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The landscape of biomedical research progress, challenges and prospects in Saudi Arabia-A systematic review

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Abstract

Introduction: The main objective of this review was to synthesize the progress, challenges and prospects of biomedical research in Saudi Arabia in order to provide a holistic view to all stakeholders, such as policy makers, decision makers, and local researchers along with external collaborators interested in the field of biomedical research in this region.

Methods: A systematic review was conducted using the scientific literature for bibliometric studies in the field of biomedical research in Saudi Arabia that comprehensively covered past few decades using PubMed. The search was performed by combining verified Medical Subject Heading (MeSH) terms: "biomedical research", "bibliometrics", "Saudi Arabia" using boolean operator "AND". The data collection was done from January to June 2022 by both authors.

Results: Out of 202 articles yielded from initial search, 13 articles met all of the inclusion criteria and were examined in details. The outcome of analysis showed that with the augmentation of Research and Development (R&D) globalization in Saudi Arabia, researchers are publishing internationally and collaborating globally, academic and research centers are enriching research environment and policies, and government is taking many initiatives to bolster biomedical research; but still more improvements needs to be achieved by Saudi Arabia to be in the list of strong competitive leading nations in the global biomedical research field.

Conclusions: There were various key challenges related to biomedical publications and bibliometric aspects for Saudi Arabia that included: publishing preferences, quality of publications, indexing services, international scientific community, and importantly barriers related to planning, funding, training, resources and support at institutional and national levels. This review provided some insights and recommendations to enhance biomedical research in Saudi Arabia that included: effective policies, health priorities, building infrastructures, greater investments, high incentives, skilled recruitment, competitive training and engagement of community that can play a vital role in this context.

Keywords

Biomedical research, bibliometrics, publications, PubMed, systematic review, Saudi Arabia

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Introduction

Kingdom of Saudi Arabia, a developing country with the population of 35.34 million and literacy rate of 95.3% (15 years and older), is one of the world's leading oil producers and exporters.[1] While possessing around 298 billion barrels of oil reserves, which is 67% of the Gulf Cooperation Council (GCC) reserves and 17% of the world's proven petroleum reserves, this country has not only achieved largest

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economy rank in the Arab world and Middle East, but also made its place in top 20 economies of the world.[2] While mainly relying on oil and natural gas reserves, and limited experience in health and scientific research as compared to the other leading nations in scientific research, Saudi Arabia recognizes the importance of biomedical Research and Development (R&D), and envisions much more progress for its adoption and implementation as planned by the national transformation program - Vision 2030.[3] As a part of this vision, some of the key healthcare related strategic themes include: 'transforming healthcare, improving living standards and safety, and supporting digital transformation'. Keeping these targets in consideration, Saudi Arabia is progressing well in terms of biomedical research with a consistent pace but there are a number of challenges that have affected its progress, focus and outcome in this endeavor that must be addressed.

Research activities and outcomes play a pivotal role in the strategic planning and policy making at the national level, and have a clear and direct impact on improving the health of the population in a country.[4,5] Bibliometrics are statistical methods used for the quantitative analysis of the academic/scientific/research literature. They are firmly established and proved assessment measures of the research impact and quality of scientific publications, and have been widely used by different institutions, countries and regions in the literature.[6–10] Mainly based on the number and visibility of published scientific publications and citations, these represent the research development and outputs of institutes and countries.[11] Recently, a rising interest has been seen in the literature in using bibliometric tools for objective evaluation of global scientific productivity and ranking among many academic disciplines.[12]

The overall global contribution of Eastern Mediterranean (Arab Countries), including Saudi Arabia, in the field of biomedical research is quite less with respect to their global share of population and wealth.[13] In the literature, there are various bibliometric analyses pertaining to specific subjects as well as various academic disciplines for Saudi Arabia; however, none has a strong focus on integrated multidimensional approaches that include progress, challenges, and prospects of biomedical research altogether within Saudi Arabia. Therefore, in this study, we concentrated on bibliometric analyses in the field of biomedical research only that comprehensively covered the timespan of past decades in Saudi Arabia, and did not consider the other bibliometric analyses of medical, health, pharmaceutical and disease specific research. We aimed to provide a brief but comprehensive and up-to-date review of biomedical research by combining and discussing the related bibliometric studies in Saudi Arabia covering the last few decades. The main objective of this study was to synthesize the history, progress, challenges and prospects of biomedical research in Saudi Arabia in order to provide a holistic view to all stakeholders, such as policy makers, decision makers, local researchers as well as external collaborators interested in the field of biomedical research in this region. To the best of our knowledge, the existing literature review in this specific domain only contains the correlational/ecological (bibliometric) studies, and this study is the first of its kind that utilizes systematic review methodology and synthesizes the progress, challenges and prospects of biomedical research in Saudi Arabia.

Methods

Study design

A systematic review was performed to search the scientific literature for bibliometric studies in the field of biomedical research that comprehensively covered the timespan of past few decades in Saudi Arabia. The data collection was performed from January to June 2022 by both authors using PubMed.

Search strategy

In the field of biomedical research, PubMed is one of the most widely used, verified and freely accessible resource, to search for high quality scientific publications online. It has been successfully utilized for a variety of bibliometric studies to assess the research outputs.[14] PubMed was used for a thorough search using search strings by combining verified Medical Subject Heading (MeSH) terms: "biomedical research", "bibliometrics", "Saudi Arabia" with boolean operator "AND". The keywords were also used with variations like "Kingdom of Saudi Arabia" instead of "Saudi Arabia", "bibliometric" instead of "bibliometrics", "biomedical" instead of "biomedical research", etc. Moreover, for covering all possible related bibliometrics aspects, combinations of the other closely related terms like "biomedical publications", "publications", and "citations" were also used along with the term "Saudi Arabia". The details of search strings used and their results are listed in Table 1.

Inclusion and exclusion criteria

The following inclusion criteria were followed for the study:

- Studies that involved bibliometric analysis only
- Studies in the field of biomedical research specifically
- Studies performed in Saudi Arabia at national level or covering the region of Saudi Arabia as a part of wider regions like Middle East and North Africa (MENA), GCC countries and Arab World, etc.
- Studies covering the timespan of past few decades
- Studies written in English language only

Table 1. Search strategy for scientific literature.

S. no.	Search string	Records identified and screened
1	"biomedical research" AND "bibliometrics" AND "Saudi Arabia"	30
2	"biomedical" AND "bibliometrics" AND "Saudi Arabia"	41
3	"biomedical publications" AND "Saudi Arabia"	10
4	"biomedical" AND "publications" AND "Saudi Arabia"	93
5	"biomedical" AND "citations" AND "Saudi Arabia"	28
	Total	202

The following exclusion criteria were followed for the study:

- Short reports, viewpoints and editorials
- Studies conducted at institutional levels only
- Overlapping medical, health, pharmaceutical and disease specific bibliometric studies that did not focus on biomedical research specifically

Data analysis and extraction

All selected articles matching the inclusion criteria were reviewed in details. Microsoft Excel was used for data analysis of the following aspects from included studies:

- Characteristics of Bibliometric Studies (First Author and Reference, Title of the Article, Publication Year, Covered Time Span, Used Search Engine, Covered Geographical Region, and Main Area of Focus)
- Progress Overview
- Challenges (and Barriers)
- Prospects (and Recommendations)

In order to address the risk of biases like selection bias, information bias and publication bias, a strict and clear criteria for inclusion/exclusion of articles was followed using latest PRISMA 2020 Flow Diagram[15]; both authors independently screened the search results, assessed the articles for eligible studies, resolved minor disagreements to reach the consensus, and evaluated the eligible studies with valid association to the context for inclusion from the quality point of view. Moreover, both authors contributed in the interpretation of results and critical discussion for incorporating multi-dimensional perspectives.

Results

The articles' identification, screening and inclusion process was performed using the PRISMA Guidelines. Figure 1, The PRISMA 2020 Flow Diagram,[15] shows the complete process with details.

The initial search outcome of the selected keywords yielded 202 articles in PubMed (see Table 1). As per the inclusion criteria of this study, many bibliometric studies conducted for Saudi Arabia in other fields, such as pharmacy, dentistry, vaccines, coronavirus, medical disorders, cancer, diabetes, neurology, ophthalmology, gastroenterology, critical care, and surgeries were excluded. Moreover, few brief reports and commentaries discussing biomedical research were also excluded. After initial screening, 17 articles were found to be relevant and were sought for retrieval. Out of those 17 articles, three bibliometric analyses studies were found to be overlapping with biomedical research but fell in other closely related domains, such as health sciences research,[10] global medical sciences research,[11] health informatics research[16] and were excluded. One bibliometric study conducted at an institutional level (a university) in Saudi Arabia[17] was also excluded. After applying the complete inclusion and exclusion criteria, 13 articles met the eligibility criteria and were examined in details to highlight the history and progress, identify the challenges and suggest future prospects for biomedical research in Saudi Arabia.

Characteristics of bibliometric studies

Three out of 13 included studies looked at overall biomedical research aspects, six looked at biomedical publications, one covered the biomedical citations, and the remaining three focused on biomedical journals including the Institute for Scientific Information (ISI) and SCImago Journal Rank (SJR) rankings, as shown in Table 2. In terms of geographical region, four studies were conducted in Saudi Arabia at national level, four covered the GCC region, one was conducted at both GCC and Association of Southeast Asian Nations (ASEAN), two were done at Eastern Mediterranean Region, two covered Arab World and one was conducted at Middle East Region. With respect to the time span, the analysis period for all of the studies was somewhere in between 1970 to 2014. Most of the studies covered a time span within the last one or two decades, except for two studies that covered 1970–2010[5] and 1953–2003.[18] The first study[18] only showed the historical view of Arab published citations in PubMed during the timespan of 1953–2013 by analyzing the biomedical journals, but did not cover all other biomedical publications aspects; and the second study[5] focused on finding out the number of biomedical publications in GCC area from 1970 to 2010. Looking at the publishing dates of all included studies, the

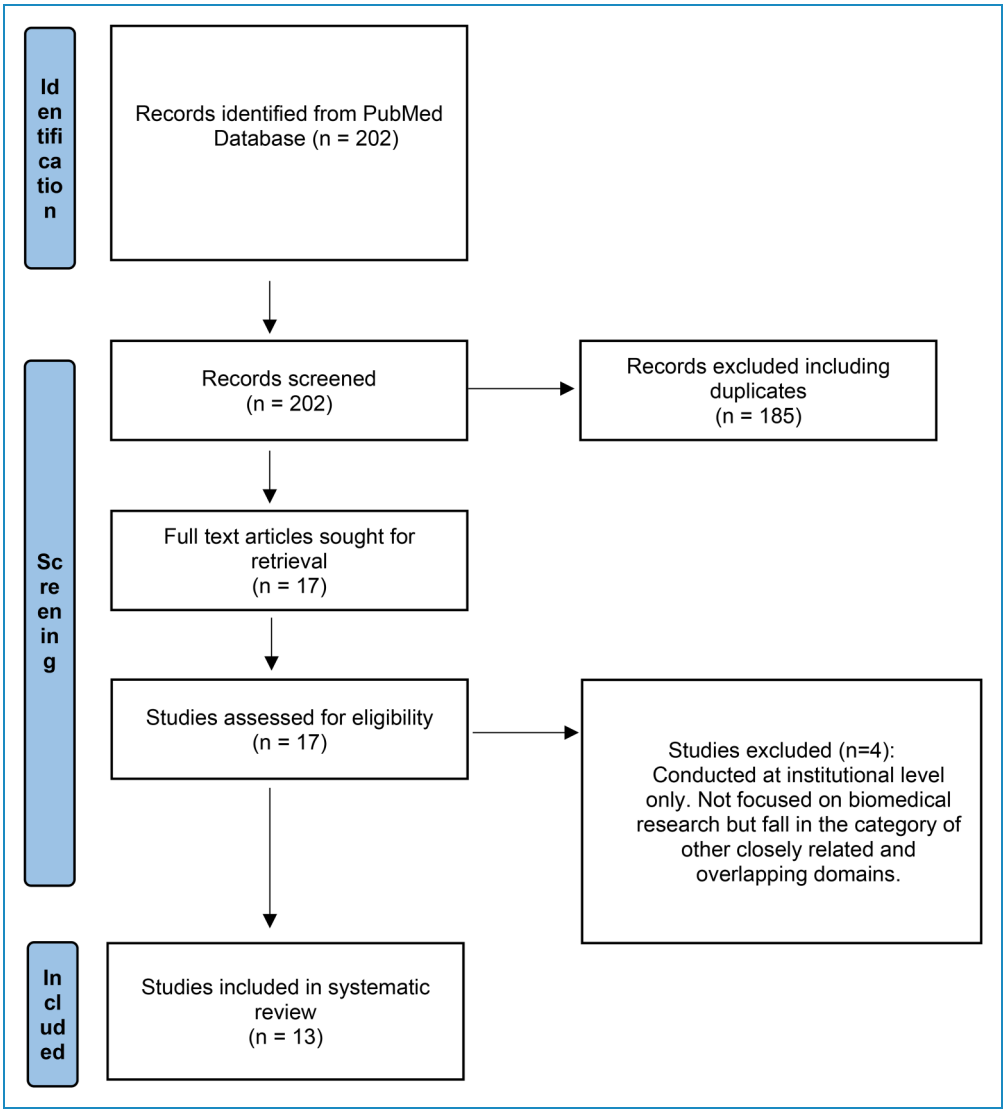

Figure 1. PRISMA 2020 flow diagram for articles identification, screening and inclusion process.[15]

initial one was published in 2001, and the latest one appeared online in 2017. Of note, most of the selected studies were published in Saudi Medical Journal.

Historical overview of biomedical research

In the included studies, there were three main bibliometric studies[13,19,20] that provided some insights of the past developments of biomedical research in the Saudi Arabia by covering the time period ranging from 1982 to 2000, 2004 to 2013 and 2008 to 2012, respectively. The analysis from these studies showed a clear linear increasing trend for biomedical research production in these years and a gradual increase of the published articles from Saudi Arabia every year. The study[13] that was conducted in Eastern Mediterranean Countries (EMR), covering 21 countries, informed that out of 5 countries that contributed to nearly 80% of published articles, Saudi Arabia had a share of 11%. Universities and affiliated teaching hospital in Saudi Arabia were the major contributors in this total figure of publications. Most of biomedical citations were originated from Riyadh region as a research hub followed by Jeddah. The two prominent institutions for published articles and citations were King Saudi University (KSU) and King Faisal Specialist Hospital and Research Center (KFSHRC). In the 25 topmost institutions in EMR, the two most prolific institute names within Saudi Arabia included KSU at 3rd rank (3.2% share) followed by KFSHRC at 20th rank (1.1% share).[13] Importantly, the analyses revealed that majority of the articles were published in the journals with impact factor (IF) lower than 1 or with no IF, with a small portion of papers was published in high IF journals.

Table 2. Characteristics of included bibliometric studies.

First author and reference	Title of the article	Year published	Time span covered	Search engine used	Geographical region covered	Main area of focus
Tadmouri[19]	Biomedical research in the Kingdom of Saudi Arabia (1982–2000)	2002	1982–2000	Science Citations Index and PubMed	Saudi Arabia	Biomedical Research
Tadmouri[13]	Biomedical and health research geography in the Eastern Mediterranean Region	2017	2004–2013	PubMed	Eastern Mediterranean Region	Biomedical and Health Research
Latif[20]	Medical and biomedical research productivity from the Kingdom of Saudi Arabia (2008–2012)	2015	2008–2012	PubMed	Saudi Arabia	Biomedical and Medical Research
Abu-Dawas[4]	Comparative analysis of quantity and quality of biomedical publications in GCC countries from 2011 to 2013	2015	2011–2013	PubMed	GCC Region	Biomedical Publications
Shaban[21]	A quantitative analysis of medical publications from Arab countries	2003	1987–2001	Medline	Arab Countries	Biomedical and Medical Publications
Deleu[22]	Geographical distribution of biomedical publications from the GCC countries	2001	1990–1999	Medline	GCC Countries	Biomedical and Clinical Publications
Tang[23]	Is research related to a country's economic development? An analysis of biomedical publications from several GCC and ASEAN countries from 1994 to 2013	2016	1994–2013	PubMed	GCC Countries and ASEAN	Biomedical Publications
Al-Maawali[5]	Biomedical publications profile and trends in GCC countries	2012	1970–2010	Medline	GCC Countries	Biomedical Publications
Al-Bishri[24]	Evaluation of biomedical research in Saudi Arabia	2013	2010–2011	PubMed	Saudi Arabia	Biomedical Publications
Tadmouri[14]	Development of an Eastern Mediterranean Region search strategy for biomedical citations indexed in PubMed	2017	2004–2013	PubMed	Eastern Mediterranean Region	Biomedical Citations
Tadmouri[18]	Biomedical science journals in the Arab world	2004	1953–2003	PubMed	Arab World	Biomedical Journals
Alenzi[25]	Biomedical research in the Middle Eastern countries: update and insight using SCImago Journal Rank indicator	2010	1996–2008	Scopus	Middle East Region	Biomedical Journals (SCImago)
Rohra[26]	Institute for Scientific Information-indexed biomedical journals of Saudi Arabia. Their performance from 2007 to 2014	2016	2007–2014	Web of Science	Saudi Arabia	Biomedical Journals (ISI)

Biomedical publications

Six bibliometric studies[4,5,21–24] analyzed biomedical publication aspects, such as profiles, trends, quality and quantity of publications. The time period of these studies was variable but covered 1987–2013, as following: 2011–2013,[4] 1970–2010,[5] 1987–2001,[21] 1990–1999,[22] 1994–2013,[23] and 2010–2011,[24] respectively. The covered regions included Saudi Arabia, Arab Countries, GCC and ASEAN Countries. All of these studies used either PubMed or Medline database for the search and selection of articles. Interestingly, in terms of quantity of biomedical publications, Saudi Arabia appeared to be in top order of the list for almost all of these studies followed by Egypt[21] in Arab countries, Kuwait[22] in GCC countries and Malaysia[23] in ASEAN countries. For most of these analyses, when the publications data was normalized to different parameters, such as population size and GDP, the results showed different ranking. For example, in one of GCC study,[4] after normalizing publications to country's population, the performance of Oman, Qatar and Kuwait preceded in the ranking. The normalization was done to show number of publications per 100,000 people.[4] In an Arab countries' study,[21] the 15-year results appeared different after normalization by population as Kuwait followed by UAE were leading; and after normalization by GDP Jordan followed by Lebanon were prominent. In another study from several GCC and ASEAN countries,[23] after normalization to population, Kuwait and Qatar had the highest publications per 100,000 people for an average of 5 years; and Kuwait followed by Malaysia were ahead in number of publications per billion of GDP as 5 years' average. Similarly, in another 40 years' study of GCC countries,[5] when the publications were normalized to population size, Kuwait had the highest publication profile followed by Qatar. These findings highlighted the normalization of publications, using different parameters like population size and GDP, as a way of analyzing biomedical research outcomes in a country. Different perspectives could be taken by decision makers in Saudi Arabia for the possible improvements in this area.

Biomedical citations

In one bibliometric study[14] related to biomedical and health related citations for articles originated from EMR between the period of 2004 and 2013, the outcome showed five-fold increased productivity in these 5 years for this region with five countries that represented 80% of publications in PubMed included: Iran (39.3%), Egypt (14.1%), Saudi Arabia (10.6%), Tunisia (8.1%), and Pakistan (7.8%).

Biomedical journals and indexing

Three bibliometric studies[18,25,26] explored biomedical journals of Arab World, Middle East Region and Saudi Arabia for their indexing related aspects using PubMed, Scopus and Web of Science. Based on PubMed's indexing, the outcome of detailed data analysis covering 50 years (1953–2003) of biomedical journals published in Arab countries[18] showed that, from the total citations of articles published in regional journals, the originating share of 40% came from Egypt, 24% from Tunisia, 15% from Lebanon, 8% from Saudi Arabia and 8% from Morocco; moreover, in a 3-year (2000–2002) analysis of journals, Saudi Medical Journal was one of the four topmost Arab biomedical journals. Based on SJR indicator of Scopus, the data analysis from 1996 to 2008 for the contribution of medical scientific research worldwide[25] found Saudi Arabia followed by Egypt as the leading Middle East countries in terms of publications, citations and h-index. Similarly, using Journal Citation Reports (JCR) of the ISI, the data analysis[26] identified 6 dedicated biomedical journals for Saudi Arabia, and the results from 2007 to 2014 showed improvement in overall quality of these journals.

Challenges and prospects of biomedical research and bibliometric aspects

By analyzing the included studies, two main categories of challenges and prospects were identified. First, the key challenges that must be addressed to facilitate the progress of biomedical research, and then the important prospects that were required to move forward to the next level in the biomedical research arena, as shown in Table 3. Second, the challenges related to bibliometric aspects that could impact on the productivity of publications, citations and journals, and then the prospects that could improve the quality and quantity of these bibliometric aspects, as shown in Table 4.

Authors' Disclaimer: The term "lack" mentioned by authors of studies,[18,24] and[25] to describe resources may not be accurate, but rather "limited" resources. In addition, it should be noted that these included studies covered the biomedical research aspects of Saudi Arabia up to the time period of 2013 and bibliometric aspects of Saudi Arabia up to the time period of 2014, therefore cannot be generalized exactly to the level of current biomedical research outcomes.

It can be observed from the outcomes of selected bibliometric analyses in Table 3 that some of these studies discussed few common challenges and prospects that need to be addressed and considered in order to raise the productivity and impact of biomedical research in Saudi Arabia. These challenges and prospects can be categorized at three levels: researcher's level, institutional level and governmental level.

Most of the above bibliometric studies in Table 4 identified limitations of PubMed and non-indexing of local journals in indexing services as the key challenges. In terms of generalized prospects and recommendations, most of these

Table 3. Key challenges and important prospects for biomedical research.

First author and reference	Year published	Key challenges and barriers	Important prospects and recommendations
Tadmouri[19]	2002	• Absence of uniformity in authors' address in published articles • Low number of articles in journals with high IF • Possibility of bias and economics of scientific publishing • Level of quality of science reported from developing countries like Saudi Arabia and its significance as compared to industrialized countries	• Further detailed investigations for biomedical research in the Saudi Arabia for better future strategies
Tadmouri[13]	2017	• Low investment in health research in relation to estimates of disease burden in the Eastern Mediterranean Region	• Stringent academic promotion requirements • Development of research parks, units, centers and institutions with variety of activities including education, patient care and services • Establishment of national programs by considering the disease burden in the Eastern Mediterranean Region • Implementation of the outcomes of translational biomedical research in the healthcare sector • Exploration of qualitative, organizational, and social aspects of biomedical and health research. Alignment of these aspects with the major health priorities in the Eastern Mediterranean Region
Latif[20]	2015	• Increasing trend of publishing articles in local Saudi journals • Appearance of most of the publications in journals without an IF or with a low IF • Appearance of limited number of articles in journals with high IF • Issues faced by new universities in producing good number of biomedical publications	• More promotion of biomedical and medical research in Saudi Arabia • Engagement of medical colleges in research • Putting education pedagogy in parallel with the research training • Setting of strategic goals for research by Saudi academics • Support for training and provision of funding for research by the government • Setup of short-term and long-term targets, and their monitoring and evaluation on a regular basis
Al-Maawali[5]	2012	• Indexing of local journals in indexing services like Medline/PubMed • Need to increase institutional support for R&D • Need for more spending and allocation of research funding	• Consideration of several factors determining the bibliometric productivity including but not limited to population size, number of physicians and economic status • Giving incentives to health professionals and those in the allied fields to pursue research as a career option • Establishment of knowledge based health care system • Evidence based resources' allocation • Establishment of enlightened health care system at the national level

(continued)

Table 3. Continued.

First author and reference	Year published	Key challenges and barriers	Important prospects and recommendations
Al-Bishri[24]	2013	• Lack of research resources in biomedical research • Lack of training in biomedical research methods • Lack of technical staff and awareness issues • Lack of research funding and research skills • Research publication issues • Academic recognition issues	• Greater investment in the field of biomedical research • Recruitment of experts and skilled research specialists • Provision of high incentives and enormous funding for research • Building and running more medical/biomedical research centers
Tadmouri[14]	2017	• Considering the limitations of PubMed - not representing all published scientific and biomedical journals	• Utilization of bibliometric data should be considered carefully for evaluating research systems, assisting decision-makers for policies' design, improving research activities and aligning research outcomes with health priorities,
Tadmouri[18]	2004	• Short and limited lifespan of journals in Arab region • Rare journals with specially oriented narrow disciplines • Lack of archiving and indexing of local journals in major bibliographies • Limited number of Arab biomedical journals' exposure to the international scientific community	• More active cooperation among Inter-Arab countries • Formation of consortium for Arab biomedical journal publishers • Balancing of biomedical data consumption and data production
Alenzi[25]	2010	• Lack of resources along with the abuse of those available • Lack of motivation for research • Lack of a strategic planning for biomedical research • Lack of economic support to university staff • Lack of funding	• Running a national research policy • Introducing a strategic plan defining priorities according to the social needs • Restructuring of the scientific research pattern • Formation of autonomous research centers focusing on academia • Development of proper standards of excellence for research centers with regular internal and external inspections • Accreditation of quality research centers • Search for more funding options • Provision of training to research personnel for funding organization and management • Provision of training to researchers for achieving competitive funding targets • Enhancement of research innovations with original ideas • Development of curriculums for enhancing creativity • Development of research ethics codes for academics • Encouragement of researchers to target international publications • Development of accredited performance indicators for researchers and institutions

Table 4. Key challenges and important prospects related to bibliometric aspects.

First author and reference	Year published	Key challenges and barriers	Important prospects and recommendations
Abu-Dawas[4]	2015	• Non-indexing of GCC countries' journals in PubMed • Trend of publishing papers in low quality journals by local researchers	• Normalization of publications using different economic and social indicators in order to yield different outcomes • Usefulness of IF for assessing the quality of research - but whether it is a true measure of research publication quality is somehow debatable
Shaban[21]	2003	• Impact of publications in practice and benefits to the community	• Normalization of publications (outcomes) with respect to economic and social indicators like a country's population, school enrollment, adult literacy and GDP for assessment/comparison of research • The value of the journals that have local nature and not indexed in PubMed should not be downgraded
Deleu[22]	2001	• Reliance on the biomedical publications count only - not reflecting quality of the research and its value to the community • Using Medline as the only single database, giving probably under-recorded total number of publications	• Citations analysis and journal impact factor - examples of useful tools for the evaluation and measure of quality of research
Tang[23]	2016	• PubMed search may not have accurately captured all publications as all journals are not indexed by PubMed • Identification of publications affiliated from each country does not guarantee that the affiliated country is responsible for all or partial contribution (including funding) to the published research • Consideration of unusual external factors like global financial crisis and economic influences that can possibly have an impact on a country's biomedical and medical research sectors	• Normalization of publications with the population size to provide a clearer comparison between the country and its population size • Quality of published medical research are linked with the study's funding • Development of effective government policies to stimulate research as well as the culture of research promotion
Rohra[26]	2016	• Non-indexing of several Saudi biomedical journals in indexing services like Medline and ISI	• Raise of standards of Saudi biomedical journals • Proactive role of journals' editors

studies highlighted the importance of normalization of publications with different economic and social indicators and mentioned few research quality aspects.

Common challenges and barriers

Overall, Tables 3 and 4 showed that there were some common challenges reiterated directly or indirectly in the selected studies, including but not limited to the following: trend of publishing in local and low IF journals, focus on the quantity of publications, missing the quality publications factor, shortage of archiving and indexing of Saudi journals in major indexing services - for example PubMed and Web of Science, consideration of other indexing services for journals apart from PubMed, limited exposure of Saudi biomedical journals to the international scientific community, low or limited funding

in health and biomedical research, low institutional support for R&D, low motivations and incentives for research, limited research training, limitations of resources and funding, lack of efficient strategic plan for research, and consideration of the effect of external factors like global financial crisis and economic influences on the biomedical research.

Common prospects and recommendations

Most of the selected studies in Tables 3 and 4 have proposed recommendation to improve biomedical research in Saudi Arabia. These include but not limited to the following: recruitment of skilled research specialists, provision of high incentives to researchers, training of researchers and personnel for competitive scientific projects, focus on the quality of research and its value to the community, normalization of publications (outcomes) to economic and social indicators like country's population and GDP for the assessment of research outcomes, effective policy to stimulate research as well as a culture of research promotion, establishing and running more and effective biomedical research centers, designing policies to improve research activities and aligning them with health priorities, and greater investment in biomedical research at the national level.

Table 5. Ratings of the quality of the evidence for included studies.

First author and reference	Title of the article	Type of evidence	Rating of the quality of evidence (Oxford Center for EBM[27])
Tadmouri[19]	Biomedical research in the Kingdom of Saudi Arabia (1982–2000)	Correlational/ Ecological Study	2c
Tadmouri[13]	Biomedical and health research geography in the Eastern Mediterranean Region	Correlational/ Ecological Study	2c
Latif[20]	Medical and biomedical research productivity from the Kingdom of Saudi Arabia (2008–2012)	Correlational/ Ecological Study	2c
Abu-Dawas[4]	Comparative analysis of quantity and quality of biomedical publications in GCC countries from 2011 to 2013	Correlational/ Ecological Study	2c
Shaban[21]	A quantitative analysis of medical publications from Arab countries	Correlational/ Ecological Study	2c
Deleu[22]	Geographical distribution of biomedical publications from the GCC countries	Correlational/ Ecological Study	2c
Tang[23]	Is research related to a country's economic development? An analysis of biomedical publications from several GCC and ASEAN countries from 1994 to 2013	Correlational/ Ecological Study	2c
Al-Maawali[5]	Biomedical publications profile and trends in GCC countries	Correlational/ Ecological Study	2c
Al-Bishri[24]	Evaluation of biomedical research in Saudi Arabia	Correlational/ Ecological Study	2c
Tadmouri[14]	Development of an Eastern Mediterranean Region search strategy for biomedical citations indexed in PubMed	Correlational/ Ecological Study	2c
Tadmouri[18]	Biomedical science journals in the Arab world	Correlational/ Ecological Study	2c
Alenzi[25]	Biomedical research in the Middle Eastern countries: update and insight using SCImago Journal Rank indicator	Correlational/ Ecological Study	2c
Rohra[26]	Institute for Scientific Information-indexed biomedical journals of Saudi Arabia. Their performance from 2007 to 2014	Correlational/ Ecological Study	2c

Ratings of the quality of evidence

Table 5 summarizes the rating of the quality of the evidence for the selected studies using the Levels of Evidence from Oxford Centre for Evidence-Based Medicine.[27]

Discussion

In this study, the scientific literature was searched for bibliometric studies focusing on the field of biomedical research in Saudi Arabia. The outcomes of the analysis showed that from 1953 to 2014, the biomedical research output of Saudi Arabia has been steadily increasing in numbers but some common issues, such as low quality of publications, limited citations count and journal indexing were observed. However, the authors expected that this status is up to 2014 and it might have improved to a certain level in the last decade; moreover, it might also change soon in the near future as Saudi Arabia is shifting from oil-based economy to knowledge-based economy. In addition, the recent government initiatives of investing more funds in R&D could yield in remarkable increase in overall publications and citations.[28] Though a noticable and steady increase has been witnessed in biomedical research in Saudi Arabia in the recent years (after the time-span of the current study), still there is a need to look upon various important factors. Knowledge sharing and research collaborations, especially at the international level, among researchers could not only increase the productivity and impact of the publications but are also important in portraying the image and reputation of the researchers and their affiliated institutions in the scientific community with impactful research outcomes. Looking at the history of biomedical bibliometrics in Saudi Arabia, it can be perceived that most of the time the journals targeted by researchers were local ones due to the likelihood of acceptance, perceived lenient criteria and fast processing. Though publishing in local journals might increase the citation impact of those journals, researchers should target high IF journals,[10] which requires cutting-edge and timely research studies. It was also pointed out that biases and economics of scientific publishing, quality of science reported, and authors' affiliations linked with developing countries might hinder the researchers from these countries to publish in quality-indexed journals; but on the other hand it was highlighted that as per the recent surveys this publication scenario will change soon in the near future.[13] On the practical grounds, the main purpose of the biomedical research, at the national level, should be improving health and economy; and at the government level, it should be to provide evidence and recommendations to decision and policy makers for priority setting, resource planning and actions plans.[29]

To foster impactful biomedical research in this region, Saudi Arabia would need to improve strategic planning, attainable research targets, prioritization of research areas, sustainability of funds, and overcoming research logistic supply issues. In order to improve the quantity as well as quality of research publications in Saudi Arabia, the identification, implementation, assessment and monitoring of strategic goals is crucial. These strategic goals must be set and prioritized by the government along with the relevant training, sustainable funding and uninterrupted support[20]; although there has been some efforts for setting up national research priorities, these have to be monitored, improved, and conducted in a more efficient way. In addition to the financial support for higher education and research, the government could also launch institutional research-based projects and programs in universities rather than Principal Investigator based research projects, recruit experienced and talented researchers from abroad, build academia-industries partnerships, provide platforms for international research collaborations, establish research labs within hospitals to inculcate the culture of translational research in practice, enhance a sustainable research environment, and create research ecosystem that has efficient supply of research logistics, efficient continuity and utilization of fund, and efficient incentive system for researchers.[10]

In order to achieve these broader national targets, development of research policies and strategic plans at the academic institutional level to enhance the research outcomes and productivity should be a national focus. Recently, Saudi government has worked on this and has taken various initiatives, such as the establishment of Saudi NIH, Saudi Research, Development, and Innovation Authority (RDIA), in addition to Saudi FDA, Saudi CDC, and other newly emerging national agencies. Moreover, many specialized research centers were established or came to active existence in the last decade (after the time span of this study). Some centers were established in a number of universities, such as Princess Nourah Bint Abdul Rahman University (PNU), Imam Abdulrahman Bin Faisal University (IAU), King Abdulaziz University (KAU); and others were established as a part of the hospitals, such as King Fahd Medical City (KFMC) and Prince Sultan Military Medical City (PSMMC). The governmental bodies, with clear and dynamic interlinks and mandates, could bring about a real improvement to the biomedical research arena considering the strategic planning, environment and ecosystem mentioned above. In addition, with collective teamwork and extraordinary leadership, these could create a research-oriented culture to achieve sustainable goals at institutional and national levels. In order to nurture this culture, motivation strategies providing financial as well as moral support, for example, introducing competitive reward schemes, giving incentives to researchers, multi-cultural profile-based recruitment, merit-based contract renewals and job promotions, long-term career paths for researchers are sine qua non.[28]

The authors want also to highlight that in Saudi Arabia the first university was established in 1957, mainly focusing

on teaching essential academic disciplines; and until 2006, there were only seven state universities across the large country and one medical research center (KFSHRC). These factors and the young age of the academic system in Saudi Arabia could partially explain slightly low outcomes of biomedical research reported here. Although, this study covers up to the year 2014, it is worth mentioning that Saudi Arabia has invested well in academic arena lately, as there are more than 35 state universities and many other private ones. The governmental massive scholarship program that was enhanced in 2006 is still running with Saudi postgraduate students in top international universities. King Abdullah University of Science and Technology (KAUST) was established and gained high international recognition for its scientific impactful output. Various medical research centers have been established in different medical cities, such as King Abdullah International Medical Research Center (KAIMRC). King Abdulaziz City for Science and Technology (KACST) has played an important role in fostering research by funding and establishing biotechnology incubators. Saudi NIH and RDIA were recently announced. Relevant ministries, such as investment, industry, and health have all pushed the boundaries to establish reliable biotechnology platforms and R&D ecosystem; albeit humble so far, these efforts will encourage researchers to focus on impactful biomedical research. In a nutshell, with the augmentation of R&D globalization in Saudi Arabia, the researchers are publishing internationally and collaborating globally, academic institutes and research centers are enriching the research environment and policies, and the government is taking many initiatives to support the academic research; thus contributing significantly to the national ranking of Saudi Arabia in the research world. Therefore, with this type of investment and setup, Saudi Arabia has now higher expectation to meet in the future.

Limitations

This study was limited to the results from PubMed search, bibliometric studies and biomedical research domain only; but we expect that this study would pave the way for subsequent research analyses by encouraging the researchers to conduct research reviews covering the other scientific indexing services like Web of Science and Scopus, search wider scientific as well as gray literature resources; consider all types of articles including short reports, viewpoints and editorials; and include the domains that are closely related and overlap with biomedical research like medical research and health research separately as well as at combined level for their comparative analysis and findings in Saudi Arabia. Due the widespread scientific literature in the field of biomedical research bibliometrics, the current study synthesized the literature for Saudi Arabia specifically to narrow it down, but during the review process it was noticed that the other GCC countries were also at a similar status. Therefore, some of the generalized challenges and prospects presented in this study could also possibly be applicable for other developing countries around the world that are at similar level, for example, Middle East and ASEAN countries; and they could possibly benefit from the outcomes of this study, as the research and its standards remain same globally but challenges and prospects can vary based on the economic status and scientific progress of each country. Another limitation of this study was the covered time span by the selected studies, as it was up to 2014, almost a decade ago. This has to be carefully taken into consideration.

Conclusions

The outcomes of the historical analyses of biomedical research in Saudi Arabia from the current study showed that, in the past few decades, universities and affiliated teaching hospital were the major contributors in terms of biomedical publications, most of biomedical citations were originated from Riyadh region as the center of the research hub followed by Jeddah, and the two prominent institutions in the top lists of published articles and citations included KSU and KFSHRC. Various key challenges related to biomedical publications and bibliometric aspects for this nation were linked with publishing preferences, quality of publications, indexing services, international scientific community and last but not the least the planning, funding, training, resource and support barriers at institutional and national levels. On the other hand, it was also found that some of the key recommendations which were related to the effective policies, health priorities, building infrastructures, greater investments, high incentives, skilled recruitment, competitive training, and quality and impactful research for the community can play a vital role in the improvement of biomedical research in this part of the world. To sum up, though Saudi Arabia is somehow among the nations with leading bibliometric indicators for biomedical research in the GCC, Middle East, Eastern Mediterranean Region and Arab world, but it still has to address and overcome the challenges in order to compete with the top biomedical research leaders and play an impactful role in the national and global biomedical scientific arena.

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