.3% of the articles found publication in Latin American journals. The distribution by Bradford's Classification of all journals is shown in Table 3.

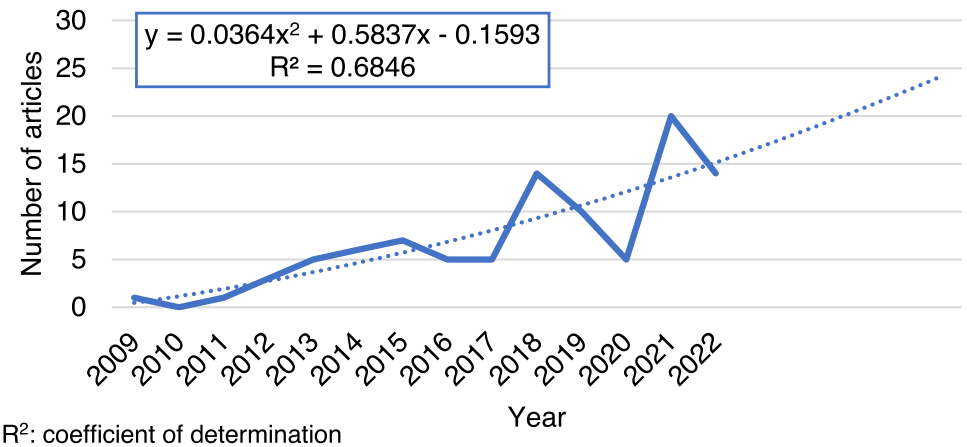

Fig. 1 Scientific production in robotic surgery in Latin American 2009–2022

Table 1 Most cited articles in robotic surgery by Latin American authors in 2009–2022

Manuscript title. DOI	Author, year, journal	Total citations
Minimally invasive versus abdominal radical hysterectomy for cervical cancer. https://doi.org/10.1056/NEJMoa1806395	Ramirez PT, 2018, New Engl J Med	1002
Laparoendoscopic single-site surgery: initial hundred patients. https://doi.org/10.1016/j.urology.2009.02.083	Desai MM, 2009, Urology	239
Perioperative outcomes of robotic and laparoscopic simple prostatectomy: a European-American multi-institutional analysis. https://doi.org/10.1016/j.eururo.2014.11.044	Autorino R, 2015, Eur Urol	104
The learning curve associated with robotic total knee arthroplasty. https://doi.org/10.1055/s-0037–1608809	Sodhi N, 2018, J Knee Surg	92
Robotic bronchoscopy for diagnosis of suspected lung cancer: a Feasibility study. https://doi.org/10.1097/LBR.0000000000000499	Rojas-Solano JR, 2018, J Bronchol Intern PU	72
Radical trachelectomy in early-stage cervical cancer: a comparison of laparotomy and minimally invasive surgery. https://doi.org/10.1016/j.ygyno.2015.06.023	Vieira MA, 2015, Gynecol Oncol	60
Robotic versus laparoscopic adrenalectomy: a comparative study in a high-volume center. https://doi.org/10.1007/s00464-012–2496-9	Pineda-Solis K, 2013, Surg Endosc	47
Advantages of robotic right colectomy with intracorporeal anastomosis. https://doi.org/10.1097/SLE.0000000000000384	Lujan HJ, 2018, Surg Laparo Endo Per	46
Effects of robotic manipulators on movements of novices and surgeons. https://doi.org/10.1007/s00464-014–3446-5	Nisky I, 2014, Surg Endosc	45
Faster return to sport after robotic-assisted lateral unicompartmental knee arthroplasty: a comparative study. https://doi.org/10.1007/s00402-018–3042-6	Canetti R, 2018, Arch Orthop Traum Su	44

The selected studies had an average of 9.53 authors per article. International cooperation in co-authorship was observed in 65.62% of the cases. The authors with the highest scientific production were Castillo and Ramirez, each of them with 6 documents. Ramirez was affiliated with The University of Texas MD Anderson Cancer Center and Castillo with INDISA Clinic from Santiago, Chile.

There were 313 affiliations, of which The University of Texas MD Anderson Cancer Center was the most frequently reported in the articles. Among Latin American institutions, the Pontificia Universidad Católica de Chile had the highest production with 7 articles affiliated, followed by Universidad Andrés Bello, also from Chile, and Dr. Manuel Gea González General Hospital from Mexico. Figure 2 shows sources in Latin America and from the rest of the world. The density of the main affiliations and the collaboration networks between them can be observed in Fig. 3.

Mexico, Chile, and Brazil were, in descending order, the Latin American countries with the highest number of corresponding authors counting nine, eight and six authors, respectively. In addition, they had the highest number of articles' citations with 110, 47, and 40 citations, respectively. On the other hand, when considering the overall number of articles, Brazil ranks ahead of Chile, the distribution of scientific production by country in the region was also analyzed, as shown in Fig. 4.

Foreign countries with the highest collaboration authors were, in descending order: the United States of America, France, and Italy. A total of 570 keywords were identified. After setting thesauri and establishing a minimum occurrence of 5, the predominant keywords were "outcomes", "robotic surgery", "surgery", "laparoscopy", and "experience".

Discussion

The present study aimed to determine the Latin American scientific production in robotic surgery since its beginnings from a bibliometric analysis perspective. Such endeavor has not been performed before despite the great potential for the development and expansion of this technology in the region. Unlike prior analyses that have only considered the most relevant articles or focused on certain specialties [12, 13], this study aimed to provide a more comprehensive evaluation across all specialties relevant to the use of robotic surgery in Latin America.

Growth rate of scientific production

An increase in the number of original articles from the authors with Latin American affiliation was observed throughout the study period as time progressed, with the highest production occurring in 2021. The rising trend in the region clearly aligns with the global trend, in which

Table 2 Common topics in robotic surgery articles from Latin American institutions

Topic by specialty	*n* (%)
Urology and nephrology	31 (32.3)
General surgery	21 (21.9)
Obstetrics and gynecology oncology	6 (6.3)
Medicine, general and internal	5 (5.2)
Orthopedics surgery	5 (5.2)
Obstetrics and gynecology	4 (4.2)
Gastroenterology and hepatology	3 (3.1)
Cardiac and cardiovascular systems	2 (2.1)
Gastroenterology and hepatology	2 (2.1)
Otorhinolaryngology	2 (2.1)

United States has been consistently the undisputed leader over the years [14, 15]. However, Latin America has exhibited a faster growth rate compared to the United States over the past 5 years, with 22.5% versus 5.6%, respectively, according to a preliminary analysis conducted by this group of authors corresponding to unpublished data which followed a similar methodology, a Web of Science-based bibliometric analysis but focused on the USA.

Table 3 Distribution of Bradford's classification for scientific journals publishing articles related to robotic surgery from Latin American institutions

Category	*n* (%)
Zone 1	8 (13)
Zone 2	21 (35)
Zone 3	31 (52)
Zone 4	0 (0)

Distribution by specialties

Urology remains the predominant specialty within robotic surgery outcomes research [7], even within Pediatric Surgery [16], although other specialties such as Gynecology and Obstetrics have been noted as some of the most common in broader analyses encompassing all fields [17], In this study, Urology, General Surgery, and Obstetrics and Gynecology were the three most common specialties. The most cited article belonged to the field of Obstetrics and Gynecology, published in a non-specialty journal with multiple authors from different parts of Latin America, reflecting its international reach and collaborative efforts.

Other specialties studied in previous bibliometric analyses, such as spinal surgery [18] or robot-assisted arthroplasty [19] were not significantly represented in the region. Meanwhile, scientific production in pediatric robotic surgery, well documented in Cundy et al.'s analysis [20], constitutes only 3.1% of the registered original articles.

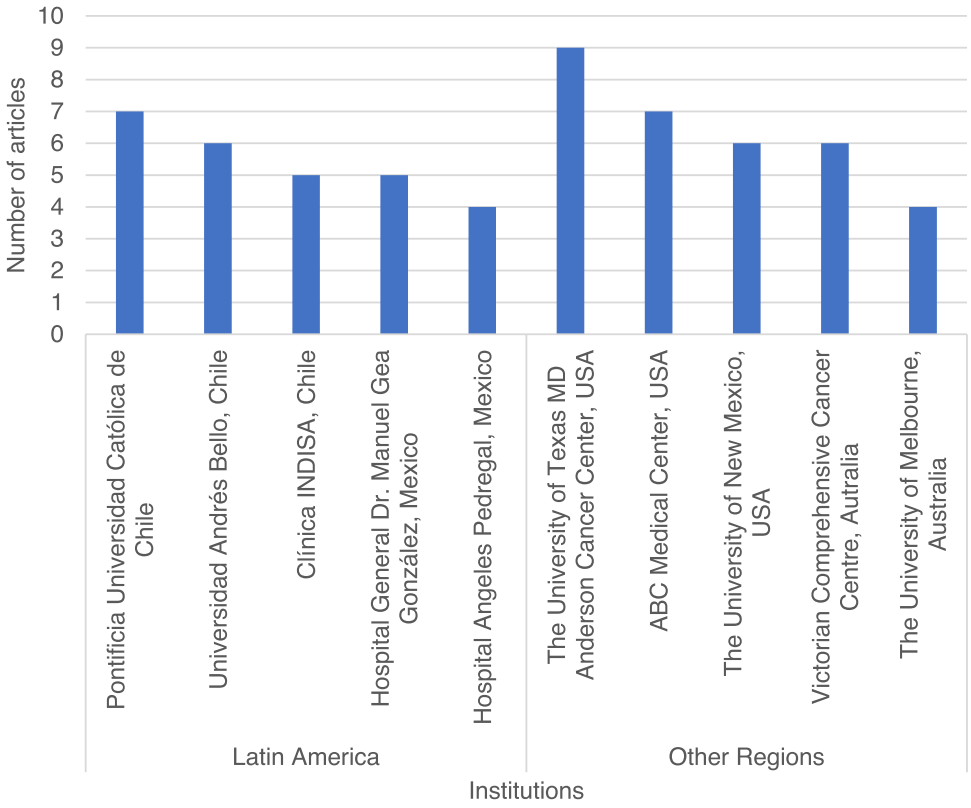

Fig. 2 Most common global regional affiliations in robotic surgery research by Latin American authors in 2009–2022

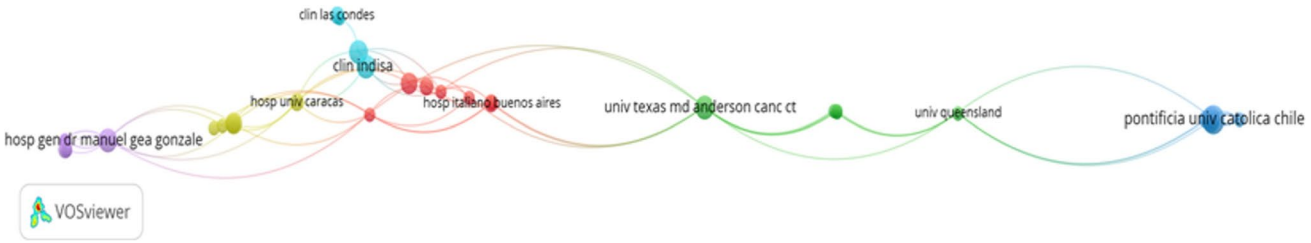

Fig. 3 Affiliations network in robotic surgery research by Latin American authors in 2009–2022

Scientific journals

Interestingly, the journal with the highest number of articles related robotic surgery in Latin America is European, particularly from Spain, likely due to historical ties and a shared language. The Latin American journal with most articles was from Brazil. Both journals are oriented towards Urology, reflecting the predominance of this subspecialty in the field. It is worth mentioning that local production related to robotic surgery tends to be directed towards specialized journals. This differs from what was reported by Brandt et al. in their bibliometric analysis of Top-Cited Journal Articles in Obstetrics and Gynecology, where 64.1% were published in non-specialty journals [21]. It was also intriguing to observe that more than two-thirds of the analyzed articles were published in journals from the United States and Great Britain, rather than in local journals, which represented a minority at 7.3% of the total. This trend could be attributed to various factors, including authors' pursuit of higher impact journals to disseminate their research for greater visibility. This is particularly noteworthy considering that English-language journals tend to have higher impact factors compared to non-English-language journals, as demonstrated in studies such as the one conducted by Vinther et al., which analyzed all journals classified as "medicine" over a 10-year period [22].

In a previous global bibliometric analysis of robotic surgery from 2001 to 2021 [7], when sources were clustered using Bradford's Law, only 2.39% ($n = 21$ sources) were in Zone 1, while in this analysis 13% were in Zone 1 most likely because only original articles were considered in this analysis, which would have had a greater impact.

Institutional and country affiliations and collaborations

In Musbahi et al.'s analysis of over 20 years of history in global robotic surgery research, on average, there were 3.48 authors and 5.05 co-authors per document [7], However, in Latin America, the average number of authors per article was 9.53, reflecting a possibly higher degree of collaboration. Furthermore, the primary affiliation was The University of Texas MD Anderson Cancer Center. This observation underscores the strong academic ties that Latin American maintains with the rest of the world, particularly with the United States, the leading country in robotic surgery and the first country collaborating with the region. This was followed by France, and Italy, which rank third and sixth in terms of global scientific production, as reported by Musbani et al. [7]. Interestingly, from the top five international institutions with more collaboration with the regions, two are from Australia, ninth in the ranking. Other global leaders such as China, second in the ranking, make little contribution to Latin American research in this field and did not have extensive collaboration with the region. These findings highlight the significant contributions from international collaborations, emphasizing the importance of global scientific partnerships in advancing research and knowledge dissemination.

Mexico leads the region in scientific production, boasting the highest number of publications and citations among all Latin American countries, surpassing Brazil, which held the top position in the region according to records from 2015 [14]. By September 2015, Brazil had 16 robotic units, contrasting with Mexico's seven units [23]. Mexico's predominance in terms of scientific production may be attributed to its longer experience with robotic systems, since Mexico initiated robotic-assisted laparoscopic surgery with AESOP 1000 in 1996 [24], while in Brazil, the first robotic system was acquired in 2007 at Albert Einstein Hospital, with the first robotic General Surgery program established in 2008 [25].

The General Hospital Doctor Manuel Gea González, which is among the top five most productive Latin American institutions in terms of robotic surgery research, was the first public center to introduce Robotic Surgery in Mexico [26]. At that center, surgical procedures initially started with urological interventions and then expanded their scope to encompass General Surgery [27].

Chile, on the other hand, secures the third position in terms of absolute scientific production and ranks second

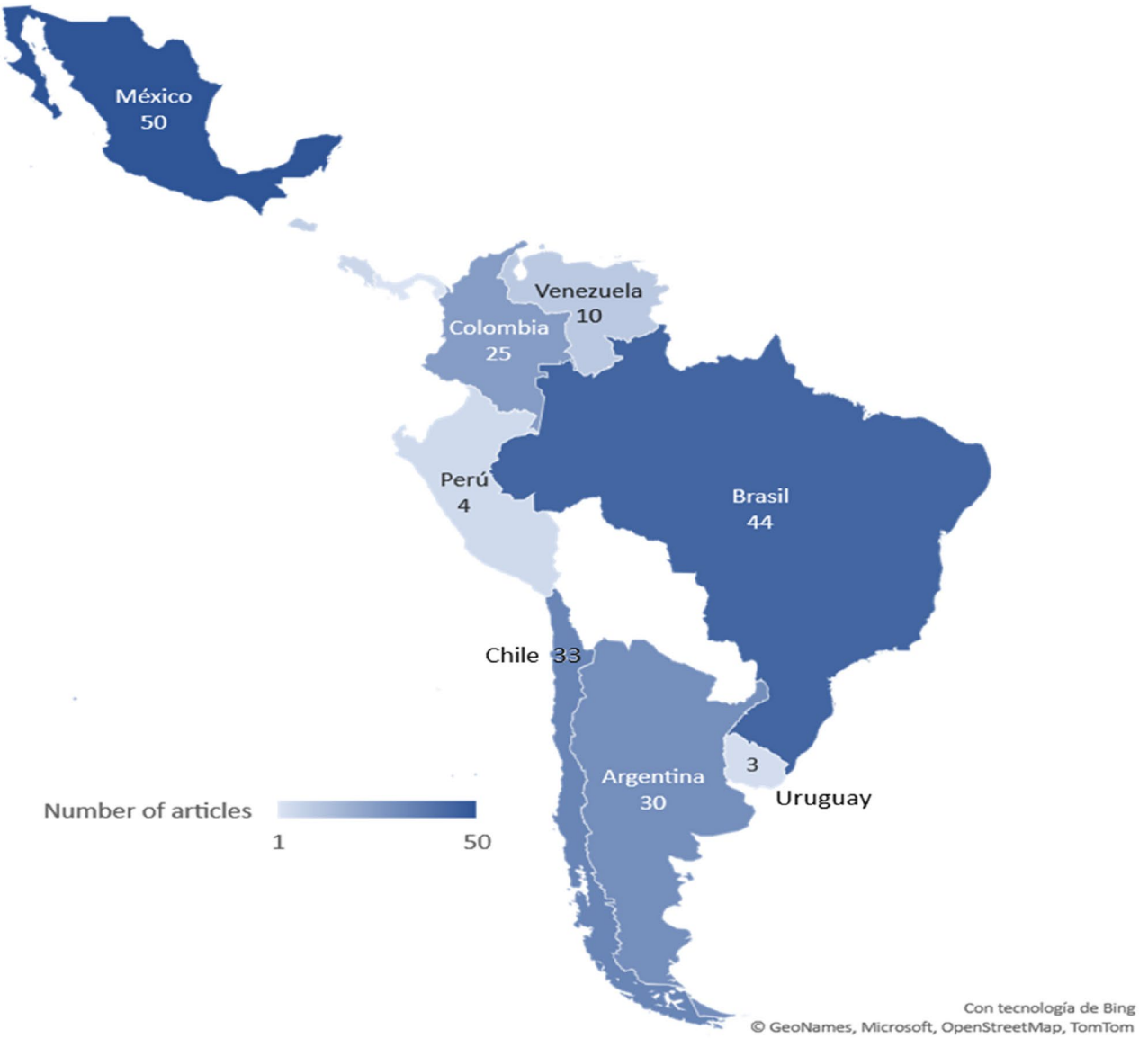

Fig. 4 Absolute distribution of articles related to robotic surgery by country in Latin America, 2009–2022

in terms of impact due to its total citations. The Urology Unit and Robotic Surgery Center at Clínica INDISA in Santiago de Chile established the country's first Robotic Surgery Center in 2009 and has since experienced exponential growth. Initially launched for urological surgery, the program later incorporated general, gynecological, and pediatric surgery. In 2012, a majority of the surgeries conducted were related to urological surgical pathology, with radical prostatectomy for prostate cancer being the most common procedure [28].

This bibliometric analysis relied on the availability of data from articles obtained through the search strategy. In addition, the search was conducted in WOS, therefore, excluding Latin American production on robotic surgery from other bibliographic databases such as Scopus or Medline. Despite these limitations, WOS is one of the most prominent bibliographic databases, enabling us to demonstrate the advancements in knowledge within these research areas and objectively highlight the leading role of academic institutions.

Conclusion

With great potential, scientific production related to robotic surgery in Latin America has experienced exponential growth since its inception. Aligned with the global upward trend, it exhibits high-impact scientific production and upholds urology's predominance as the most studied specialty. This growth has been supported by the high degree of collaboration that the region maintains with leading countries in robotic surgery worldwide.

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Data availability De-identified data provided within the manuscript or supplementary information files and available upon request from a prospectively maintained database.

Declarations

Conflict of interest Dr. Rodolfo J. Oviedo is deputy editor for Journal of Robotic Surgery. Dr. Rodolfo J. Oviedo and Dr. Adel Abou-Mrad are consultants and proctors for Intuitive Surgical.

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