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Metabolism and Target Organ Damage

Review

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Robotic metabolic and bariatric surgery in community *vs*. academic centers in USA: a bibliometric analysis on behalf of TROGSS - The Robotic Global Surgical Society

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Abstract

Robotic metabolic and bariatric surgery (RMBS) has emerged as the most effective approach in the treatment of severe obesity in academic medical centers (AMCs) and community medical centers (CMCs) in the United States of America (USA). However, differences in their scientific productivity in their fields remain unexplored. This bibliometric analysis evaluates the differences in the scientific production related to RMBS in AMC *vs.* CMC in the USA from the point of view of bibliometric analysis. In the core collection of the Web of Science database, the research technique used in this bibliometric analysis includes specific keywords for "robotic" and "bariatric surgery". Original articles released up until 2023 were included. A total of 89 articles were included in the study, with 73 originating from AMC and 16 from CMC. Compared with CMC, AMC had a higher average number of articles per year (3.48 *vs.* 1.1, $P = 0.002$) and a higher annual growth rate (13.23% *vs.* 7.6%). However, in terms of scientific impact, there was no difference in the average citations per article (22.73 ± 32.96 *vs.* 12.25 ± 9.59, $P = 0.213$) or the proportion of articles published in the highest quality scientific journals (54.8 *vs.* 56.3, $P = 0.916$). The scientific output of RMBS increased by 14.5% annually, showing a rising linear trend in AMC and an unclear trend in CMC. The University of Illinois was the most frequent AMC, while the Orlando Health network was the most common CMC. Both CMC and AMC play a pivotal role in the scientific production related to RMBS in the USA, with academic centers having a higher scientific production, but with similar scientific impact to the field at this time.

Keywords: Bariatric surgery, community centers, academic centers, robotic surgery, United States of America

INTRODUCTION

Metabolic and bariatric surgery (MBS), initially conceptualized for weight reduction, has emerged as a powerful tool not only for weight loss but also for the improvement and potential eradication of multiple obesity-associated diseases. The landscape of MBS in the United States of America (USA) has witnessed a transformative shift with the integration of robotic-assisted technologies[1].

Since the first incidence of this kind was described by Cadière *et al.* in 1999, the application of robotics in MBS operations has changed. By downscaling the surgeon's movements and removing physiological tremor, robotic surgery gives surgeons benefits such as improved precision, better dexterity, and three-dimensional vision. By using remote center technology, it reduces port site stress and gets around the restriction of torque on ports caused by a thick abdominal wall[2]. Robotic metabolic and bariatric surgery (RMBS) is a novel strategy to treat severe obesity that combines the advantages of metabolic surgery and weight loss with the accuracy of robotic technology[1].

As pivotal components of the USA healthcare landscape, community medical center (CMC) and academic medical center (AMC) serve diverse populations and play vital roles in medical education, research, and patient care. Community hospitals are generally smaller but closely aligned with the community in terms of their aim, the needs that they cater to, and their philosophy of care. They can sometimes be affiliated with medical schools, and residency and fellowship programs from other institutions. Positive aspects of primary university-based programs, on the other hand, include the depth and complexity of patient exposure, the

quality of their teaching curriculum, the academic experience of the faculty, and the ability to recruit competitive resident physicians due to affiliation with more prestigious institutions[3]. Several studies have been conducted to explore specific differences between community and university-affiliated hospitals, such as in the number of patients, breadth and depth of diagnoses[4], or the number of patients with chronic illnesses[5]. However, no bibliometric analysis has been reported in the literature in terms of RMBS in these two types of hospital systems in the USA.

Even if robotic surgery is becoming more commonplace, it is still crucial to evaluate and appraise the research effects in this particular area. One quantitative method for evaluating the caliber and impact of scholarly research is bibliometric analysis. Numerous factors, such as the quantity of citations, author productivity, and collaboration networks, can be quantified. It offers perceptions regarding the significance of writings, authors, and establishments. To date, no bibliometric analysis has been published that focuses on RMBS or on the variations in this surgical super-specialty between healthcare facilities.

While AMCs are generally presumed to have higher levels of scientific output, there are currently no previous bibliometric analyses comparing the RMBS research output between AMCs and CMCs in the United States, which is at the forefront of this field. The primary objective of this study was to elucidate and analyze such disparities.

MATERIALS AND METHODS

A bibliometric analysis was carried out on original works published in journals indexed in the Web of Science (WOS) database (1997) by writers affiliated with North American universities.

Search strategy

The search strategy derived from the Mesh Terms: "Robotic surgery" and "Bariatric surgery". After these, the following strategy was defined with the Entry Terms suggested for each MeshTerm, trying to be as broad as possible to include all the articles related with this specific field: TS = (Robotic Surgical Procedure OR Robotic Surgical Procedures OR Robot Surgery OR Robot Surgeries OR Robotic Surgery OR Robotic Surgeries OR Robot-Assisted Surgery OR Robot Assisted Surgery OR Robot-Assisted Surgeries OR Robot Assisted Surgeries OR Robot-Enhanced Procedures OR Robot Enhanced Procedures OR Robot-Enhanced Procedure OR Robot Enhanced Procedure OR Robotic-Assisted Surgery OR Robotic Assisted Surgery OR Robotic-Assisted Surgeries OR Robotic Assisted Surgeries OR Robotic-Enhanced Procedures OR Robotic Enhanced Procedures OR Robotic-Enhanced Procedure OR Robotic Enhanced Procedure) AND TS = (Bariatric Surgeries OR Bariatric Surgery OR Metabolic Surgery OR Metabolic Surgeries OR Bariatric Surgical Procedures OR Bariatric Surgical Procedure OR Metabolic Surgical Procedures OR Metabolic Surgical Procedure OR Stomach Stapling OR Gastric Bypass OR Greenville Gastric Bypass OR Gastrojejunostomy OR Gastrojejunostomies OR Roux-en-Y Gastric Bypass OR Roux en Y Gastric Bypass OR Gastroileal Bypass OR sleeve gastrectomy OR duodenal switch OR Gastroplasties OR Collis Gastroplasty OR Vertical-Banded Gastroplasty OR Vertical Banded Gastroplasty OR Vertical-Banded Gastroplasties OR Vertical Banded Gastroplasties OR Jejunoileal Bypass OR Jejunoileal Bypasses OR Jejuno-Ileal Bypass OR Jejuno-Ileal Bypasses OR Jejuno Ileal Bypass OR Jejuno Ileal Bypasses OR Ileojejunal Bypass OR Ileojejunal Bypasses OR Intestinal Bypass OR Intestinal Bypasses). This strategy was applied to look for articles in the Core Collection of the WOS database (1997) while simultaneously applying a country filter to select only studies with affiliations from the USA. The search strategy was conducted on January 15th, 2024. Data analysis was finished on February 10th, 2024.

Selection of articles

A .ciw file with the metadata of the records that were found during the search was downloaded. They were then imported into the Rayyan web platform, where they were reviewed. The titles, abstracts, and authors of every record were scrutinized throughout the review process to ascertain whether they fulfilled the inclusion criteria: (1) original studies published up until 2023 (because 2024 was still in progress); (2) containing patient data from a healthcare facility situated in the USA; (3) including information related to RMBS. To determine the type of institution, a detailed review of the methodology section of each article was performed to identify the study setting and the name of the institution. The type of institution was then determined based on the description and publicly available information on the web. We excluded: (1) studies where we could not determine the type of center where patients were treated; (2) studies that included data from patients from both types of centers or hybrid centers, to avoid overlapping data; (3) studies that did not present the bibliometric indices (variables) that we studied. Survey studies that did not include information related to patients were also excluded. In the review process in the Rayyan web application, the included articles were marked as from either "Academic center" or "Community center" to differentiate the two groups. The WOS "Accession Number" was extracted from each included record, sorted by group, and re-searched in WOS to obtain the final set of complete records for the bibliometric analysis.

Bibliometric analysis

Bibliometric indices were derived using the Bibliometrix package in R[6], while VOSviewer software (version 1.6.17, Leiden University, Netherlands) was employed for constructing bibliometric networks based on co-authorship[7]. The analysis encompassed key bibliometric indicators, including publication volume, journal distribution, annual growth trends, citation impact, highly cited articles, prevalent research topics, scientific contributions by authors and institutions, international collaboration, and keyword trends.

The R programming language's Bibliometrix package was utilized to obtain bibliometric indices[6]. Similarly, co-authorship-based bibliometric networks were created using the VOS viewer software version 1.6.17 from Leiden University in the Netherlands[7]. The number of articles and journals, the average number of articles published annually, the average number of citations per document, the most cited articles, the most pertinent topics, the average number of authors per article, the average number of citations per journal, the average number of authors worldwide, affiliations, and keywords were all taken into consideration during this analysis.

The author, institutional affiliation, and keyword fields underwent a manual data harmonization process before the network analysis. By generating thesauri in .txt format and adhering to the two-column approach (label and replace by) as detailed in the VOSviewer version 1.6.17 software handbook, the goal was to remove duplication and inconsistencies[8]. Furthermore, tables and graphs for data presentation were made using Microsoft Excel. Bradford's Law was used to classify the papers that were examined. Bradford's Law illustrates how zones relate to an object's usefulness in a particular field. The most productive journals or sources in robotic surgery would be found in Zone 1, and they would constitute "the core" of the literature. It helps identify the journals driving the field's research and allows us to compare which type of institution publishes more frequently in high-impact, specialized journals. This can offer insights into the dissemination and perceived impact of research from each type of institution[9]. A map of articles published by states in the USA was created, taking into account the location of the institutions where they were produced. For institutions with multiple campuses, such as the University of California, we ensured that each article was attributed to the state corresponding to the campus where it was produced.

Statistical analysis

Microsoft Excel 2019, Redmond, Washington, USA, was used to gather and compile data. IBM SPSS Statistics for Windows, Armonk, NY, USA, version 29.0.2.0 was the statistical program used for statistical analysis. The mean and standard deviation, or percentages, were used to describe the quantitative and qualitative data, respectively. To find correlations, t-Student and chi-square tests were employed. *P*-values less than 0.05 were regarded as statistically significant. When applicable, graphic representations were used for visual illustration. The degree to which the data in the scientific production in both groups fit the regression model of the growth line was assessed using the R2 value, or the coefficient of determination.

RESULTS

Study selection

The search strategy resulted in 379 articles. Figure 1 describes the flowchart for the article selection. Finally, 89 articles, 73 from AMC and 16 from CMC, were included after the screening process from a total of 18 different journals.

The comparison of specific features of AMC and CMC regarding scientific production on RMBS, their impact, authors, and affiliations are shown in Table 1.

Scientific output and growth trends

Between 2003 and 2023, the scientific output of RMBS in the USA increased by 14.5% annually on average. However, CMC experienced a different time period, with the first article being filed in 2008. On average, 4.23 original articles were published annually, with the highest productivity recorded in 2023 (15 original articles). Moreover, an overall linear pattern with an R2 value of 0.49 was noted throughout the publication period. This suggests that there is little relationship between the number of publications and the year. However, ACM had a more clearly grown linear tendency (R2 = 0.47) compared with CMC (R2 = 0.25). The linear patterns can be seen in Figure 2.

Citation impact

On average, each document received 20.84 citations. Table 1 shows the difference between both types of institutions in terms of average citations. Table 2 shows a brief comparison of the most cited studies from ACM and CMC.

Journal distribution and bradford's law

Among the journals publishing RMBS-related studies in the USA, *Surgical Endoscopy* had the highest share, accounting for 31.5% (n = 28) of the total. This was followed by *Obesity Surgery* at 23.6% (n = 21) and *Surgery for Obesity and Related Diseases* at 12.4% (n = 11). Among all the 18 journals, 11% (n = 2) were in Zone 1, 6% (n = 1) in Zone 2, and 83% (n = 15) in Zone 3, according to Bradford's classification. The differences according to the type of center are shown in Table 1.

Authorship and collaboration

Each paper had an average of 5.47 co-authors, with international collaboration observed in 6.74% of cases. The most prolific author was Elli EF, affiliated with the University of Illinois at Chicago (AMC), with seven publications.

Institutional and geographic distribution

There were 42 affiliations, of which the most common were from AMCs. The University of Illinois was the most frequently represented institution, contributing 13.5% (n = 12) of articles, followed by the Mayo Clinic and the University of California, each with 7.9% (n = 7). Among CMC, the Orlando Health network was the

Table 1. Scientific production-related RMBS by type of institutions in the USA

Feature[a]	Academic center (*n* = 73)	Community center (*n* = 16)	*P*-value
Scientific production			
Annual growth rate (%)[b]	13.23	7.6	
Average articles per year	3.48 ± 2.87	1.0 ± 1.46	**0.002**[†]
Scientific impact			
Average citations per article[c]	22.73 ± 32.96	12.25 ± 9.59	0.213[†]
Journals according to Bradford Law (%)			
Zone 1	40 (54.8)	9 (56.3)	0.916[*]
Zone 2	9 (12.3)	2 (12.5)	0.985[*]
Zone 3	24 (32.9)	5 (31.3)	0.900[*]
Authorship			
Co-authors per article	5.26 ± 2.27	6.31 ± 3.0	0.118†
International co-authorships (%)[b]	6.849	6.25	

[*]Chi-square; [†]T-Student; [a]Continuous data are shown as the mean ± standard deviation and categoric data as number and percentage (%); [b]no statistical test was applied due to a lack of individual data; [c]citations register in web of science core collection. Bold values are statistically significant. RMBS: Robotic metabolic and bariatric surgery; USA: United States of America.

Table 2. Detailed comparison between the most cited articles from AMC and CMC

Institution	AMC	CMC
Name of the article	"A prospective analysis of 211 robotic-assisted surgical procedures" from Talamini *et al.*[10]	"Robotic Roux-en-Y Gastric Bypass, Is it Safer than Laparoscopic Bypass?" by Moon *et al.*[11]
Year published	2003	2016
Total number of citations	197	31
Annual citations	8.95	3.4

AMC: Academic medical centers; CMC: community medical centers.

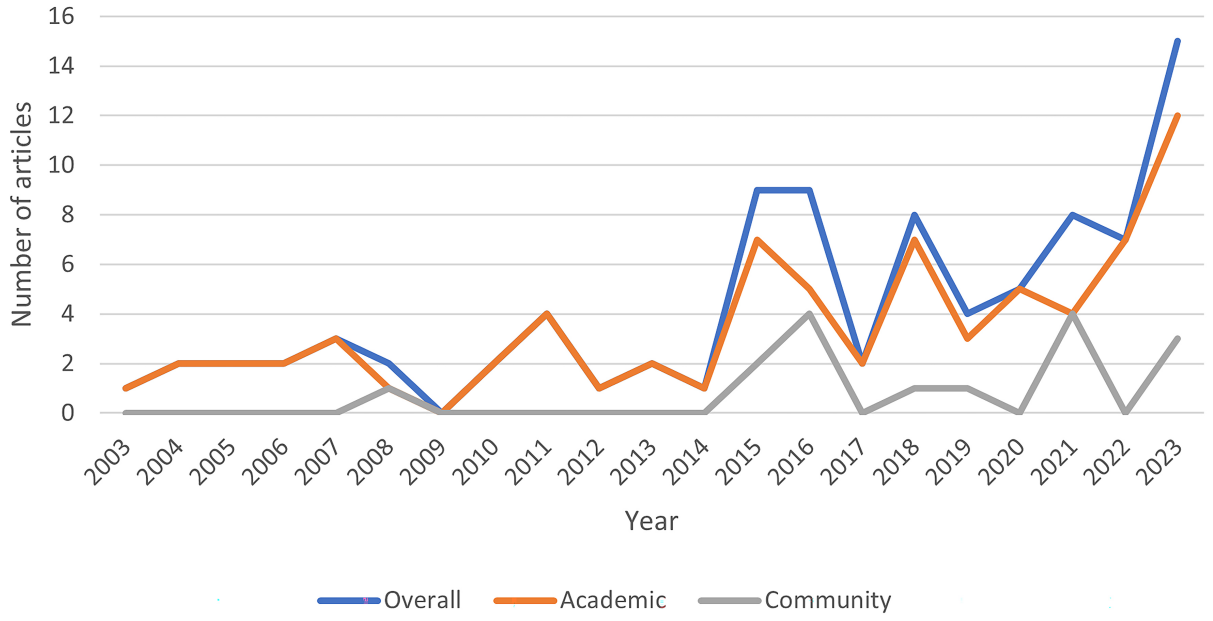


Figure 1. Flowchart for article selection. RMBS: Robotic metabolic and bariatric surgery.

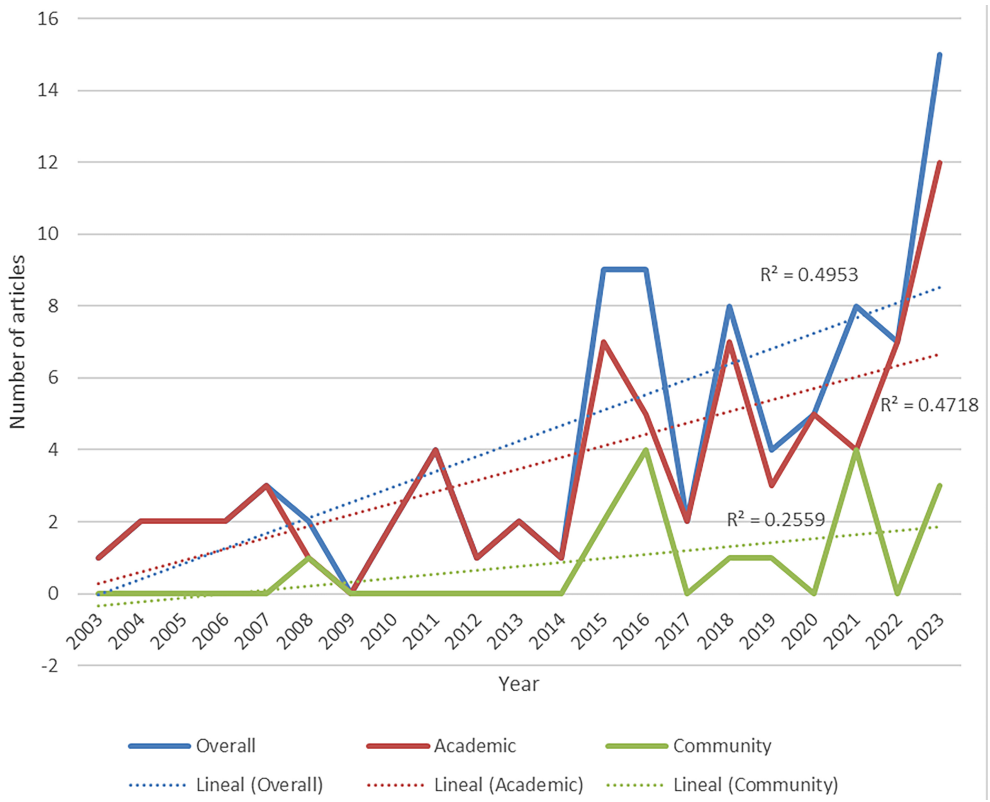


Figure 2. Scientific production related to RMBS in the USA by type of affiliation, 2003-2023. RMBS: Robotic metabolic and bariatric surgery.

most common, with 6.7% (n = 6). The distribution of scientific production by state according to the corresponding author's affiliation and the type of institution is shown in Figure 3.

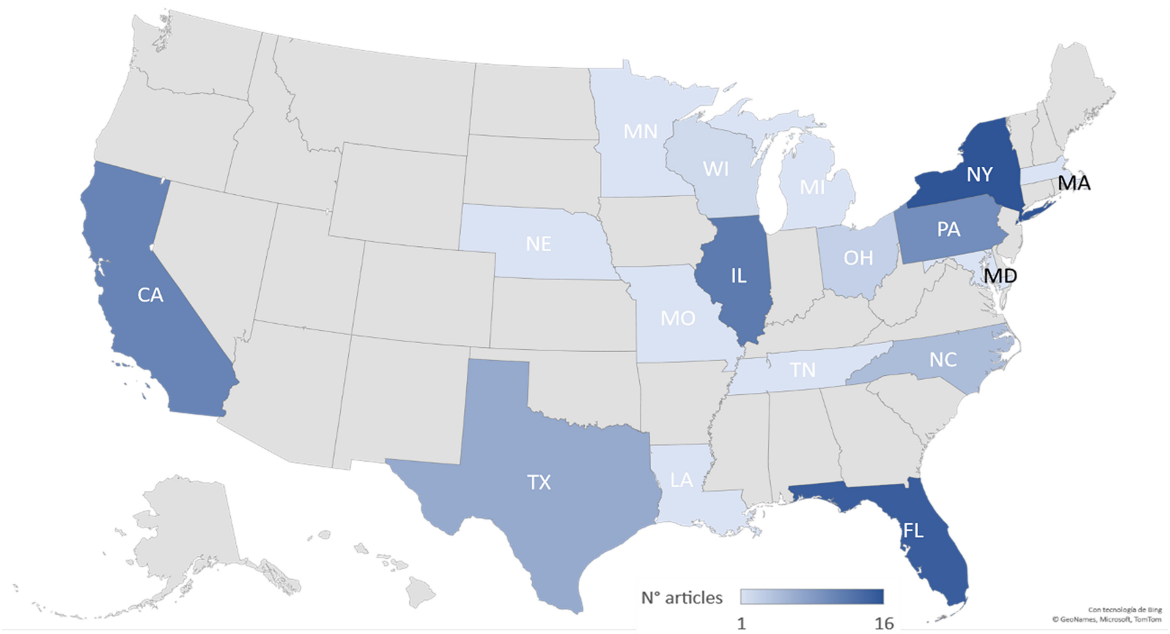
Keyword analysis

A total of 181 keywords were identified. After processing and setting a minimum frequency of five, the most commonly used keywords were "bariatric surgery", "robotic surgery", "outcomes", "gastric bypass", and "sleeve gastrectomy".

DISCUSSION

The current study used a bibliometric analysis methodology to ascertain the scientific output of RMBS in the USA since its inception. Despite the enormous potential for this technology's development and expansion in this particular surgical field, no such endeavor has been carried out before. While some bibliometric analyses related to MBS have been published[9], none of them included the robotic surgery component, much less compared production in AMC *vs.* CMC in the USA. This lack of thorough examination in the scientific literature regarding RMBS may be related to the technology's principal application in other domains, such as urology, which continues to be the most common specialty for studies on the effects of robotic surgery[12].

Our study indicated a 14.5% yearly rise in the scientific output of RMBS in the USA between 2003 and 2023, similar to prior assessments on MBS[13], and this was consistent with the global trend of continuous development in scientific production linked to robotic surgery[12]. This growth is explained by the USA's



State	New York (NY)	Florida (FL)	Illinois (IL)	California (CA)	Pennsylvania (PA)	Texas (TX)	North Carolina (NC)	Ohio (OH)	Wisconsin (WI)	Hawaii (HI)	Louisiana (LA)	Maryland (MD)	Massachusetts (MA)	Michigan (MI)	Minnesota (MN)	Missouri (MO)	Nebraska (NE)	Tennessee (TN)
AMC	10	13	12	9	8	6	2	0	2	0	0	0	0	0	0	0	0	0
CMC	6	2	0	2	2	1	3	3	0	1	1	1	1	1	1	1	1	1
Total by state	**16**	**15**	**12**	**11**	**10**	**7**	**5**	**3**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Figure 3. Absolute frequencies of articles related to RMBS by state in USA, 2003-2023. RMBS: Robotic metabolic and bariatric surgery; AMC: academic medical centers; CMC: community medical centers.

undisputed leadership over the years in robotic surgery[14,15], which also extends to MBS. The 8th International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) 2022 Registry Report indicates that the USA contributed 43.6% of all reported MBS cases globally[16]. This aligns with 2022 data showing that in the United States, 22 states had an adult obesity prevalence of 35% or higher[16]. The significant contribution of the USA to both MBS and robotic surgery, in general, likely amplifies its influence and productivity in the emerging field of RMBS.

In previous analyses, the journals Obesity Surgery and Surgery for Obesity and Related Diseases have been reported as commonly used for the publication of articles related to MBS[17-19]. This trend is consistent even in studies focused on the scientific production of MBS in Latin America, where Obesity Surgery (the official journal of IFSO) is often identified as the primary journal[20]. However, in our study focused on the applications of robotic surgery in this field, those journals ranked second and third, respectively, behind the journal Surgical Endoscopy.

In our study, the most productive institution was the University of Illinois, followed by Mayo Clinic and the University of California. However, the dominance of institutions appears to depend on the specific field within robotic surgery. Contrasting with previous studies related to MBS, Seckin *et al.* in 2024 reported Harvard University as the most prolific publishing institution[17], and in Shen *et al.*'s analysis in 2019[15],

Mayo Clinic ranked third. On the other hand, the analysis of MBS by Ozsoy *et al.* in 2018 identified the University of California among the most productive institutions[21]. For CMC, the Orlando Health network was the most common, but this health network is not currently reported in any bibliometric analysis.

Historically, AMCs have played crucial roles in the U.S. healthcare system, fostering innovation, research, and education while serving as safety net hospitals. Data from the American Association of Medical Colleges (AAMC) indicate that in 2014, hospitals affiliated with AAMC teaching programs accounted for only 5% of all hospitals. In contrast, CMCs handle approximately 80% of annual hospital admissions, with their physicians and surgeons acting as primary healthcare providers in most communities. While AMCs prioritize the tripartite mission of clinical care, education, and research, CMCs, with a more generalist staff, focus on efficiency. Both entities contribute distinctively to the healthcare landscape in the USA, each with its own emphasis on mission and patient population. The complex matrix organizational structures of AMCs reflect their multifaceted missions[22,23]. However, despite the higher proportion of publications in AMC, our study did not report a statistically significant difference regarding the impact of their publications: the number of citations and the percentages of journals in Bradford Zone 1 where their studies were published. This observation has important implications, particularly in the USA, where influential contributions from the literature on RMBS have arisen from both AMCs and CMCs alike. We believe that the lack of a significant difference in scientific impact is due to the similar quality of the articles produced by CMCs and AMCs, as well as the fact that journals maintain the same standards and requirements for publication, regardless of the type of institution the research comes from. Therefore, once an article is published, it is assumed to meet a consistent standard of scientific quality, which is reflected in similar citation numbers.

A few studies have been conducted evaluating the difference between surgical patient outcomes in both hospital settings. For example, a 2021 study by Horsey *et al.* examining patients post-rectal cancer surgery reported that AMCs had notably lower odds of conversion and positive margins, while demonstrating significantly higher odds of examining ≥ 12 regional nodes[24]. Another study by Khuri *et al.* in 2001, which analyzed all major non-cardiac operations performed between 1997-1999 in U.S. veterans, reported more complex operations and longer operation times in AMCs[25]. Specifically in the field of MBS, López *et al.* in 2002 reported that complications, length of stay, and hospital charges were greater in AMC than in CMC, on the other hand[26]. However, no previous study has reported the differences between the two types of centers in terms of scientific output related to MBS or RMBS.

The reason for the higher average yearly number of articles in AMC compared to CMC (3.48 *vs.* 1.0) that our study found is that, in the USA, the majority of research on RMBS has been produced in academic hospital settings; results from community/rural hospital settings have only recently been covered in the literature. Moreover, the majority of these data originate from the experience of large academic institutions, making it less evident how a community hospital setting affects the results of these operations[27,28]. CMCs in the USA typically handle a higher volume of patients, according to the study of Mills *et al.* in 2023, reporting that with more than 2,300,000 robotic procedures, 89% of them were performed at CMCs[29]. However, the prevalence of and focus on outcomes research at AMCs may explain the greater scientific production from the latter[22]. In addition, particularly for the RMBS literature productivity subtype, Mills *et al.* reported that between 2015 and 2021, AMCs produced a higher volume of procedures[29].

Despite the existing differences, some studies advocate for building bridges between both types of centers[30], and as mergers between AMC and CMC continue to increase, these differences will become a thing of the past in years to come.

This study had some important limitations. For this bibliometric analysis, data management was contingent upon the availability of information from articles retrieved through the WOS database. The bibliometrix package in R only enables the analyses of information coming from one database at the time, which is why only articles from WOS were included. This limited the number and variety of studies that could be indexed in other databases like Medline or Scopus but not in WOS, and thus were excluded. Notwithstanding these drawbacks, WOS is regarded as one of the most reliable and extensive bibliographic databases. With this decision, we were able to demonstrate new findings in the designated fields of study and unbiasedly highlight the importance of universities as leaders in the field. Additionally, WOS has been used in isolation in previous bibliometric analyses, as observed in studies related to MBS[21].

To further advance research in this field, it is crucial to explore the underlying factors contributing to the variations in RMBS-related scientific output across different institutions. A detailed examination of the unique challenges and opportunities faced by each type of institution could yield valuable insights for fostering collaboration and improving research outcomes. International collaborations could greatly enhance the quality and impact of RMBS research by promoting the exchange of diverse expertise, access to larger and more varied patient populations, and the development of multicenter studies with broader applicability. Such partnerships can improve methodological rigor, attract higher-impact publications, and increase citation rates. To foster these collaborations, strategies like establishing research consortia, organizing international conferences, promoting researcher exchange programs, developing joint grant opportunities, and using digital collaboration platforms can be highly effective. These efforts would ultimately advance innovation and improve patient care in the field of RMBS globally. Continuous investigation into these areas is vital for expanding knowledge and optimizing care delivery in the fast-evolving domain of robotic surgery for severe obesity. After all, it is through international collaborations that even CMCs are becoming AMCs and producing high-quality manuscripts in the new era of global research in surgery.

CONCLUSION

Scientific production in RMBS in the USA has experienced substantial growth over the last 20 years, primarily led by academic institutions with greater scientific and literary output than traditional community hospitals. However, despite their research-oriented focus, AMC did not exhibit superiority over community hospitals in terms of the clinical impact of their publications. As RMBS continues to evolve and expand, future research should focus on identifying the factors driving differences in scientific output between AMCs and CMCs. Understanding these dynamics could enhance collaboration, improve research quality, and ultimately advance patient care in the field of MBS.

DECLARATIONS

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Authors' contributions

Conceptualization and study design: Rivero-Moreno Y, García-Nunes A, Oviedo RJ
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Systematic literature review and methodology: Rivero-Moreno Y, Goyal A, García-Nunes A, Suárez-Carreón LO
Critical review, supervision, and manuscript refinement: Blanc P, Pouwels S, Abou-Mrad A, Marano L, Oviedo RJ
All authors contributed significantly to the development and completion of this manuscript.
All authors have read and approved the final version for submission.

Availability of data and materials
The datasets generated and/or analyzed during this study are not publicly available but can be obtained from the corresponding author upon reasonable request.

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None.

Conflicts of interest
Pouwels S is an Editorial Board member of the journal *Metabolism and Target Organ Damage* and the Guest Editor of the Special Issue *Clinical Advances in Bariatric Surgery: Current Trends, Outcomes, and Future Perspectives*. Pouwels S was not involved in any steps of editorial processing, notably including reviewer selection, manuscript handling, and decision making. The other authors declared that there are no conflicts of interest.

Ethical approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

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