

Research Productivity in the Health Sciences in Saudi Arabia: 2008-2017

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The purpose of this study was to analyze the published research on health sciences carried out by researchers in Saudi Arabia in the last decade by assessing bibliometric output. Data for 2008 to 2017 was retrieved from Scopus. During this period, there was significant growth, from 1332 publications in 2008 to 5529 in 2017, with an average annual growth rate of 14.1%. King Saud University was the most productive institution. Most of the published research was done in collaboration with Egypt. The subject area of medicine was predominant with the main publication source being the *Saudi Medical Journal*, *Life Science Journal*, the *Acta Zhengzhou University Oversea Version*, and the *Annals of Saudi Medicine*, primarily in the form of original research articles. The growing trend in publications is a sign of the increasing quality of education and more research and development activities, which are made possible by a sufficient budget allocation to these activities during the last decade.

Saudi Arabia spends 5.1% of its gross domestic product (GDP) on education and 4.7% of GDP on health, with the result that there are 2.39 physicians per 1000 population, which is highest in the Middle East and comparable to the United States (2.59), the United Kingdom (2.81) and the United Arab Emirates (2.39).¹ The literacy rate in Saudi Arabia is 94.7%. Research and development have been prioritized in the Saudi Vision 2030 program with ambitious goals set to attain an international standard in higher education. A goal of Saudi Vision 2030 is that at least five Saudi universities be among the top 200 universities in the world by 2030.² The 2020 Times Higher Education World University Ranking includes seven Saudi universities among the 1400 universities of the world. This ranking criterion takes into account important parameters of research productivity namely teaching, research, citations, industry outcome and international outlook.³ King Abdulaziz University (KAU), the number 1 university in Saudi Arabia, has reached a world ranking in the 201-250 universities group. KAU is followed by Alfaisal University that is ranked in the 251-300 group. King Saud University (KSU) and King Saud bin Abdulaziz University for Health Sciences (KSAU-HS) are within the 501-600 rank/. KSAU-HS, a specialized health sciences university has been included in this ranking recently.³

To ensure that a certain policy is producing the desired benefits, it is important to monitor and evaluate the programs. Productivity in the field of medical education and research can be measured by several variables. The

number of research publications is one of the indicators that can be used to evaluate productivity as well as the quality of research.^{4,5} This can be achieved by using bibliometric analysis.

Bibliometric analysis involves a combination of statistics and mathematics in the assessment of scholarly published research.⁶ It is frequently used to measure the research output of an institution,⁷ a country,^{8,9} or a region.¹⁰ It can also be used to evaluate different parameters of research published in a specific journal.¹¹ This kind of analysis presents a quantitative portrait of research performance and local and international collaboration, highlights the prevailing trends, indicates strong and weak areas of research, and provides new guidelines for researchers and policy makers.^{8,9}

Many studies in this area have yielded valuable insights. One such study on biomedical research in Saudi Arabia covered the period of 19 years from 1982 to 2000.¹² A total of 5962 documents were published in PubMed indexed journals with an average of 313.78 papers per year. Slightly more than half of the publications (51.0%) came from KSU and King Faisal Specialist Hospital and Research Center (KFSHRC). Saudi Arabia published 27.6% of the total research published in the Arab World during this period.

Shehatta and Mahmood⁸ presented the research productivity status of researchers affiliated with institutions in Saudi Arabia over the period of 1980-2014. A total of 74767 publications were recorded, out of which 24 937 (33.4%) publications were in the 'Clinical, Pre-Clinical, and Health' categories. Meo et al⁶ reviewed research growth in the medical and allied sciences in Saudi Arabia for 1996-2012. A total of 27246 publications were identified in the Web of Science database, at an average 1816.4 papers published per year during the 15-year period. However, only 151 papers were published in high impact factor journals during the period, including 16 in the New England Journal of Medicine and 17 in the Lancet.

A study on pharmaceutical research in Saudi Arabia reported that 1386 papers were published during the ten years from 2001-2010 with an average annual growth rate of 14.21%.¹³ In a similar analysis, Latif⁵ analyzed the quantity and quality of medical research produced by Saudi Arabian researchers during 2008-2012. A total of 1562 publications were recorded with an average of 312.4 articles per year. Almost half of the papers included in this study were published in journals having an impact factor of less than 1.0. Another analysis by Jamjoom calculated the relative specialization index of different specialties of medicine in Saudi Arabia and made worldwide comparisons.¹⁴

Bibliometric studies from the rest of the Arab world have also revealed notable findings. AlRyalat and Malkawi executed a study on research output by Jordan-affiliated authors. Using the Scopus database, they found 20359 publications published between the years 2008 to 2017. The analysis revealed that researchers working in Jordan frequently collaborated with the United States, Saudi Arabia and the United Kingdom. Almost half of the publications (47.9%) were produced by the University of Jordan and Jordan University of Science and Technology.¹⁵ Similarly, Sweileh et al examined the publication growth of biomedical science in Palestine during the period of 2002 to 2011, and found 2207 articles in Scopus index journals. More than one-third (n=770; 34.9%) were related to medical sciences. Al Quds University was the most productive institution with 162 publications. Most of the publications were published in the Eastern Mediterranean Health Journal.¹⁶

The data used in bibliometric studies of all health-related disciplines have come from PubMed^{4,5,12} and the Web of Science database.^{6,8} All of the studies from the Scopus database were limited to a single medical specialty¹³ or institution.^{17,18} KSU was the most productive institution in the studies retrieved from the Scopus database. Most of the research was produced from Riyadh Province and original research articles were the most frequent choice of format. Other studies have analyzed barriers that impede research productivity.¹⁹ Among the factors identified in this regard include rank of full professor and tenured status, possibly due to lack of time and administrative burden.²⁰

The present study was conducted using the Scopus Database, which provides comprehensive coverage of the global literature in contrast to PubMed and Web of Science.¹³ Furthermore, no comprehensive study has covered all the major disciplines of the health sciences in Saudi Arabia during the most recent decade. The aim of this study was to present the bibliometric indicators of publication output in health sciences research in Saudi Arabia for the period of ten years from 2008 to 2017.

METHODS

Research productivity is a measure of the production of new knowledge. In bibliometric terms, this is quantified by the number of publications.²¹ The bibliographic data were retrieved in September 2018 from Scopus, a multidisciplinary database (<https://www.elsevier.com/en-gb/solutions/scopus>), using the terms 'Saudi Arabia' and the option 'affiliation country'. The limit search option of Scopus was used to obtain the data published between 1 January 2008 and 31 December 2017.

Publications having at least one researcher with Saudi Arabia as the affiliated country (an affiliated address in Saudi Arabia) were included in the data, whether principal author or contributing authors.

Saudi researchers contributed to publications in 28 subject categories during the specified time period; nine categories were related to health sciences. The current study focused on research productivity in nine health-related subject categories: (1) medicine, (2) biochemistry, genetics and molecular biology; (3) dentistry; (4) health professions; (5) immunology and microbiology; (6) neuroscience; (7) nursing; (8) pharmacology, toxicology and pharmaceuticals; and (9) psychology. The results were downloaded as a comma-separated values (CSV) file format and transferred into Microsoft Excel. To ensure the reliability and reproducibility of our search, authors individually repeated the searches on Scopus using the same criteria. In addition to this, the authors separately checked the study results to exclude duplicates. Data were distributed in chronological order to gauge the growth rate by year. The following formula²² was used to calculate the average annual growth rate. $\text{Annual growth rate} = 100 \times ((\text{most recent value} - \text{past value}) / (\text{past value}))$

The data on research institutions mainly consisted of the number of publications produced by the affiliated researchers. Affiliated countries and institutions, other than Saudi Arabia, were considered as research collaborative countries and institutions. The data were analyzed using Microsoft Excel and SPSS software. The independent sample *t* test was used to assess differences based on type of publication (teaching vs health care) and age (founded before 1990 vs founded after 1990) of the institutes.

RESULTS

Distribution of publications by year

Figure 1 shows the number of publications by year. There were a total of 35 291 items and an average annual growth rate of 17.7%. The highest annual growth rate (34.3%) occurred during 2010-2011. The number of publications increased each year with the highest number of publications in 2017, the last year of data collection ($n=5529$; 15.7% of the total). Growth during the last four years was promising ($n=20\,796$; 58.92%) (2014 to 2017).

Distribution of publications by institution

Table 1 shows the top 20 research-producing institutions consisting of 14 universities, 5 hospitals and the Ministry of Health, Saudi Arabia. KSU produced the highest num-

ber of research papers ($n=10\,162$; 28.79%), followed by KAU with 5962 (16.89%) publications and KFSHRC with 3268 (9.26%) publications. During the same period, KSAU-HS produced 1678 (4.75%) publications, Imam Abdulrahman Bin Faisal University (IAU) produced 1617 (4.58%) and King Khalid University Hospital (KKUH) had published 1223 (3.46%) articles. Only eight organizations produced more than 1000 publications in health sciences during the targeted period. Out of a total 35 291 publications, 34 685 research documents ($n=27901$; 79.1%) were produced by 12 organizations, established before the year 2000 whereas the remaining eight institutions contributed only 7610 (21.56%) of the total publications.

There were no statistically significant differences in productivity based on type (teaching vs health care) using the independent sample *t* test ($P=.614$), but the apparent trend was towards a greater number of publications from teaching institutions (1914 vs 1314 publications). The research productivity comparison based on the age of the institute (founded before 1990 vs founded after 1990) showed a statistically significant difference, with older institutions producing more publications during the period ($P=.03$).

Distribution of publications by country

Authors affiliated with Saudi Arabia collaborated in scholarly publications with the researchers of 159 countries. The largest number of collaborative research articles were produced in collaboration with Egypt ($n=5813$, 16.5%) and the United States ($n=5768$, 16.3%).

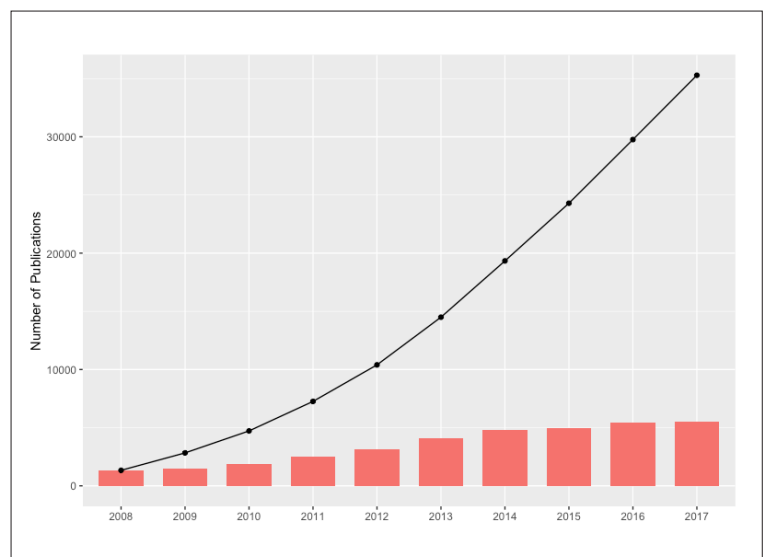


Figure 1. Annual number of publications (bars) and cumulative number of publications (line). Average annual growth rate available on interactive graph <http://plaguescapes.io/F10830x.html>

Table 1. Top 20 research-producing institutions in health sciences in Saudi Arabia (2008-2017).

Rank	Institution	Type of Institution	Founded in	Publications (n) (%)
1	King Saud University	Teaching	1957	10 162 (28.8)
2	King Abdulaziz University	Teaching	1967	5 962 (16.9)
3	King Faisal Specialist Hospital and Research Centre	Healthcare	1975	3268 (9.3)
4	King Saud bin Abdulaziz University for Health Sciences	Teaching	2005	1678 (4.8)
5	Imam Abdulrahman Bin Faisal University	Teaching	1975	1617 (4.6)
6	King Khalid University Hospital	Healthcare	1982	1223 (3.5)
7	King Abdulaziz Medical City	Healthcare	1983	1110 (3.1)
8	Taibah University	Teaching	2003	1002 (2.8)
9	Alfaisal University	Teaching	2002	894 (2.5)
10	Ministry of Health	Healthcare	1950	836 (2.4)
11	King Khalid University	Teaching	1998	826 (2.3)
12	Umm Al Qura University	Teaching	1981	778 (2.2)
13	Al Qassim University	Teaching	2004	752 (2.1)
14	King Khaled Eye Specialist Hospital	Healthcare	1983	726 (2.1)
15	King Fahad Medical City	Healthcare	1983	721 (2.0)
16	Taif University	Teaching	2004	716 (2.0)
17	King Faisal University Al-Hasa	Teaching	1975	672 (1.9)
18	Jazan University	Teaching	2006	650 (1.8)
19	King Abdullah University of Science and Technology	Teaching	2009	588 (1.7)
20	Prince Sattam Bin Abdulaziz University	Teaching	2009	504 (1.4)

$P=.614$ for comparison by type of institution (independent t test).

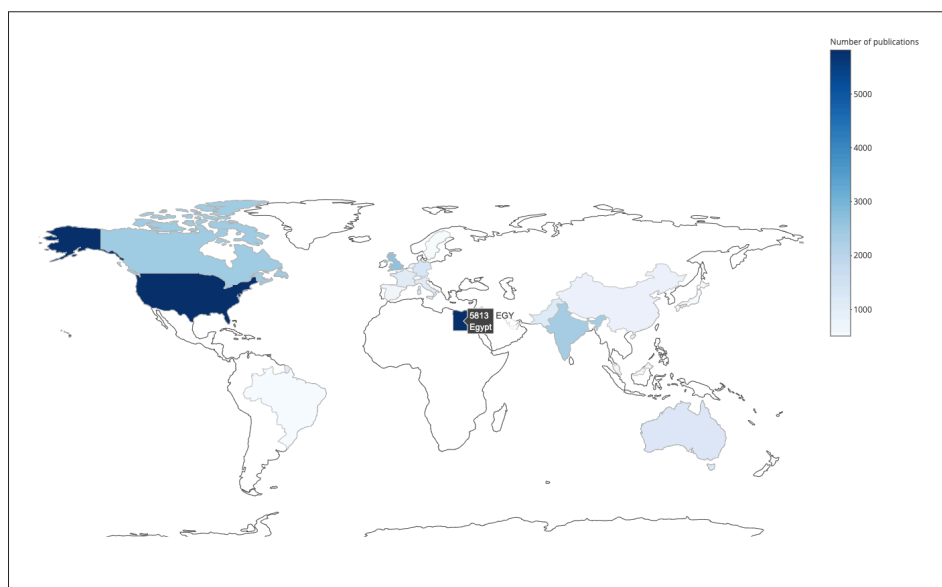


Figure 2. Top 20 countries collaborating with Saudi Arabia in health research from 2008-2017 as measured by number of publications (total n=35 291). For interactive map with data on all countries go to: <http://plaguescapes.io/0830T3F1.html>

The United Kingdom was in the third position followed by Canada, India, Germany, Australia and Pakistan. At least 1000 jointly published papers were recorded in collaboration with authors from 10 different countries. This indicates that Saudi Arabia has strong intellectual ties with these countries and their academic communities. Among the top 20 collaborating countries, Egypt, UAE, and Jordan are in the Arab region (**Figure 2**).

Table 2 shows the international co-authorship of researchers by institution. The majority of research was in collaboration with Cairo University in Egypt followed by the National Research Centre in Egypt and Mansoura University in Egypt. Other major research collaborations existed with the University of Toronto in Canada, Harvard Medical School in the United States and University College London in the United Kingdom (n=373; 1.1%).

Distribution of publications by subject

Health sciences publications were classified in nine broad subject categories by Scopus as shown in **Table 3**. Medicine as a subject had the most publications followed by biochemistry, genetics and molecular biology, pharmacology, toxicology and pharmaceuticals and immunology and microbiology. Nursing and other health professions (n=600; 1.3%) produced less research than the other categories.

Keywords

The targeted 35291 publications covered a large number of keywords. Scopus produced a list of 160 most frequently used keywords. In Scopus, keywords are a combined field that searches the keywords and index terms supplied by the author. It helps to identify the subtopic of a document. The keyword 'controlled study' was used 10852 times (**Figure 3**). 'Child' was used 4047 times. The keyword 'clinical trials' was found 988 times. Saudi Arabia ranks 40th in the world in frequency of the keyword "clinical trials" used in the published research on Scopus during the specified period.

Article category and publication type

Most of the publications (n=34,537; 97.9%) belonged to the category 'journal articles', including original research articles for 28 931 (82.0%) followed by review articles (n=3,237; 9.17%), letters (n=1088; 3.08%), and editorials (n=475; 1.34%). Other types of publications included 37 conference proceedings and 9 trade publications. Following the journal article category, publications in the books category (n=750) that included book chapters as well as book series were most numerous. Four publications remained undefined. Amongst the top 20 most frequently targeted journals, 12 are published by orga-

nizations inside Saudi Arabia, whereas two journals from the United States and Pakistan each, and one journal published by organizations based in China, India, Iran and Switzerland each. A total of 6453 (18.28%) articles were published in the top 20 of the included journals. The majority of the articles (n=1328; 3.8%) were published in the *Saudi Medical Journal*, followed by the *Life Science Journal* (n=977; 2.8%) and the *Annals of Saudi Medicine* (n=540; 1.5%).

DISCUSSION

We selected Scopus for our study because it is a multi-disciplinary database that covers all academic subjects. It is the largest abstract and citation database of peer-reviewed literature.²³ Scopus features smart tools that allow tracking, analyzing and visualizing the targeted research. It has more than 69 million records from 22 800 periodicals, 8 million conference papers and 150

Table 2. Top 20 international institutions in collaboration with institutions in Saudi Arabia (2008-2017).

International Institutions	Country	Publications (%)
Cairo University	Egypt	1088 (3.1)
National Research Centre	Egypt	688 (1.9)
Mansoura University	Egypt	686 (1.9)
Al-Azhar University	Egypt	637 (1.8)
Alexandria University	Egypt	591 (1.7)
Ain Shams University	Egypt	579 (1.6)
University of Toronto	Canada	573 (1.6)
Zagazig University	Egypt	472 (1.3)
Assiut University	Egypt	456 (1.3)
Harvard Medical School	United States	409 (1.2)
University College London	United Kingdom	373 (1.1)
Inserm (French National Institute of Health and Medical Research)	France	367 (1.0)
McGill University	Canada	367 (1.0)
Suez Canal University	Egypt	334 (0.9)
University of Tanta	Egypt	306 (0.9)
The University of British Columbia	Canada	286 (0.8)
Beni-Suef University	Egypt	280 (0.8)
Karolinska Institutet	Sweden	255 (0.7)
Johns Hopkins University	United States	250 (0.7)
University of Oxford	United Kingdom	244 (0.7)

000 electronic books from more than 5000 publishers in 105 countries. Out of the total 22 800 titles in Scopus, almost one-third (n=7133; 31.3%) are related to health sciences.²³

We found 35291 publications with an average of 3529 publications per year affiliated with Saudi Arabia for the years from 2008-2017. There was a growing trend with an average annual growth rate of 17.7%. The results indicate that Saudi health sciences research is moving ahead in terms of number of publications and international collaboration. These results are consistent with other studies that report that research in health sciences has increased over the last ten years. Saudi Arabia has played a leading role in medical education and research

Table 3. Distribution of publications by subject.

Subject	Frequency of publications (%)
Medicine	24546 (54.3)
Biochemistry, genetics and molecular biology	8568 (19.0)
Pharmacology, toxicology and pharmaceuticals	4531 (10.0)
Immunology and microbiology	2743 (6.1)
Dentistry	1970 (4.3)
Neuroscience	1197 (2.7)
Psychology	325 (0.7)
Nursing	708 (1.6)
Health professions	600 (1.3)

in the Arab world during this time.^{4,6,8} These findings are also in line with the overall advancement in scientific research in the Middle Eastern region as one Scopus based bibliometric study from Jordan reported similar increases in the number of research articles and international collaborations between 2008-2017.¹⁵ Our finding that KSU was the most productive institute and that 2017 was the most productive year are also consistent with the the data reported by Gadhouma and Karamb.²⁴ The *Saudi Medical Journal* remained the most favorite journal for researchers during the period. As universities are considered the hub of research activities, the majority of research (75%) was produced by the university sector. The most active organizations included KSU, KAU and KFSHRC. KSU has been previously reported as the top of the four Arab world universities in terms of health-related research productivity.²⁵ The top 3 universities of Saudi Arabia are all at least 50 years old. Two are located in Riyadh and one in Jeddah. By virtue of their history and location, they seem to be attractive places for researchers and professionals. This may indirectly explain the diverse team structure and availability of more funds. By comparison, in a similar Scopus query on the health research productivity of Jordan, the University of Jordan (established in 1962) was the most productive and newer universities like the Jordan University of Science and Technology (established in 1986), and the King Hussain Cancer Center (established 1997) were next in number of research publications.

Participation in collaborative research programs is positively related to the productivity of individual researchers.²⁶ An analysis of international research collaboration shows that Saudi Arabia affiliated researchers mostly collaborate with Egyptian universities, followed by the United States, United Kingdom and Canada. Shehatta and Mahmood⁸ also confirmed these results. Saudi Arabia has strong cultural and educational relations with Egypt. In addition to that, Saudi Arabia has established reliable collaborations with technologically advanced countries like the United States, Canada and the United Kingdom by sending students to those countries for higher education.²⁷ The active collaboration with technologically advanced countries leads to training of personnel in the latest and cutting-edge technology. This practice also improves the quality of publications. Collaborative papers are more often accepted in high impact factor journals and get a higher number of citations and visibility.²⁸ Another important indicator of quality of research is the type of research publication. The finding that original research articles outnumbered all other types is an indication that researchers have conducted genuine research.

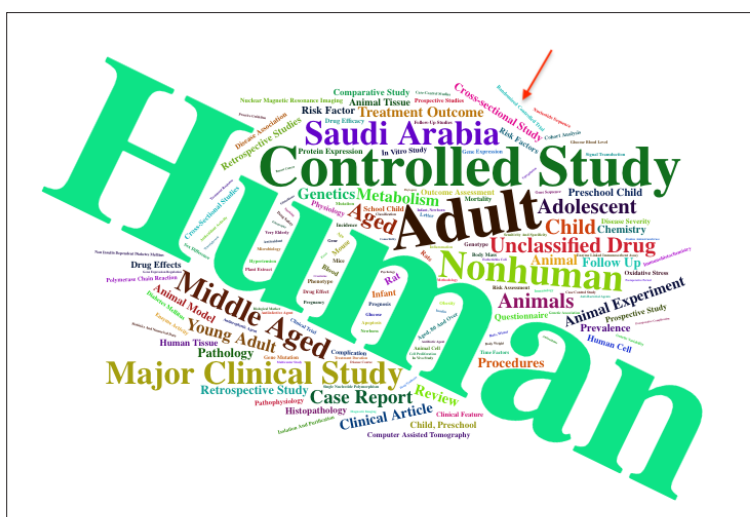


Figure 3. Word cloud of most frequent keywords in Saudi health-related articles in the Scopus database (larger font size indicates more frequent term).

Analysis of distribution by subject category reveals that the specialty of medicine has the highest number of publication entries, followed by biochemistry, genetics, and molecular biology. Nursing, psychology and neuroscience were the categories with the least number of publications. When compared to the results of a separate search query in Scopus on the worldwide productivity of the aforementioned 9 categories during the same period of time, nursing, psychology and neuroscience were second, third and sixth in rank, respectively. This implies that these areas need more attention from policy makers as well as researchers in order to achieve a globally streamlined research focus.

It is noteworthy that researchers affiliated with KSU and KFSHRC are the most productive in terms of number of publications. This can be attributed to multiple factors. Among these, institution-specific factors like availability of funds, research infrastructure, opportunities for collaboration, a large and multidisciplinary research team, large datasets and an enabling environment are notable. However, individual factors including dedication and commitment, original ideas, good academic writing and research skills and simultaneous attention to empirical and conceptual work also bear significance. These parameters, however, remain unquantifiable in a bibliometric analysis.

Twelve of the 20 most frequently targeted journals by Saudi researchers are locally published entities. It is a good sign that high-quality articles have been published in local journals. This practice helps to improve the citations impact of local journals in the global ranking. Other factors that may contribute to selection of a local journal are that local studies may be more easily accepted in locally published journals, publication and review criteria may be lenient as compared to high impact factor journals, faster review and processing, and low publications charges. Latif's study suggested that Saudi researchers should try to publish their papers in higher impact factor journals⁵. In our opinion, population-based studies should be published in local journals while basic and applied research should target a wider audience through high impact factor international journals.

The Saudi government needs to not only maintain current financial support to higher education, but also provide more incentives to researchers by launching research-based postgraduate degree programs for clinicians, facilitate collaboration between academia and industry, establish multidisciplinary research labs in hospitals and increase the involvement of graduate students in research. The rank of 40 for Saudi Arabia in the frequency of the keyword 'clinical trials' in the

Scopus search reflects the rarity of this more expensive type of research and the need to address the issue. Research output is one of the important indicators of the international standards of higher education institutions. Other indicators include standard of teaching, citations, industry income and international outlook. Furthermore, ranking is calculated on the basis of the number of full-time equivalent students, student-staff ratio, enrollment of foreign students, and male-female student ratio.²⁹ Postgraduate medical research programs and high-quality health care with a research motivated staff and international research collaboration can help create a sustainable research environment. Publications with innovative ideas will enhance the visibility and credibility of Saudi Arabia research-producing institutions.

Limitations of research and future directions

Our study only analyzed the number of publications and not the quality and citation impact of publications, which is a limitation. The current study was also limited to Scopus. The number of publications produced by researchers affiliated with Saudi Arabia might be higher if one included Scopus results with Google Scholar. Future research might compare Saudi health research productivity with other countries (high income, scientifically advanced countries, middle income with proficient research contribution, and low-income developing countries). Another interesting study could be a citation analysis of subjectwise research publications and multidisciplinary collaboration. The contribution of expatriate and foreign faculty working in Saudi Arabia may also be explored to guide the policy making process.

CONCLUSION

This study documents an increase of 14.1% in the number of publications per year from 2007-2018 in the health research category. Moreover, the study identified institutions that contributed the highest number of publications, namely KAU, KSU and KFSHRC. In addition to this, Egypt and the United States collaborated more frequently than other countries with researchers in Saudi Arabia. Additionally, the journals that published most of the research studies in the specified period were the *Saudi Medical Journal*, *Life Science Journal* and the *Annals of Saudi Medicine*. Our study also highlighted the fact that older institutions are more productive than newly established institutions. Lastly, the categories of medical research that need most attention to increase publication output are neuroscience and nursing.

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