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Original Article

Radiology Section

A Scientometric Analysis of Scholarly Literature on Radiological Sciences from Saudi Arabia over the Last Thirty Five Years (1985-2020)

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ABSTRACT

Introduction: Scientometric analysis helps to measure the research growth and highlights the salient characteristics of the specific dataset. Saudi Arabia is rapidly growing country in the field of science and technology and remarkably contributing in the research productivity in all areas of health sciences, including radiological sciences from 1995 to 2000 and is drastically increased globally.

Aim: To analyse the credible literature on radiological sciences research from Saudi Arabia as reflected in the Scopus database.

Materials and Methods: This was a quantitative exploratory study based on scientometric analysis. The data was extracted from the Scopus database. The subject category of "radiology, nuclear medicine and imaging" was selected in the advanced search feature of the Scopus database. All the relevant scholarly literature consisted of articles and reviews indexed under the country name of Saudi Arabia published in English language from 1985 to 2020 were included for analysis.

Results: Saudi Arabia was ranked 33rd with 1,587 papers in radiological sciences, representing 0.43% of the global share. The slow progress was observed in the first 20 years but the remarkable growth was recorded during the last five years of study. King Saud University and King Faisal Specialist Hospital and Research Centre were the most contributing institutions. Saudi radiologists collaborated with 99 countries of the world and the United States was on the top. Four national journals were included in the list of top 10 preferred journals.

Conclusion: Although the rising tendency in radiological sciences research was evident during the last 10 years, still the share of Saudi Arabia was found much lower in comparison with the developed countries. Few well-established Institutions have taken lead in research productivity but a prioritised response from other Research Institutions is recommended.

Keywords: Radiology, Scientometrics research, Scopus

INTRODUCTION

In Arab peninsula, Saudi Arabia is the biggest country with a population of approximately 29.19 million. The country is bestowed with natural resources (natural gas, crude oil and minerals) which provides high income. The significance of higher education and research has been fully recognised and encourage young and seasoned researchers to conduct innovative research in the country. The present generation contribute positively in every share of knowledge. Presently, the countries provide broad education sector nation-wide, which delivers free education from pre-school to the university level [1].

The term Scientometrics was coined by Nalimov and Mulchenko in 1969 [2]. It is a quantitative method to monitor the scientific literature and research productivity of individual researcher, in a specific area of knowledge, research unit, Institution, country and it can be global as well [3]. The dataset of the academic literature is statistically analysed to describe publication patterns in a certain field of research. The raw data in scientometric studies is often generated from the reliable sources like, PubMed, Web of Science and Scopus to calculate the number of papers and their properties, e.g., citation count, authorship pattern, chorological growth, most productive authors and countries, preferred journals, collaborative design etc., [4]. The results of these studies are supportive in decision-making, allocation of research funding and examining the research policies as well as to identify the weak and strong area of research targets [5]. Glänzel W and Moed HF opined that it is difficult to quantify the value of research paper but the impact of journal and the number of citation speaks the credibility [6]. The citation means that how many times the other researcher used a research paper as reference in their papers. It is the best example of fair exchange of knowledge. In another article, it is stated that citation impact provides an unbiased and objective way to evaluate the performance of research [7].

Radiology is considered as one of the major specialty in medicine, which benefit the physicians in diagnosis and treatment of various diseases. Medical imaging improves the accuracy of diagnosis and effectiveness of the treatment. Several imaging modalities which are used for both diagnosis and treatment purposes include X-ray, computed tomography, fluoroscopy, magnetic resonance imaging and nuclear medicine. For example, X-rays are used for diagnosis of bone fractures and radiotherapy is used to treat different type of cancers [8].

The radiological science research productivity by 15 European countries from 1995 to 2000 based on the data extraction from Indian Standards Institute (ISI) Web of Science revealed that European authors contributed 40% of the global radiological research. Germany and United Kingdom were the leading contributors [9]. Another study dealt with the Ireland's research contribution in radiological sciences as indexed in PubMed from 2000 to 2015. A total of 781 articles were found and 71% were published in radiological journals, while 29% of the literature was published in medical journals. One-third percent of the articles belonged to abdominal radiology and 75% of the research was in collaboration [10]. Another study conducted in Pakistan from 1993 to 2008 focused on clinical radiology research, concluded that about half (47%) of the documents were indexed in PubMed and almost three-fourth (74%) were consisted of articles. The public sector Institutions contributed 64%, while 36% were

produced by private Institutions but 81% of the private sector research published in PubMed indexed as compared to 19% by public sector. The highest number of articles (n=43; 11%) were published in the Journal of Pakistan Medical Association and only 5% of the research was published in international journals [11]. Another study examined the publication growth and bibliometric indicators of the papers published in Radiological Clinics of North America from 2000 to 2019. A total of 1401 papers were identified and these documents gained 34,145 citations with an average of 24.37 citations per paper. Harvard Medical School and EY Lee were found to be the most productive institution and author with 123 and 26 documents, respectively. About 85% (n=1,194) of the total research was produced by the United States [12]. The present study is limited to the one database, Scopus and other databases were not taken into account. The present study aimed to analyse the credible literature on radiological sciences research from Saudi Arabia as reflected in the Scopus database from 1985 to 2020. The present study was conducted to achieve the following research objectives:

- To find out the global perspective of radiological sciences research from 1985 to 2020
- To assess the growth of radiological sciences research in Saudi Arabia by years and intervals
- To review the authorship patterns with citation impact of radiological sciences research in Saudi Arabia
- To segregate the papers by types and publication formats with citation impact
- To scrutinise the top 10 most preferred sources of publications
- To examine the productive Institutions and collaborating research countries in radiological sciences research in Saudi Arabia.

MATERIALS AND METHODS

The quantitative research method using scientometric analysis was applied on the dataset extracted in first week of May 2021 using the Elsevier-Scopus database. The Scopus provides comprehensive coverage of abstracting and other bibliographic indicators of peer-reviewed scholarly literature. The authors used the advanced search option, from the broad subject terms of health sciences, selected the *Medicine (MEDI),* and further its sub-category of "Radiology, Nuclear Medicine and Imaging" was selected. This term was pasted in the search box under the option of Enter query string. The principal author retrieved the metadata by using this method. The second author repeated the same method to validate the accuracy of data, the findings were the same. The investigators analysed the data and all the authors contributed significantly in the writing of manuscript.

Inclusion criteria: The time period of January 1st, 1985 to December 31st, 2020 was chosen from the year index and article and review were selected in the document type. First data was collected globally, then Saudi Arabia was selected in country index. Only papers published in English language were selected for analysis.

Exclusion criteria: The literature of 2021 was excluded as the year was not completed at the time of data collection and all the papers other than article and review were excluded.

Study Procedure

The complete bibliographic records of Saudi Arabian literature on Radiological Sciences were downloaded in Comma Separated Value (CSV) file to review the scientometric indicators of literature. Research performed by atleast one author affiliated to Saudi Arabia was selected. In Institutions and collaborative countries analysis, papers were written by more than one authors who belonged to more than one Institution or countries, these were included as distinct author, institution and country in the analysis. The ethical approval was not required for present study, since no human and animal subjects were involved and the data was readily available in the Scopus database.

STATISTICAL ANALYSIS

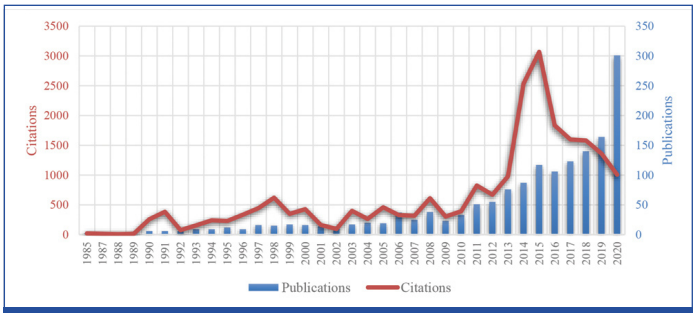
Descriptive statistics were used to analyse the data and the results are presented in the form of numbers and percentages.

RESULTS

Overview of global research in Radiological Sciences: A total of 3,66,673 papers (articles and reviews only) were produced by all world during the period of 35 years and more than one-third of the papers (n=1,31,471; 35.85%) were open accessed. The majority of research was produced by the United States (n=1,42,443; 38.84%), followed by Germany (n=34,495), Japan (n=30,384), China (n=27,278) and United Kingdom (n=27,228). The slightly less than two-third (n=2,38,763; 65.11%) of the total research on radiological sciences was contributed by top five countries.

Radiological Sciences research produced in Saudi Arabia by years: Saudi Arabia stands on 33rd rank with 1,587 papers during the same period, representing 0.43% of global share. [Table/Fig-1] demonstrated that growth of radiological sciences in Saudi Arabia from 1985 to 2020. A very slow productivity was recorded during the first twenty years from 1985 to 2005. A total of 211 (13.29%) papers were identified and first time, during the year 2011, Saudi Arabia crossed the figure of 50 and in 2015, the figure reached in three digits (n=117). Less than half (n=753;47.44%) of the research was published from 1985 to 2015 and the last five years marked tremendous progression of research productivity (n=834; 52.56%).

A total of 22,360 citations were gained by 1,587 papers with an average of 14.08 citations per paper. [Table/Fig-1] verified that first visible peak was observed with six papers published in year 1991 and these papers gained 383 citations. A gradual increase in citations was noted from 1992 (n=76) to 1998 (n=620). A fluctuated frequency of citations was detected from 1999 to 2010, but a remarkable progress in citations was seen from the year 2013 to 2015 as the highest peak shown in the year 2015, when 117 papers gained 3,068 citations with an average of 26.22 citations per paper. Although, the papers published in the last five years showed a decline in number of citations usually the latest papers received less citations as compared to older papers.



[Table/Fig-1]: Distribution of papers and citations by years.

Intervals	Total papers (%)	Total citations (%)	Average citation per paper
1985-1990	15 (0.94%)	315 (1.40%)	21
1991-1995	42 (2.64%)	1083 (4.84%)	25.79
1996-2000	73 (4.59%)	2173 (9.71%)	29.77
2001-2005	81 (5.10%)	1379 (6.16%)	17.02
2006-2010	156 (9.82%)	1952 (8.72%)	12.51
2011-2015	386 (24.32%)	8076 (36.11%)	20.92
2016-2020	834 (51.92%)	7382 (33.01%)	8.85

[Table/Fig-2]: Distribution of total papers, total citations and average citations per paper by five years' interval.

Distribution of papers, citations and average citations per paper by five years' interval: [Table/Fig-2] shows the distribution of 35 years into seven intervals consisting of five years each with total number of papers, citations and average citations per paper. The slow progress was recorded during the first four intervals while a little encouraging growth (n=156;9.82%) was noted during fifth interval (2006-2010) and more than three-fourth of total papers (n=1220;76.87%) has been produced during the last two intervals (2011-2020).

The highest numbers of citations (n=8,076;36.11%) was received by 386 (24.32%) papers published during the second last intervals from 2011-2015, followed by 7,382 (33.01%) citations of 834 (51.92%) papers during last interval (2016-2020), while the lowest being 1.40% during the first interval (1985-1990). The analysis of citation impact revealed that 73 papers published in the third interval (1996-2000) gained the highest average, 29.77 citations per paper, followed by 42 papers published during second interval (1991-1995) received 25.79 citations per paper. The lowest citation impact was observed in the last interval.

Authorship pattern with citation impact: [Table/Fig-3] described the authorship pattern of radiological sciences research in Saudi Arabia and its citation impact. About 9% (n=140) of the papers were written by single author pattern and these papers received 2,189 citations with an average of 15.64 citations, while slightly more than 91% (n=1,447) of the papers were the results of collaborative research papers in multi-author pattern and these papers gained 20,171 citations with a mean ratio of 13.94 citations per paper. The maximum 240 (15.12%) papers were written by four-author pattern but the highest citation impact was gone to 239 papers written by more than nine-author pattern with 29.76 citations per paper. The three-author pattern's paper got the lowest citation impact.

Authorship pattern	Total papers (%)	Total citations (%)	Average citations per paper
Single-Author	140 (8.82%)	2189 (9.79%)	15.64
Two-Author	137 (8.63%)	1653 (7.39%)	12.07
Three-Author	197 (12.41%)	1699 (7.60%)	8.62
Four-Author	240 (15.12%)	2614 (11.69%)	10.89
Five-Author	211 (13.29%)	2062 (9.22%)	9.77
Six-Author	173 (10.90%)	1799 (8.05%)	10.40
Seven-Author	120 (7.56%)	1517 (6.78%)	12.64
Eight-Author	83 (5.22%)	918 (4.11%)	11.06
Nine-Author	47 (2.96%)	797 (3.56%)	16.96
More than Nine-Author	239 (15.05%)	7112 (31.81%)	29.76

[Table/Fig-3]: Distribution of publications by authorship pattern with total papers, total citations and average citation per paper.

Segregation of the papers by types and publication formats with citation impact: Two types of paper, article and review were selected for analysis. [Table/Fig-4] stated that the most papers consisted of article type (n=1,342;84.56%) while 15.44% (n=245) of the papers belonged to review type. Although the review papers were much less in numbers but gained the higher average citations per paper as compared to articles. The review papers comprised of 15.44% total, which received 28.62% of the total citations with an average of 26.12 citations per paper whereas the articles gained an average of 11.89 citations per papers.

Out of total 1587, 43.91% (n=697) papers were open-accessed, the ratio of open accessed was more in articles as compared to reviews. Overall the open-accessed papers gained 9,740 citations with an average of 13.97 citations but an average ratio of citations was much higher in review (40.93 citations per review as compared to 10.03 citation per article). A more than half (n=880; 55.45%) of the papers fall in category of subscription-based and these papers gained slightly the higher citation impact with 14.34 citations per paper as compared to open-accessed paper.

Preferred sources of publications: [Table/Fig-5] verified that almost one-fifth (n=304;19.15%) of the total papers were published in top 10 frequently used journals and 151 (9.51%) papers were published in four national journals, Saudi Medical Journal, Annals of Saudi Medicine, Neuroscience and Annals of Thoracic Medicine.

Saudi Medical Journal was found the topmost preference with 62 papers followed by Annals of Saudi Medicine and Egyptian Journal of Radiology and Nuclear Medicine with 49 and 44 papers, respectively. Although Clinical Nuclear Medicine ranked 7th with 21 papers but having the highest average citations, 28.80 citations per paper in the top 10 category.

Fifteen topmost contributing Saudi Institutions: [Table/Fig-6] shows the top-15 research producing Saudi institutions in radiological sciences and top-four Institutions contributing more than 100 papers each. King Saud University, the oldest and premier Institution emerged as most productive Institution with 373 papers followed by King Faisal Specialist Hospital and Research Centre, King Abdulaziz University and King Saud bin Abdulaziz University for Health Sciences with 302, 191 and 157 papers, respectively. Princess Nourah bint Abdulrahman University stood on 15th number with 27 papers. Collectively, 1,236 (77.88%) papers were produced by the authors affiliated to top 15 Institutions of Saudi Arabia. In instance, a paper written by authors affiliated to two different

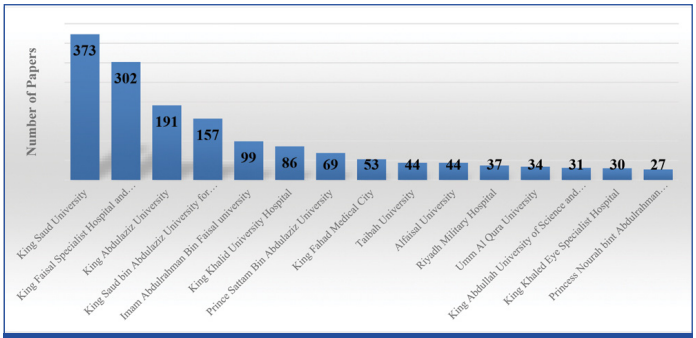
Types	Total papers (%)	Total citations (%)	Average citations per paper	Open-accessed papers (%)	Total citations (average citation per paper)	Subscription-based papers (%)	Total citations (average citation per paper)
Articles	1342 (84.56%)	15960 (71.38%)	11.89	608 (45.30%)	6097 (10.03)	734 (54.69%)	9863 (13.44)
Reviews	245 (15.44%)	6400 (28.62%)	26.12	89 (36.32%)	3643 (40.93)	146 (59.59%)	2757 (18.88)

[Table/Fig-4]: Distribution of type of papers, total papers, total citations, average citation per paper with open and subscription-based modes.

Serial no.	Name of journal	Total papers	Total citations	Average citations per papers
1.	Saudi Medical Journal	62	253	4.08
2.	Annals of Saudi Medicine	49	288	5.87
3.	Egyptian Journal of Radiology and Nuclear Medicine	44	52	1.18
4.	International Journal of Surgery Case Reports	29	25	0.86
5.	Radiation Physics and Chemistry	28	103	3.67
6.	Neurosciences	24	58	2.41
7.	Clinical Nuclear Medicine	21	605	28.80
8.	Plos One	16	391	24.43
9.	Annals of Thoracic Medicine	16	192	12.00
10.	Applied Radiation and Isotopes	15	61	4.06

[Table/Fig-5]: Top 10 preferred sources of publications.

Institutions, were treated, as separate entities, but collectively it was considered as single paper.



[Table/Fig-6]: Top-15 most contributing Saudi Institutions.

International research collaboration: Saudi authors collaborated with 99 countries, out of which 26 countries contributed in one paper each, while seven countries contributed in two papers each and 13 countries with three papers each. There were 35 countries having the research collaboration in more than 10 papers each and top-15 countries were shown in the [Table/Fig-7]. The highest number of papers (n=271;17.07%) were collaborated with the United States followed by Egypt, Canada and United Kingdom, respectively. However, Switzerland being 9th in the list was having the highest average citation with 54.17 citations per paper, this ratio was recorded 29.12 with the United States. The Sudan had the lowest citation impact in top-20 countries with 4.15 citations per paper. Vintage Original Specification (VOS) viewer software was also used to identify the total publications, citations, and their impact and link strength [Table/Fig-8].

Serial No.	Name of country	Total papers	Total citations	Average	Link strength
1.	United states	271	7892	29.12	960
2.	Egypt	195	2185	11.20	381
3.	Canada	178	3864	21.70	613
4.	United Kingdom	153	3923	25.64	626
5.	Germany	74	3531	47.71	559
6.	Italy	68	2857	42.01	516
7.	Australia	64	2023	31.75	374
8.	Netherlands	60	2098	34.96	470
9.	Switzerland	56	3034	54.17	493
10.	South Korea	55	1210	22.00	315
11.	France	50	2045	40.90	362
12.	Malaysia	49	318	6.48	139
13.	India	46	642	13.95	184
14.	Austria	44	2285	51.93	385
15.	Sudan	40	166	4.15	101

[Table/Fig-7]: Top-15 research collaborative countries.

[Table/Fig-8]: Co-occurrence of collaborative research.

DISCUSSION

The improvement in the healthcare delivery system is linked to the quality research and the research findings support in policy making process [1]. Over the last two decades, the Saudi Government has significantly invested in the field of higher education, upgradation of academia and established new universities, as well as, state of the art hi-tech research centers [3]. All these efforts enhance the research output so it is imperative to assess the growth of research time to time. The scientometric method help to analyse quantitatively the various attributes of scientific research publications over a given period of time [13].

In the past, scientometric analysis on pharmaceutical sciences research in Saudi Arabia from 2001 to 2010 and another study on the growth of diabetics' research were performed [14,15]. The data of first study was extracted from the Scopus database while the later study based on the Web of Science. Some other bibliometric studies on Saudi Arabian medical research productivity, were also performed, identifying the various trends and characteristics of publications [3,10,16]. Other bibliometric analysis covered the areas of neuroscience and cardiovascular research in Saudi Arabia [17,18]. The review of related literature exposed that no scientometric study was carried out on radiological sciences in Saudi Arabia. The current study was performed to fill the knowledge gap.

In the present study, it is encouraging to perceive that the scientific research output in radiological sciences by Saudi Arabia significantly increased during the last decade. Overall, the findings reveal that research productivity of radiologists in Saudi Arabia is comparatively low (0.43%) in comparison with global research in radiological sciences. The possible factors behind inadequate radiology research during the first 20 years were the lack of research expertise, archiving facilities and non availability of advanced technology in radiological departments. These problems have been overcome through promotion of academic research training, and by providing hi-tech radiological equipment and digital archiving.

A total of 1,587 papers were identified with the atleast one author affiliated to Saudi Arabia in the Scopus database with an average annual growth rate of 22.83. The scholarly literature consisted of article and review were selected and these papers gained 22,360 citations with a mean ratio of 14.08 citations per paper. The papers published during 1996-2000 gained the highest, 29.77 citations per paper.

Although a total of 19,890 authors contributed in 1,587 papers, but there were 16 global level studies having more than 100 authors each, consisted of about half of the authors (n=9990; 50.22%). To avoid the bias in number of authors per paper, these 16 papers were excluded. The remaining 1,571 papers were written by 9,900 authors with an average of 6.30 authors per paper. The majority of research was multi-author and the highest number of papers were written in four-author pattern. Interestingly, the single author papers got the third highest citation ratio, 15.64 citation per paper. In present study, 90% of the research was performed in collaborative pattern while in Aldhebaib AM et al., study reported that the 1,401 papers were published in Radiological Clinics of North America from 2000 to 2019, 72% of the research was multi-author [12].

The analysis of paper's type revealed that review papers gained more citations as compared to articles and the toll-based articles received the higher number of citations as compared to open-accessed articles. One-fifth of the total papers were published in top 10 journals and Saudi Medical Journal had been the top preference followed by Annals of Saudi Medicine. King Saud University was emerged as the most productive institution with slightly less than one-fourth (n=373; 23.50%) of the total publications, followed by King Faisal Specialist Hospital and Research Centre (n=302;19.02%). Previous studies also endorsed the same results [3,19]. In research collaborative countries, the United States had been on the top with 271 papers, followed by Egypt, Canada and United Kingdom with 195,178 and 153, respectively. In the analysis of citation impact, Switzerland was on the top in the quality research collaboration as 56 co-author paper gained an average of 54.17 citations per paper, whereas the

papers with the United States gained 29.12 citations per paper. Shehatta I and Mahmood K evaluated the research productivity of Saudi Arabian authors from 1980 to 2014 and they also recognised that most of the research was performed, in collaboration with these four countries [20].

Limitation(s)

The present study covered only the scientometric properties of radiological research produced by Saudi Arabia only indexed in one database, Scopus. The future studies could include PubMed and Web of Science database also. The authors didn't perform the subject dispersion and research methodologies of the retrieved data. The search was performed in the Scopus database that have comprehensive coverage of scholarly literature, hence, the study weakness was that the findings did not include studies, that were not indexed in the Scopus, especially some local journals and unpublished data was also not included. The authors used the advance search strategic term that was highly sensitive. The finding of the present study would be considered as bench for the future studies. The future studies can segregate the research by specialty and research method to highlight the research trends and discuss the factors of low productivity, as compared to other developed countries of the world.

CONCLUSION(S)

Research productivity in radiological sciences has been adequately improved in the recent past, as Saudi Arabia contributed 0.41% in global radiological research, during 2011 to 2015 and this ratio reached 0.61% from 2016 to 2020. It was possible due to the solid research support through academic Radiological Departments and provision of sufficient financial support. There is a dire need for building research capacity, amongst radiologists working in academic Institutions and hospitals for promoting evidence-based radiological research.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: May 14, 2022
- Manual Googling: Oct 12, 2022
- iThenticate Software: Oct 28, 2022 (5%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:

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- For any images presented appropriate consent has been obtained from the subjects. NA

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