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Research Performance in Anesthesiology and Pain Medicine by Saudi Arabia

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ABSTRACT

Aim: A medical practice known as anesthesia, prevents patients from feeling pain before, during and after surgical procedure. The present study aims to present the bibliometric evaluation of the Saudi Arabian research in Anesthesiology and Pain Medicine (APM) during the last 40 years from 1983 to 2022.

Method: The meta-data was retrieved on 31st August 2023 from the Scopus database for conducting bibliometric research. An advance search option was used, and selected the sub-category "Anesthesiology and Pain Medicine" from the major subject area of Medicine. We excluded the documents published after 31st December 2022. We downloaded the global summary of publications on APM and later selected the Saudi Arabia from the country filter and downloaded the bibliographic information of the documents. Microsoft Excel and VOSviewer software were used for data analysis.

Results: A total of 207,683 documents were found on APM worldwide and the highest number of documents has been contributed by the United States (39%). About 41% of the documents were published in the last five years (2018-2022). Saudi Arabian authors produced 1,085 (0.52%) documents in 40 years from 1983 to 2022. More than half of the documents were published in the last five years and the ratio of open-accessed documents was found higher as compared to subscription-based documents. Saudi authors collaborated with authors from 109 countries but most of the research was performed with Egypt and the United States. Saudi Journal of Anaesthesia was the most frequent source of publication. The major funding sources and most occurred keywords were also analyzed.

Conclusion: The current study has examined the research growth on APM produced by Saudi Arabia for 40 years. Overall, the share of Saudi Arabia in APM research at the global level was recorded at 0.52 percent, but the share was a bit increased and reached on 0.70 percent during the last five years of study. This increase has been strongly correlated with government investment in human resources and the development of healthcare and educational infrastructure.

Keywords: Bibliometric, Anesthesia, Research productivity,

INTRODUCTION

Saudi Arabia is an important country in the Arab World and it strives to be a global leader in higher education, research, and development. The country has accepted the significance of quality education, creative research and continuing professional development in achieving long-term sustainable growth. One of the goals of the National Development Plan of Saudi Arabia is to foster a research culture in higher education in order to achieve social and economic objectives, particularly the transition from a petroleum-based economy to knowledge-based. [1,2] Saudi Arabia increased enrolment in the sector of the healthcare system, generously invested in the infrastructure and started research fellowships. The availability of high-quality biomedical education and research directly affects the community's level of health.[3]

Anesthesiology is an important branch of health sciences that focuses on total patient care, including the alleviation of pain and takes patient safety into account before, during, and after any surgical intervention.[4] The scientific literature has been increasing remarkably in every branch of knowledge same trend is prevailing in the discipline of anesthesia.[5] There is a need to examine the publication growth and its characteristics periodically to redefine the research priorities.[6] For this purpose, a bibliometric method has been employed. The bibliometric research technique is the combination of mathematics and statistics which is applied to the set of scholarly communication.[7] These studies have gained acceptance in the academic community since the invention of the internet and the introduction of electronic databases, like PubMed, Web of Science, Scopus and Google Scholar.[8] The outcomes of bibliometric studies have been used to make strategic decisions, allocate finances, and devise research. The research output and the effect of its citations are essential measures for ranking agencies to rate nations and institutions.[9,10]

Anesthesiology is a recognized discipline and few bibliometric studies have been carried out. The first notable bibliometric study was conducted by Boult et al., and this study quantified the amount of research published between 1996 and 1997 in 30 different journals on the subjects of anesthesia, pain, critical care and emergency medicine. More than half of the journals (n=17) were published in the United States, followed by United Kingdom (n=8) and both these countries (United States, 40.2%, United Kingdom 13.3%) contributed the highest number of research.[11] Another bibliometric study on anesthesia limited to the data set of two years from 2007-2008 reported that high-income countries contributed 89% of the literature and middle-income countries had also contributed significantly.[12] A 2007 study analyzed 6,736 clinical research studies on anesthesia indexed in PubMed from 2000 to 2005. The highest number of papers were published in Anesthesia and Analgesia (18.92%), and the United States contributed 20% of the literature. The study distributed the publications by income categories of the countries, high-income countries contributed 45%, followed by Upper-Middle, Lower-Middle and Low income countries with 25%, 19% and 11%, respectively.[13] Another study compared the 10-year (1999 to 2008) research performance in anesthesia by the regions of China, Taiwan and Hong Kong and these regions contributed 2.3% (n=721) of the global research. Taiwan contributed the most number of papers, followed by China and the highest number of papers were published in Anesthesia and Analgesia.[14] Dogan and Karaca examined the Web of Science-Indexed literature on anesthesia published from 2009 to 2018. A total of 84,290 documents were identified, 89.7% of the documents were published in the English language and 28.9% of the literature was produced in the United States. A few notable studies related to anesthesia have been published in the Saudi Arabian context.[5] Mowafi analyzed the contribution of Saudi anesthetics in 15 leading journals of anesthesia from 1991 to 2011. Fluctuation has been found in the growth of papers over the years and a growing trend was found in the last decade. About one-fourth of the papers were published in Anesthesia and Analgesia followed by Canadian Journal of Anaesthesia. King Saud University contributed the maximum number of papers followed by Dammam University (Now Imam Abdulrahman Bin Faisal University). The Saudi universities produced more research as compared to the hospital sector.[15]

It's crucial to evaluate the development and influence of research in anesthesia contributed by Saudi Arabian authors in the global perspective. The current research would serve as a

benchmark for future studies. The present study aimed to scrutinize the selected bibliometric parameters of the Scopus-indexed documents on anesthesia produced by Saudi Arabia from 1983 to 2022. The study was performed to achieve the following objectives:

1. To analyze the research growth on anesthesia at the global level, ascertain the periodic growth of publications, most productive countries, prolific institutions, frequently used journals and some other bibliometric indicators.
2. To examine the development of anesthesia research in Saudi Arabia by year.
3. To compare the open and non-open accessed documents on anesthesia research.
4. To highlight the trends of international research collaboration at county and institutional levels.
5. To review the frequently used sources of publication, top funding agencies and the most occurred keywords.

MATERIALS AND METHODS

A bibliometric research method was used to quantify the publication growth on the topic of "Anesthesiology and Pain Medicine". The data was extracted from the Scopus database on 31st August 2023. We opted for the advanced document search, we clicked on the subject area of Health Sciences, and then clicked "Medicine". There are several sub-categories of medicine, Anesthesia or Anesthesiology but the sub-category of "Anesthesiology and Pain Medicine" exists in the Scopus database. We wrote the term "Anesthesiology and Pain Medicine" in the search box. Firstly, we used only the year filter and excluded the documents that were published in 2023, as the year is not yet over. We downloaded the complete summary of this data to yield the salient characteristics of global research and to describe the share of Saudi Arabia in global research output. Further, we selected Saudi Arabia from the filter of country/territory to highlight the selected bibliometric properties of the literature contributed by Saudi Arabia. The Scopus database segregates the documents based on at least one author's affiliated address to Saudi Arabia.

We used the following search query to extract the data set of Saudi Arabia:

(Anesthesiology and Pain Medicine AND (EXCLUDE (PUBYEAR, 2023) OR EXCLUDE (PUBYEAR,2024)) AND (LIMIT-TO (AFFILCOUNTRY, "Saudi Arabia")))

Microsoft Excel and VOSviewer software were used to present the data in tabular format. The dataset was limited to Scopus-indexed documents under the topic of "Anesthesiology and Pain Medicine". It is stated that some documents may be indexed in Web of Science, PubMed and Google Scholar but may not be indexed in Scopus. Every database has its coverage but the Scopus database provides comprehensive bibliographic and citation records of scholarly literature than the Web of Science and PubMed.[16] Google Scholar has its limitations and it does not offer the affiliation search query.

RESULTS

Global Scenario of Research in Anesthesiology and Pain Medicine (APM): A total of 207,683 documents were indexed in the Scopus database on the subject of Anesthesiology and Pain Medicine (APM) from 1932 to 2022. A very slow research progress (n=12,183; 5.86%) was found from 1932 to 1999 and moderate growth (n=37,393; 18%) was witnessed in the next ten years (2000 to 2009), whereas about 41% (n=84,383) of the documents were published during the last five years of study (2018-2022). The authors belonging to the United States contributed the highest number of documents (39%), followed by China (8.26%), United Kingdom (6.64%), Germany (6.52%), and Canada (6.01%). Saudi Arabia stood on 31st rank with 1,085 documents and it contributed 0.52% share in the global output on APM.

At institutional level, the authors from Harvard Medical School produced the maximum number of documents (4.11%),

followed by Brigham and Women's Hospital (2.07%), Massachusetts General Hospital (1.84%), University of Washington (1.71%) and University of Toronto (1.69%). The analysis of the source publications stated that the highest number of documents were published in Anesthesia and Analgesia (2.43%), followed by Regional Anesthesia and Pain Medicine (1.63%), Anesthesiology (1.52%), Pain (1.34%) and British Journal of Anaesthesia (1.11%). Kaye, A.D. was found to be the most productive author with 734 documents, followed by Tobias, J.D., Urman, R.D., Manchikanti, L., and Kehlet, H. with 567, 514, 422 and 366 documents, respectively.

All the documents were published in 39 languages of the world, and 94.56% of the research was published in the English language, followed by German (1.15%), Spanish (1.02%), French (0.90%) and Chinese (0.75%), while only 23 documents were indexed in the Arabic Language. The analysis of document's type showed that 67.83% of the documents comprised of original research articles, then review articles (17.17%), book chapters (5.89%) and other documents (letters, editorials, conferences papers, notes, books, short surveys, erratum, retreated and data papers) consisted of 9.07%. Forty-four percent of the documents have been published in open-accessed format while 56% of documents are subjected to subscription. Slightly more than 11 percent of the documents were sponsored by the top five funding agencies, National Institutes of Health, National Natural Science Foundation of China, National Institute of Neurological Disorders and Stroke, National Institute of General Medical Sciences and National Institute on Drug Abuse.

Research Contribution of Saudi Arabian in Anesthesiology and Pain Medicine (APM): Saudi Arabia contributed 1,085 documents to APM and these documents were published during the span of 40 years from 1983 to 2022. Only 20 documents were identified during the first 16 years from 1983 to 1999. A moderate growth of documents (n=94) was found in the next ten years (2000 to 2009) with an average of 9.4 docs/year. More than half of the documents (n=591; 54.47%) were published in the last five years of study from 2018 to 2022 (Figure-1). The ratio of citable documents was found 85 percent. It is worth mentioning that 93 documents comprised of the studies on the global burden of diseases and mostly published in The Lancet, gained 124,754 citations with an average of 1341.44 cites/doc. The other 992 documents were cited 11,640 times with an average 11.74 cites/doc.
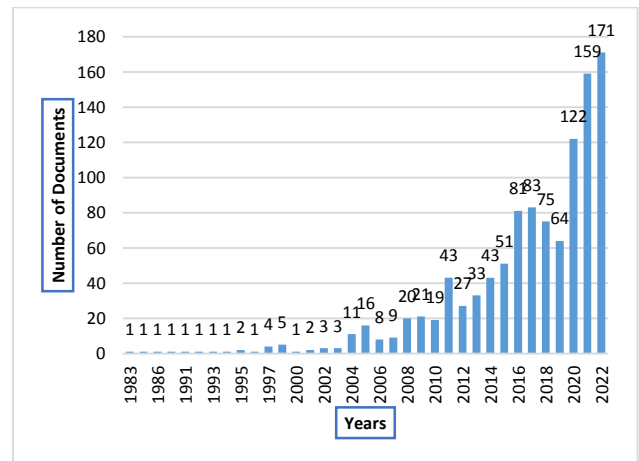

Figure 1: Periodic growth of documents on Anesthesiology and Pain Medicine (n=1085)

All the selected documents have been published in the English Language. In the examination of types, about 77% of the documents were published as original research articles, followed by review articles (17%) and 6% of the other documents consisted

of book chapters, letters, editorials, conference papers, erratum, books, notes, retracted, short survey.

The ratio of open-accessed documents has been found higher (n=635; 58.50%) as compared to subscription-based documents (n=450; 41.50%). The number of subscription-based documents increased considerably from 2004 to 2010 but the number of open-accessed documents was accelerated after 2015 to onward and it counted about half of the total documents (n=535; 49.30%).
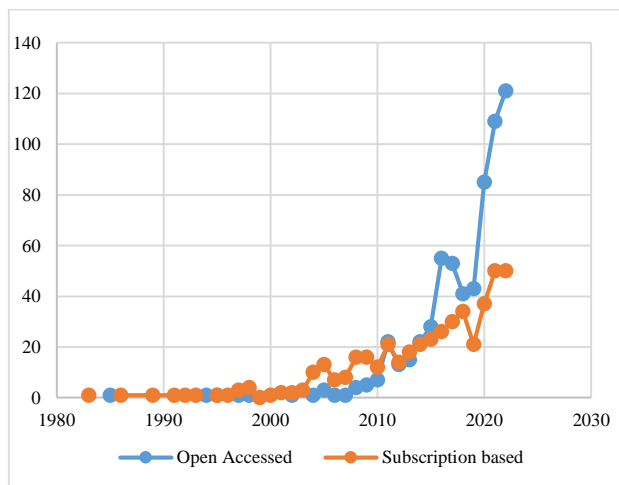

Figure 2: Comparison of open and subscription-based documents by years

Saudi Arabian authors collaborated with authors from 103 countries and the highest ratio of research was performed in Egypt (n=312), and the United States (n=309). The research collaboration with the authors of Canada, United Kingdom and India counted 199, 197 and 174 documents, respectively. Eighteen countries are having more than one hundred documents each in APM. (Table 1)

Table 1: Proportion of International Research Collaboration

Serial No.	Name of Country	Total Documents	Serial No.	Name of Country	Total Documents
1.	Egypt	312	11.	Spain	120
2.	United States	309	12.	Netherlands	116
3.	Canada	199	13.	Pakistan	112
4.	United Kingdom	197	14.	Malaysia	109
5.	India	174	15.	France	106
6.	Australia	171	16.	Japan	105
7.	China	133	17.	South Korea	103
8.	Italy	131	18.	United Arab Emirates	102
9.	Germany	128	19.	Sweden	98
10.	Brazil	124	20.	Switzerland	96

The examination of scholarly contribution at the institutional level reveals that the top four organizations of Saudi Arabia produced more than 100 documents each in APM and these organizations have belonged to an academic set-up. The authors affiliated with the King Saud University contributed one-fourth (n=270; 24.88%) of the total documents, followed by Imam Abdulrahman Bin Faisal University, King Abdulaziz University and King Saud bin Abdulaziz University for Health Sciences with 135, 130 and 115 documents. King Fahad Medical City stood at the top among the hospital sector, followed by King Faisal Specialist Hospital and Research Centre and King Khalid University Hospital (Table 2).

The analysis of international research collaboration at the institutional level shows that Cario University has been the most frequent option with 103 documents followed by Mansoura University and University of Toronto with 109 and 108 documents, respectively (Table 2).

Table 2: Top-10 Most Productive organizations

Serial No.	National Institutions	Total Documents	Serial No.	International Collaborative Institutions	Total Documents
1.	King Saud University	270	1.	Cairo University	130
2.	Imam Abdulrahman Bin Faisal University	135	2.	Mansoura University	109
3.	King Abdulaziz University	130	3.	University of Toronto	108
4.	King Saud bin Abdulaziz University for Health Sciences	115	4.	University of Melbourne	97
5.	King Fahad Medical City	90	5.	University of Washington	96
6.	Alfaisal University	78	6.	Imperial College London	94
7.	Ministry of Health Saudi Arabia	76	7.	Monash University	94
8.	Jazan University	74	8.	McMaster University	90
9.	King Faisal Specialist Hospital and Research Centre	68	9.	Ain Shams University	83
10.	King Khalid University Hospital	65	10.	University of Oxford	83

Table 3: Top 10 most frequently used journals by Saudi authors in APM

Serial No.	Name of Journal	CiteScore (Quartile)	Start and End Year	Total Documents	Total Citations	Citation Impact
1.	Saudi Journal of Anaesthesia	3.2 (Q2)	2011-2022	77	1,242	16.12
2.	The Lancet	133.2 (Q1)	2012-2021	40	86,865	2171.62
3.	Egyptian Journal of Anaesthesia	0.7 (Q3)	2003-2022	38	186	4.89
4.	Middle East Journal of Anesthesiology	0.2 (Q4)	2004-2022	32	320	10.00
5.	Saudi Medical Journal	2.2 (Q2)	2004-2022	27	151	5.59
6.	Anaesthesia Pain and Intensive Care	0.4 (Q4)	2009-2022	23	34	1.47
7.	Journal of Cardiothoracic and Vascular Anesthesia	4.5 (Q2)	2015-2022	20	201	10.50
8.	Intensive Care Medicine	34.5 (Q1)	2016-2022	15	7,361	490.73
9.	Critical Care Medicine	12.6 (Q1)	2015-2022	14	3,809	272.07
10.	Anesthesia and Analgesia	8.7 (Q1)	1997-2021	13	432	33.23

All the selected documents have been published in 519 sources and 10 journals are having more than nine documents each. The highest number of documents were published in Saudi Journal of Anaesthesia, followed by The Lancet, Egyptian Journal of Anaesthesia, Middle East Journal of Anesthesiology and Saudi Medical Journal. Only 13 documents were found in the Anesthesia and Analgesia (Table 3).

Among the top-10 funding sources, National Institute of Health has sponsored 71 documents followed by Bill and Melinda Gates Foundation and Deanship of Scientific Research, King Saud University with 56 and 54 documents, respectively. The details of seven other funding sources are shown in Table 4.

Table 4: Top-10 Funding Sources for APM Research

Serial No.	Funding Sources	Total Documents
1.	National Institutes of Health	71
2.	Bill and Melinda Gates Foundation	56
3.	Deanship of Scientific Research, King Saud University	54
4.	Medical Research Council	45
5.	National Health and Medical Research Council	45
6.	Wellcome Trust	36
7.	European Commission	31
8.	National Heart, Lung, and Blood Institute	31
9.	National Institute on Aging	30
10.	Bundesministerium für Bildung und Forschung	24

A total of 2,692 keywords have been used by the authors and the list of top-20 keywords with occurrence rates as illustrated in Table 5. The keyword of Anesthesia occurred most of the time followed by Pain, Analgesia and Covid-19.

Table 5: List of top-20 Authors' used keywords and their occurrence rate generated by VOSviewers

Serial No.	Keyword	Occurrence Rate	Serial No.	Keyword	Occurrence Rate
1.	Anesthesia	47	11.	Sedation	16
2.	Pain	46	12.	Fentanyl	15
3.	Analgesia	32	13.	Ketamine	15
4.	Covid-19	31	14.	Morphine	14
5.	Dexmedetomidine	30	15.	Bupivacaine	13
6.	Lidocaine	22	16.	Neuropathic pain	13
7.	Opioids	19	17.	Postoperative	13
8.	Postoperative Pain	17	18.	Cardiac Surgery	12
9.	Inflammation	16	19.	Critical Care	12
10.	Oxidative Stress	16	20.	Guidelines	12

DISCUSSION

This bibliometric evaluation has yielded significant findings that provide researchers with an inclusive exploration of the documents published by Saudi Arabian affiliated authors in the field of anesthesia as reflected in the Scopus database. An assessment of research output in a particular area of knowledge supports researchers, academicians and authors in comprehending the dynamics of its growth.[17]

More than half of the documents on APM were contributed by three countries, the United States, China and United Kingdom with 39%, 8.26% and 6.64%, respectively. The share of Saudi Arabia was found 0.52%. The United States and United Kingdom accomplished noticeable positions in scientific research because they formulated research-generated organizations long ago but the Chinese emphasized scholarship and research mostly during the last two decades.[14] The research culture in health sciences has flourished gradually in Saudi Arabia. Initially, most of the research was contributed by researchers belonging to the two prominent institutions, King Saud University (Estb. 1957) and King Abdulaziz University (Estb. 1967). At the start of the 21st century, extraordinary development happened in the education sector, new universities were commenced and upgraded the facilities of existing institutions. The new high-tech research centers, unusual financial support and induction of talented workforce changed the scenario.[3,18] In line with this, our study identified that only 114 documents were published in the span of 26 years from 1983 to 2009 with an average of 4.38 docs/year on APM in Saudi Arabia. However, due to the tangible efforts of the government, the ratio of docs/year reached 118.2 in the last five years of study (2018-2022).

There is an interesting thing revealed through data analysis that 44% of the APM research at the global level was published in open-accessed format while the ratio of open-accessed was found quite higher (58.50%) in Saudi Arabia. One of the possible reasons is that Saudi authors mostly published their papers in open-accessed journals e.g., Saudi Journal of Anesthesia, Egyptian Journal of Anesthesia, Middle East Journal of Anesthesiology and Saudi Medical Journal. The ratio of subscription-based documents was quite high (78%) from 2004 to 2010, but the quantity of open-accessed documents increased in the last eight years as 66.37% of total documents were published as open-accessed.

In the analysis of international research collaboration, most of the documents were co-authored with Egypt followed by United State, Canada and United Kingdom and India. Another study on research collaboration in Saudi Arabia from 1984 to 2014 endorsed the similar findings as that study reported that the United States had been on top, followed by Egypt, United Kingdom, Canada and India. This article covered the complete research productivity indexed in the InCite feature of Web of Science whereas we covered only the documents on APM, but the collaboration looked the same with little variations.

The scrutiny of research growth by institutions in our study shows that King Saud University secured the topmost rank and contributed about one-fourth of the documents. There is a minute difference in research output between Imam Abdulrahman Bin Faisal University (n=135) and King Abdulaziz University (n=130). Another study on health sciences research in Saudi Arabia also reported that King Saud University the most productive institution followed by King Abdulaziz University.[19] Imam Abdulrahman bin Faisal University, Dammam (Estb. 1975) was in the fifth rank but in the current study, it occupied the second rank. It shows that Saudi institutions are striving to create more and more research. Mowafi reported that 55% of the anesthesiology research in Saudi Arabia was conducted in universities. Faculty members need research publications for promotion and upgradation and they have opportunities to get research grant.[15]

Al-Ghamdi and Mowafi examined research productivity on anesthesia produced by King Fahd Hospital located in Dammam. The researchers of this hospital contributed 151 documents in 30 years (1983 to 2013) with an average of about 5 docs/year. The average ratio of docs/year increased by about 10 documents during the last six years. The most documents were published in Canadian Journal of Anaesthesia, followed by Anesthesia and Analgesia.[20]

Funding plays a major role in clinical research. Our study investigated the funding sources, all the listed funding sources (Table-5) are international except serial no. 3. National Institute of Health, and Bill and Melinda Gates Foundation are on the top, this finding illustrates the fact that Saudi researchers mostly collaborated as co-authors in these studies. Overall, Deanship of Scientific Research, King Saud University was found on the third-ranked funding source but first-ranked in Saudi Arabia.

We don't segregate the documents by sub-categories of APM. We only performed the co-occurrence networks of authors' used keywords. "Anesthesia" was found to be the more occurred keyword followed by "Pain", "Analgesia" and "Covid-19". Future studies can carry out in-depth analysis of subject dispersion to highlight the strong and weak areas of APM research.

The current study only analyzed the Scopus-indexed documents on APM. The papers published in non-Scopus indexed journals have not been added so there is an urgent need for the inclusion of more journals published from Saudi Arabia in Scopus, PubMed and Web of Science. This will not only add to the impact of journals but also the articles published in these journals. The visibility of our research will also increase.

CONCLUSION

This study offers crucial information on the past forty years of APM to anesthetics, researchers, academicians and trainee officers. Saudi Arabia is one of the high-income countries and the findings illustrate that there is a lack of strong correlation between the research growth in APM and economic growth, especially before the year 2000. The government took gigantic initiatives in the education and health sectors at the start of the 21st century, so the increase in research performance during the last five years has been the result of these efforts. The findings of this study would

serve as a yardstick for future studies on APM and it is necessary to conduct such a study periodically. The findings are supportive of developing expertise and setting new benchmarks.

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