Bibliometric analysis of Neurosciences research productivity in Saudi Arabia from 2013-2018

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ABSTRACT

Objectives: To review the dynamics of neuroscience research in the Kingdom of Saudi Arabia (KSA) from 2013-2018.

Methods: Subject category of Neuroscience was selected in the SciVal feature of Scopus database, which includes all relevant categories of the field limiting it to Saudi Arabia.

Results: Saudi Arabia is ranked 39th in publishing neuroscientific research worldwide. The number of yearly published articles has increased from 123 to 332 during the time period between 2013 and 2018. King Saud University & King Abdul Aziz University & their corresponding regions namely Western and Central regions are the major contributors to publications. Neuroscientists working in Saudi Arabia have collaboration with scientists from all over the world. The top 10 preferred journals are all international. In subcategories of neuroscience, developmental neuroscience seems the one that needs attention.

Conclusion: Neuroscience research is on the rise in KSA. Older and well-established institutions like King Saud University & King Abdul Aziz University have taken lead in publishing neuroscientific research. International collaboration in all subfields of neuroscience is substantial. Eastern Southern and Northern regions and developmental neuroscience require more focus and funding.

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Education and research are the cornerstones that form the basis of sustainable growth in a country. Concepts such as knowledge-based economy and bioeconomy have become popular in the 21st century. University-industry collaborations and protection
of intellectual property rights have given a boost to
scientific research and development.\(^2\) The progress in
scientific research requires periodic review. Reviewing
existing government policies allows for more flexibility
in the adaptation to ever-varying economic and
developmental conditions.\(^3\) Health and medical research
are among the pillars of the scientific advancement of a
country, given the challenges of global healthcare. Of all
the subfields of medical research, neuroscience research
is the most interesting and challenging one.\(^4\) The term
neuroscience encompasses research in the fields of
clinical specialties such as neurology, neurosurgery,
neuropsychiatry, and psychology as well as non-clinical
disciplines such as neurobiology and neurochemistry. It
also includes non-medical fields, including biomedical
imaging, physics, computer science, and artificial
intelligence. Hence, the field of neuroscience is of great
significance to the public health as well as a technical
advancement perspective.\(^5\)

The Kingdom of Saudi Arabia (KSA) is transitioning
to self-sufficiency and knowledge-based economy
by 2030. With one of the largest economies of the
world, the KSA is giving high priority to the health
and education sectors. Saudi universities have already
achieved higher international rankings among
educational institutions.\(^6\) Eight Saudi universities have
been included in Quacquarelli Symonds’ (QS) 2019
world ranking.

Bibliometric assessment is a method used to
examine published scientific research contributed
by individuals, institutions, and countries.\(^7,8\) It also
examines the collaboration between scientists across
borders. Additionally, bibliometric studies take into
account the indicators of quantity, as well as quality,
of research of a country or field in a given period.
Further, this method of assessment can be used to
review the results of the implementation of a certain
change in policy in a given time frame.\(^9\) Bibliometric
assessment may also be used to extract data regarding
a specific subfield or an individual database or journal.
These techniques can then be utilized to examine the
dynamics of international collaboration, prevailing
trends in research, the most productive authors and
institutions, journals of preference, and authorship and
collaboration patterns. Such studies can be used to direct
future guidelines for researchers, academic institutions,
policymakers, and their funding organizations.

An action plan established by the World Health
Organization indicated that there is a worldwide
increase in neurological and mental disorders, causing a
global burden and leading individuals and families into
poverty. One of the action plan’s objectives is to direct
efforts towards strengthening research and healthcare in
the fields of neuroscience.\(^10\) Neuroscience research will
allow the generation of new knowledge that will enable
the prevention of diseases, reduction of the cost of
treatment, and finding new therapeutics, thus opening
the way for new possibilities in this field. A bibliometric
study of neuroscience productivity worldwide has
documented a rapid growth of published research
during the last 30 years.\(^11\) Aware of the importance
of neuroscience, researchers from around the world and in
the Middle East are conducting bibliometric studies on
this topic to provide a solid foundation for policymaking
and strategy planning in the society’s neuroscientific
research.

The KSA is leading the Arab world in many
of the parameters of education and healthcare
research.\(^12\) Previous bibliometric analyses carried out
in a variety of fields have yielded valuable data. For
example, one such bibliometric analysis measured
computer science research publications carried out
between 1978-2012 and found out that King Fahad
University of Petroleum and Minerals (KFUPM) and
King Saud University (KSU) were the most active
institutions contributing 70% of all publications.\(^13\)
Another similar study examined research publications
during and after an outbreak of Middle East respiratory
syndrome coronavirus (MERS-CoV) in the KSA during
2013-2014.\(^14\) Yet another bibliometric study\(^15\) presented
useful findings regarding research collaboration and
publication patterns of Egyptian health scientists.

Trends in neuroscience research have been reviewed
as a subject of bibliometric analysis in different parts
of the world under different keywords, including
mental health research, stroke, and epilepsy. Moreover,
neuroscience was included in the evaluation studies
of biomedical research in the KSA.\(^16,17\) One such study
covering clinical neuroscience ranked the KSA 40th in
the world and 4th in the Middle East, highlighting a
certain dearth of physician-scientists.\(^18\) Another study
focusing on neurology lauded important achievements
in published research in this field in Saudi Arabia and
also highlighted gaps in the quality of research.\(^19\)

Previous studies are restricted in their scope\(^20,21\) or
domain\(^22\) and are limited to a city or an institution\(^23\)
in addition to the terms of consulted databases. In

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contrast, present study was conducted using the most comprehensive database of global literature, Scopus, including all the basic and clinical aspects of neuroscientific research carried out in the KSA from 2013 to 2018. The main objectives of this study were to examine the publishing trends of Saudi neuroscience researchers, the most productive and frequently cited authors, institutes and journals, and authorship and collaborative patterns. We also examined subject dispersion under the umbrella term of neuroscience.

**Methods.** This bibliometric analysis was carried out on the research productivity in the field of Neuroscience conducted by scientists working in or affiliated with institutions in the KSA, including Saudi nationals as well as expatriates. A bibliometric study involves cross

| Rank | Institutions | Publications (% | Region | Citations | Authors | Citations Impact |
|------|--------------|----------------|-------|-----------|---------|-----------------|
| 1    | King Abdulaziz University | 571 (36.43) | Western | 8461 | 347 | 14.8 |
| 2    | King Saud University | 380 (24.29) | Central | 3252 | 523 | 8.5 |
| 3    | King Abdullah University of Science and Technology | 101 (6.44) | Western | 138 | 134 | 13.7 |
| 4    | Alfaisal University | 99 (6.31) | Central | 1676 | 144 | 16.9 |
| 5    | Imam Abdulrahman Bin Faisal University | 69 (4.40) | Eastern | 219 | 67 | 3.2 |
| 6    | King Saud bin Abdulaziz University for Health Sciences | 67 (4.27) | Central | 301 | 103 | 4.5 |
| 7    | King Khalid University | 43 (2.74) | Southern | 276 | 55 | 6.4 |
| 8    | Taibah University | 29 (1.85) | Western | 199 | 35 | 6.9 |
| 9    | Umm Al Qura University | 21 (1.34) | Western | 93 | 34 | 4.4 |
| 10   | King Faisal University | 20 (1.27) | Eastern | 144 | 28 | 7.2 |
| 11   | Jazan University | 19 (1.21) | Southern | 232 | 35 | 12.2 |
| 12   | King Abdulaziz City for Science and Technology | 15 (0.95) | Central | 71 | 22 | 4.7 |
| 13   | University of Hail | 15 (0.95) | Central | 69 | 14 | 4.6 |
| 14   | King Fahd University of Petroleum and Minerals | 14 (0.89) | Eastern | 129 | 19 | 9.2 |
| 15   | Qassim University | 13 (0.82) | Central | 44 | 20 | 3.4 |
| 16   | Taif University | 13 (0.82) | Western | 13 | 22 | 1 |
| 17   | Prince Sattam Bin Abdulaziz University | 13 (0.82) | Central | 21 | 13 | 1.6 |
| 18   | Al-Imam Muhammad Ibn Saud Islamic University | 7 (0.44) | Central | 21 | 7 | 3 |
| 19   | Princess Nourahbint Abdulrahman University | 7 (0.44) | Central | 15 | 7 | 2.1 |
| 20   | Najran University | 7 (0.44) | Southern | 44 | 11 | 6.3 |
| 21   | University of Jeddah | 6 (0.38) | Western | 17 | 3 | 2.8 |
| 22   | Al Baha University | 4 (0.25) | Southern | 0 | 5 | 0 |
| 23   | Al Jouf University | 2 (0.12) | Northern | 3 | 3 | 1.5 |
| 24   | Northern Borders University | 1 (0.06) | Northern | 10 | 1 | 10 |

Table 2 - Number of Neuroscience articles produced by Saudi Arabia affiliated researchers compared with top 10 countries in this category during 2013-2018.

| Rank | Country | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Total |
|------|---------|------|------|------|------|------|------|-------|
| 1    | United States | 23483 | 25195 | 25096 | 25520 | 26179 | 27582 | 153055 |
| 2    | China | 5606 | 6049 | 6854 | 8368 | 8648 | 10664 | 46189 |
| 3    | United Kingdom | 6558 | 6814 | 7114 | 7222 | 7531 | 8106 | 43345 |
| 4    | Germany | 6115 | 6449 | 6370 | 6882 | 6869 | 7220 | 39905 |
| 5    | Canada | 4109 | 4349 | 4434 | 4374 | 4625 | 5052 | 26943 |
| 6    | Italy | 3702 | 3762 | 3913 | 3940 | 4060 | 4367 | 23744 |
| 7    | Japan | 3541 | 3579 | 3662 | 3448 | 3569 | 3928 | 21767 |
| 8    | Australia | 2870 | 3189 | 3223 | 3483 | 3568 | 3910 | 20243 |
| 9    | France | 3107 | 3114 | 3271 | 3225 | 3557 | 3578 | 19852 |
| 10   | Netherlands | 2397 | 2627 | 2584 | 2580 | 2678 | 2999 | 15865 |
| 39   | Saudi Arabia | 123 | 272 | 265 | 262 | 310 | 332 | 1564 |
sectional research design that focuses on data in a given time period that is harvested on a single point of time. The SciVal feature of the Scopus database was used at Imam Abdulrahman Bin Faisal University (IAU), Dammam Saudi Arabia from January 10, 2019, to May 30, 2019. Scopus is the largest abstract and citation database of peer-reviewed literature. The sample size under study was data generated during a period of 6 years, from January 2013 to December 2018. Targeted data were exported on January 10, 2019; thus, the database was last updated on December 14, 2018. The methodology used for data retrieval from SciVal is as follows. In the main browsing menu of SciVal, we selected the country, i.e. Saudi Arabia. We selected the Subject Area “Neuroscience” which covers its subcategories such as General Neuroscience, Behavioral Neuroscience, Biological Psychiatry, Cellular and Molecular Neuroscience, Cognitive Neuroscience, Developmental Neuroscience, Endocrine, and Autonomic Systems, Neurology, Neuroscience (miscellaneous) and Sensory Systems. All publication categories, including journal articles, book chapters, books, and conference papers were included in the analysis. Publications performed by at least one author with affiliation to a Saudi Arabian research institution were selected. Neuroscience related publications by Saudi affiliated researchers that were published before January 1, 2013 or after December 31, 2018 were excluded. The results were exported into Microsoft Excel format. The accuracy of the data, including duplication (3 duplicate records were removed), reliability, and relevance, was ensured by the repetition of the same method by another author using the same parameters. This study did not require ethical approval as the targeted data is publicly accessible in Scopus database and there is no human subject involved.

Results. Saudi Arabian affiliated authors produced 118,663 documents during 2013-2018, with an average of 19,777 documents per year and an average annual growth rate of 6.88%/yr. These documents were divided into 27 broad categories/subjects. The highest numbers of documents were found in the Engineering Sciences (n=24,082; 20.29%) followed by Medicine (n=22,940; 19.33%) and Chemistry (n=18,479; 15.57%). The lowest number of publications (n=664; 0.55%) were on the subject of Veterinary Science. The subject of Neuroscience research is ranked 20th with 1564 (1.32%) publications.

The six-year comparison of neuroscience research productivity of KSA showed a gradual increase. Additionally, the KSA ranked 39th in global neuroscience publications output (Table 1).

The SciVal feature of the Scopus database identified 24 Saudi Arabian institutions that produced neuroscience related research in the specified period (Table 2). King Abdulaziz University (KAU) was the most productive institution, with 571 (36.4%) documents produced by 347 authors. These publications received 8461 citations with an average of 14.8 citations per document. The

| Ranks | Name of Author                  | Affiliation                      | Publications | Total Citations | Citation Impact |
|-------|---------------------------------|---------------------------------|--------------|-----------------|----------------|
| 1.    | Kamal, Mohammad Amjad           | King Abdulaziz University       | 78           | 683             | 8.8            |
| 2.    | Alsadi, Faad Eid S.             | King Abdulaziz University       | 65           | 1123            | 17.3           |
| 3.    | Al- Ayadhi, Laila Yousef        | King Saud University Medical College | 36       | 424             | 11.8           |
| 4.    | Liu, Yurong                     | King Abdulaziz University       | 32           | 819             | 25.6           |
| 5.    | Alsaeedi, Ahmed                 | King Abdulaziz University       | 31           | 300             | 9.7            |
| 6.    | Alshraf, Ghulam Md              | King Abdulaziz University       | 22           | 156             | 7.1            |
| 7.    | Alhuzenadah, Adel Mohammed      | King Abdulaziz University       | 19           | 203             | 10.7           |
| 8.    | Attia, Sabry Mohamed            | King Saud University College of Pharmacy, | 19       | 133             | 7              |
| 9.    | Bakheet, Saleh Abdulrahman I.   | King Saud University College of Pharmacy, | 19       | 133             | 7              |
| 10.   | El-Ansary, Afaf Kamal E.        | King Saud University            | 19           | 179             | 9.4            |
| 11.   | Nadeem, Ahmed                   | King Saud University College of Pharmacy, | 19       | 133             | 7              |
| 12.   | Al-Qahtani, Mohammed Hussain    | King Abdulaziz University       | 17           | 100             | 5.9            |
| 13.   | Bashir, Shahid                  | King Fahad Specialist Hospital, Dammam, | 17       | 95              | 5.6            |
| 14.   | Fayaz Ahmad, Sheikh             | King Saud University College of Pharmacy, | 17       | 132             | 7.8            |
| 15.   | Bahammam, Ahmed Salem O.        | King Saud University Medical College | 16       | 264             | 16.5           |
KSU was the next most productive institution with 380 (24.3%) documents contributed by 523 authors. The citation impact of KSU was relatively low (8.5 citations per document). King Abdullah University of Science and Technology was the third most productive institution 101 (6.44%) while Alfaisal University was the 4th most productive institution with 134 authors producing 99 (6.3%) documents that received the highest citations impact (16.9 citations per document). These are only three institutions that exceeded 100 publications. Three institutions, including Alfaisal University, produced 50 to 100 publications on the subject of neuroscience while eighteen institutions produced less than 50 publications (Table 2).

The region-wise analysis indicated that among the five regions of KSA, researchers affiliated with the

Table 4 - Twenty most frequently collaborative countries with Kingdom of Saudi Arabia in the field of neuroscience during 2013-2018.

| Rank | Country                | Co-authored publications | Citations | Citations per Publication | Institutions |
|------|------------------------|--------------------------|-----------|---------------------------|--------------|
| 1    | United States          | 190                      | 1872      | 9.8                       | 160          |
| 2    | China                  | 166                      | 3546      | 21.4                      | 83           |
| 3    | United Kingdom         | 88                       | 1623      | 18.4                      | 64           |
| 4    | Canada                 | 85                       | 865       | 10.2                      | 18           |
| 5    | Egypt                  | 68                       | 467       | 6.9                       | 25           |
| 6    | India                  | 58                       | 857       | 14.7                      | 34           |
| 7    | Switzerland            | 49                       | 1056      | 21.6                      | 10           |
| 8    | Pakistan               | 46                       | 561       | 12.2                      | 13           |
| 9    | Australia              | 41                       | 676       | 16.5                      | 41           |
| 10   | Germany                | 41                       | 652       | 15.9                      | 45           |
| 11   | Italy                  | 29                       | 369       | 12.7                      | 33           |
| 12   | Japan                  | 28                       | 457       | 16.32                     | 34           |
| 13   | Sweden                 | 27                       | 432       | 16                        | 10           |
| 14   | France                 | 18                       | 415       | 23.1                      | 41           |
| 15   | Malaysia               | 18                       | 111       | 6.2                       | 13           |
| 16   | Russian Federation     | 18                       | 249       | 13.8                      | 12           |
| 17   | Spain                  | 18                       | 385       | 21.4                      | 21           |
| 18   | Jordan                 | 17                       | 178       | 10.5                      | 3            |
| 19   | Netherlands            | 17                       | 373       | 21.9                      | 15           |
| 20   | South Korea            | 17                       | 204       | 12                        | 15           |
institutions located in the Western region produced the majority of the neuroscience research (47.3%) followed by the Central (39.4%) and Eastern regions (6.6%). Seventy-three publications were contributed by the researchers affiliated with the Southern region (4.6%) and only three publications were produced by the researchers of the Northern region (0.2%).

Five hundred and twelve authors contributed 1,564 publications in the targeted period and the most productive authors in the research field of neuroscience in KSA are reported in Table 3. Of the 15 most productive authors, seven authors are affiliated with KAU and another seven to KSU, and one was affiliated with King Fahad Specialist Hospital, Dammam. The author Kamal, Mohammad Amjad of KAU was the most productive, with 78 publications and an 8.8 citation impact, followed by Alsaadi, Fuad Eid S. of KAU with 65 publications, followed by Laila Youseff Al-Ayadhi of KSU with 58 publications. The researchers affiliated with the KSA collaborated with scientists from 109 other countries. The majority of publications (96%) are the product of collaborative research, whereas only 58 (3.7%) publications were authored by single authors. A four-author pattern was found to be the most frequent co-authorship fashion with 257 (16.4%) publications, followed by three-author pattern accounting for 222 (14.2%) publications and five-author pattern resulting in 196 (12.53%) publications. Authorship patterns from 2 to 10 co-authors produced 1,340 (85.2%) publications, while more than 10 co-authors pattern created 166 (10.61%) publications. There are eight publications with more than 100 co-authors.

The impact of a given publication can also be evaluated by the number of citations it has received. Thirteen publications included in the study received >100 citations. There are 356 (22.7%) publications without any citation, while 175 (11.7%) publications have received only one citation. Majority of publications (n=609; 38.93%) received 2 to 10 citations.

The top 10 sources of publication are all international research journals. A total of 1,564 publications on neuroscience were published in 326 source publications/journals. “Neurocomputing” journal of The Netherlands published the highest number of documents (192, 12%) by Saudi Arabian authors, followed by “CNS and Neurological Disorders-Drug Targets” with 86 documents (5.5%) and “Neural Network” with 47 documents (3.1%). There are 133 journals with one publication each and 49 journals with two publications each (Table 5). All publications of neuroscience were then further divided into ten subcategories determined by Scopus.

Table 5 - Ten most preferred Journals of Neuroscience researchers affiliated with Saudi Arabia during 2013-2018.

| Sr# | Source Title                              | Publications | Country             | Total Citation | Citation Impact | Cite Score | Quartile |
|-----|------------------------------------------|--------------|---------------------|----------------|----------------|------------|----------|
| 1   | Neurocomputing                           | 192          | Netherlands         | 3198           | 16.29          | 1.07       | Q1       |
| 2   | CNS & Neurological Disorders-Drug Targets| 86           | Netherlands         | 711            | 8.26           | 0.86       | Q3       |
| 3   | Neural Network                           | 47           | United Kingdom      | 1666           | 35.44          | 2.36       | Q1       |
| 4   | Peer                                    | 35           | United Kingdom      | 58             | 3.22           | 1.09       | Q2       |
| 5   | British Journal of Ophthalmology        | 32           | United Kingdom      | 187            | 5.84           | 2.17       | Q1       |
| 6   | Canadian Journal of Neurological Sciences| 26           | United Kingdom      | 68             | 2.61           | 0.55       | Q3       |
| 7   | Investigative Ophthalmology and Visual Science | 25         | United States       | 186            | 7.44           | 2.06       | Q1       |
| 8   | Metabolic Brain Disease                 | 22           | United States       | 124            | 5.63           | 0.91       | Q2       |
| 9   | Molecular Neurobiology                  | 21           | United States       | 93             | 4.42           | 1.61       | Q1       |
| 10  | Neuropsychiatric Disease and Treatment   | 20           | New Zealand         | 164            | 8.2            | 0.91       | Q2       |
The highest number of publications (n=437; 27.88%) deals with the subcategory of General Neuroscience, followed by Neurology (n=368) and Cognitive Neuroscience (n=346). The highest number of citations (n=6303) were given to Cognitive Neuroscience with 18.2 citations per publication. The lowest number of citations (n=190) were received by Neuroscience (miscellaneous).

**Discussion.** The main objective of this study was to examine the publishing trends of Saudi neuroscience research, including the most productive and highly cited authors, institutes and journals, authorship, and collaboration patterns. We also undertook the subject dispersion under the umbrella term of neuroscience. We focused on the bibliometric analysis of the productivity of neuroscience research in KSA, covering the period from January 2013 to December 2018. For this period of time, the research in the field of neuroscience as a subject category has not been bibliometrically reviewed in KSA previously. Our results have generated significant and new findings regarding the bibliometric dynamics of neuroscience research in the KSA. The results can be used to guide research policy and targets specified in vision 2030.

Our results include a total of 1,564 publications in the neuroscience research during the period under review, with a linear increase in publication output within the KSA over the past 6 years (Table 1). This increase is in line with the overall increase in the visibility and QS ranking of Saudi universities in recent times as well as in line with the overall increase in published research in the field of neuroscience in Arab world and worldwide, namely Turkey, India, China, Pakistan, Africa, and Latin America. The subject of neuroscience ranks 20th when compared to other subject categories in the Saudi context. When compared globally, Saudi Arabia ranks 39th in neuroscience research productivity. This raises alarm as no Saudi author was included in top 10 in the categories of “most productive”, “most cited” or “most cited from Muslim countries” in a bibliometric review of global Muslim Mental health research productivity during 2000-2015. One major factor that contributes to the relatively low rank of Saudi Arabia compared to other countries is the modest government expenditure on higher education research when compared to the research expenditure of other first world countries. Saudi Arabia spends only about 0.3% of the gross national product on research. The relatively low productivity may also be attributed to absence of a specialized center of excellence for neuroscience research in the KSA. For comparison, over 1/3rd of total budget of the University College of London (UCL) is accounted for neuroscience program that considers it a strategic priority.

A comparison with the Arab world is imperative in order to understand the research progress in KSA. The review by Elie G. Karam in 2015 revealed that KSA produced highest number of research publications in the Arab world during 1996-2005 period while it fell to 5th place in the same category during 2006-2015. The analysis also showed that in mental health research articles per year per million population, the leading countries are Kuwait, Bahrain and Lebanon while KSA stood at 10th position. After adjusting this parameter for gross domestic product per capita, Egypt, Jordan and Tunisia are the ones on top while KSA stands at 7th position. Other possible reasons may be a dearth of faculty members, postgraduate research programs, international students, low faculty to student ratio, and poor quality of mentorship. Few specialized labs and funding opportunities are available, which may also be a contributing factor. Although institutional requirements of research and innovation as obligations for job promotion may have increased productivity to some extent, a genuine difference can only be made by a change in policy regarding the prioritization of research areas. Given that research in the field of neuroscience not only improves the quality of life for those with a diagnosis of a neurological disorder but also facilitates progress in many other disciplines, such as engineering and artificial intelligence, it is imperative that this area of research be prioritized.

A comparison with advancements in neuroscience research in Africa also bears significance. In Africa, there is a positive correlation between GDP per capita and neuroscience research, while this doesn't apply to KSA. In addition, it is important to mention the Nigerian model. Nigeria, Africa’s most populous country, has become a hub of neuroscientific research in the continent, following South Africa and Egypt. Bibliometric studies have cited annual increase in number of publications in Africa in general and in Nigeria in particular. The distinguishing features of neuroscientific progress in Nigeria are the involvement of neuroscience research promoters like International Brain Research Organization (IBRO), The World Academy of Sciences, The International Society for Neurochemistry, Teaching and Research in Natural Sciences for Development in Africa and Seeding labs. With the establishment of the Neuroscience Society of Nigeria and the introduction of Tertiary Education Trust Fund, the rich medicinal flora of the country seems ready to embrace the world challenges in 21st
century. The impact of these policies remains a highlight of the last 2 decades and presents an inspiration for development of neuroscience as a field of research.

Establishing an organization for Saudi neuroscience research and specialized centers for neuroscience research may provide research grants, hold annual conferences, training programs, and encourage and reward innovation. It would enable the more remote research centers, along with junior researchers, to collaborate with active investigators in the field, to receive technical support, and extend their collaborative network. Furthermore, the unification of resources, coordination initiatives, and facilitation of quality communication among research centers would prove advantageous to all neuroscience researchers. Establishing such a specialized neuroscience research center of excellence, with a dynamic environment, high-quality staff, specialized postgraduate programs, focused efforts, and a vision to develop neuroscience research, would greatly improve the current state of research in this category.

King Abdulaziz University and King Saud University, located in the western and central regions of KSA, respectively, were among the highest producers (Table 2). These universities were established in the year 1967 and 1957, respectively. Older institutions attract international faculty members and students given the well-established research culture and overall reputation. In contrast to Western and Central regions, institutions from the rest of Saudi Arabia, specifically the Eastern, Southern, and Northern regions, were less productive (Table 2). The national policymakers need to give these regions and the institutions therein special attention, incentives, and funding to raise their level of research productivity.

The ease of international communication in the 21st century facilitates collaboration across borders. Estimating the current state of networking and collaboration across disciplines and institutions may be a way of quantifying the research productivity of academia. Another metric that could prove useful in this regard is the number of authors who participate in a given publication. More than 80% of the publications included in this study listed 2–7 authors with faculty members from the USA, China, and the UK as the top contributors to Saudi researchers’ collaborative ventures in terms of the number of publications. However, our results indicate that collaborations with France, Spain, and the Netherlands received better citation impact, whereas joint publications with Egypt and Malaysia have generated the lowest citation impact (Table 5). These statistics may help to focus on more productive collaborations in the future.

A given author’s choice of target journal varies according to the journal scope, acceptance rate, processing and publication fees, and the impact factor. Observation of the pattern of the type of journals in which the majority of Saudi neuroscience researchers have published can be used to indicate the focus of most of their research. Top journals publishing Saudi neuroscience research include journals such as Neurocomputing, CNS and Neurological Disorder-Drug Target, and Neural Network. This implies that computational neuroscience, as well as patent-oriented research, are priorities. The concept of a university-industry linkage and knowledge-based economy is based on the same idea: that academia should take a practical approach in research. Surprisingly, none of the Saudi journals were among the top 10 sources of publication identified in our study, which highlights the need to improve local journals so that they become more desirable to authors.

As for the subject categorization of subfields of neuroscience, cognitive and general neuroscience remain the most frequently published fields. However, the field of developmental neuroscience remains one with comparatively fewer publications. Genetic and developmental disorders remain a high priority worldwide. For example, autism is listed as the top-cited term worldwide. While this area is indeed a priority in KSA, developmental neuroscience as a subfield still requires an increase in attention and focus.

Comparing the top institutions of Saudi Arabia to IAU, the current authors’ institution, yields encouraging statistics. The IAU contributed 4.4% of the total publications recorded in the reviewed period compared to Alfaisal University, with a contribution of 6.31%, which has an appreciably higher number of faculty members.

Neuroscience in 21st century has emerged as an indicator of scientific growth and social development because of its wide application and potential for future industrial and scientific growth. The new initiative and vision launched by the ministry of education in 2017 to motivate institutions to publish high-quality research is an excellent first step in striving to improve the status of biomedical research in KSA. Supportive leadership with a visionary approach that will encourage quality of research and publication impact in addition to focusing on quantity is highly important. Further, institutions should be encouraged to place an emphasis on the publication impact (i.e., quality) rather than merely the quantity of publications.
oriented and tend to focus on clinical training instead of research. Therefore, courses on research methodology should be included within medical and applied medical science curriculum to expose the students to a research environment early in their career. Undergraduate students should be encouraged to participate in research projects and be provided with opportunities to facilitate experience and confidence. To achieve that, emphasizing applied research skills for students enrolled in undergraduate programs, especially the professional ones including Bachelor of Medicine, Dentistry, and Veterinary Sciences should prove beneficial.

Should the implementation of such a program occur, the consideration of factors that can negatively influence research output must be given high priority. Some potentially detrimental factors include lack of funding and support and lack of proper access to the available resources. Moreover, monitoring of other factors that influence the progress of research such as smooth regulations and polices to biological samples ordering, reduction of the time gap for release of funds as well as delivery of scientific equipment, will further enhance research productivity.

The responsibility of young scientists and senior academics is to transfer the acquired knowledge and creative ideas to implement new research mindset, follow research ethics, implement flexible and research-friendly guidelines, provide healthy motivating work environment, increased investment in capacity building and as a result, construct a devoted, valued, passionate workforce.

Our findings can be used to guide a research policy for neuroscience. By highlighting collaboration and publication patterns, identifying regions and sub-categories that need attention and support, we have made it easy for the policymakers to set their priorities right.

**Limitations of Study and Future Research Directions.**
The study is limited to the publications indexed in SciVal feature of Scopus on the subject area of Neuroscience and authors affiliated with KSA published from January 1, 2013 to December 31, 2018. It was beyond the scope of our study to ascertain whether the included research was carried out in KSA or not. Moreover this is purely a quantitative study, and citation analysis and quality of publication of the included research were not analyzed. Saudi researchers working outside KSA but with no current affiliation inside the Kingdom may have been omitted. Other databases like Web of Science, PubMed, and Google Scholar may have some other records which were not included. Future research with broader criteria of inclusion encompassing wider period of research and including citation analysis of the research can help analyze remaining bibliometric aspects of neuroscientific research in KSA.

**Conclusion.** This study successfully documents patterns and growth of neuroscience research in the KSA that has not been documented earlier. A steady increase has been observed in the number of publications. Substantial regional and international collaboration is noted. Most productive institutions and authors are based in the central and western regions. We have made concrete suggestions for future policymaking regarding a need to focus on developmental neuroscience. Centers of excellence are needed to boost research in this area. Eastern, Southern, and Northern regions need support in terms of research strategy and uplifting of existing labs. Given the modest growth of research in the field Neuroscience, comparing productivity in the KSA with the global neuroscience community sheds light on the necessity for continued assessment of progress in this area.

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