

# Diabetes mellitus research in Saudi Arabia: A bibliometric study (2010-2021)

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## ABSTRACT

Diabetes Mellitus (DM) causes global exhaustion, consumes economic resources, and has several risk factors. The bibliometric studies re-evaluate the research efforts on this illness using mathematical and statistical tools to indicate current research and future trends. This study examines KSA's DM research during 2010–2021. Data were acquired from Scopus and analyzed using VOSviewer and MS Excel. Several characteristics were examined to measure the quantity and quality of KSA-related DM articles. In total, 1,919 journal and conference papers were published. DM research included researchers from multidisciplinary sectors. Thirty-seven percent of them have ten or more scientific publications. Al-Daghri, N.M. (King Saud University) leads the pack. In total, 757 (39.44%) research projects got funding from 159 sources within and outside KSA. Memish, Z.A. is the most cited author. The Saudi Medical Journal has the most citations (1214). Al-Daghri, N.M. (KSU) collaborates the most. One hundred forty-one nations aided KSA's diabetes research. Egypt's High Institute of Public Health has the most scientific collaboration with KSA. Authors' and all Keywords analyses indicated a rich knowledge structure. Diabetes Care Journal has the most cocitations with 2,220 and a total link strength of 19,283, followed by The New England Journal of Medicine. The study results will be helpful to stakeholders to understand better the trends and performance of diabetes-related regional research, which will be beneficial.

**Keywords:** Bibliometrics, diabetes mellitus (DM), knowledge structure, KSA, VOSviewer program

## Introduction

Diabetes mellitus (DM) has been spreading at an alarming pace in KSA (KSA) during the past several years. In all, one-fourth of the adult population is affected by DM, and the number is expected to more than quadruple by 2030.<sup>[1-5]</sup> The most concerning trend is the rise in DM prevalence in recent years, with a roughly tenfold increase in KSA during the previous 30 years.<sup>[6,7]</sup> According to the World Health Organization, KSA has the second-highest DM rate in the

Middle East and is seventh in the world.<sup>[8]</sup> It is estimated that over seven million people are diabetic, with almost three million having pre-DM. Perhaps even more concerning is the recent increase in DM cases in KSA.<sup>[3-5,8,9]</sup> DM has been linked to increased mortality, morbidity, vascular problems, poor overall health, and reduced quality of life.<sup>[10,11]</sup> However, compared to wealthy nations, the amount of research done on the incidence, prevalence, and sociodemographic features of DM is woefully insufficient. The health burden of DM in KSA is expected to reach catastrophic proportions unless a comprehensive epidemic management program is implemented, strongly focusing on encouraging a healthy diet, including exercise and active lifestyles, and weight control.<sup>[6,9,12-15]</sup>

The management of diabetes has moved into primary care. According to a 2014 report by the Endocrine Society, there will

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be a shortage of 2,700 endocrinologists in the United States by 2025 due to the growing demand for them relative to the amount that is currently available.<sup>[16]</sup> The aging population is mostly to blame for this rising need since type 2 diabetes prevalence rises with advancing age. According to a 2012 research that used the National Provider Identifier Registry, the average wait time to see an endocrinologist was 3–4 months, and the ratio of endocrinologists to individuals under 65 was 6,194 to 1.<sup>[17]</sup> In total, 90% of people with type 2 diabetes are now treated clinically by primary care practitioners, and this number is expected to rise over time.<sup>[18,19]</sup> And due to this great need for this group of doctors to care for diabetics, it was necessary for them to delve into the depths of the research on this disease in order to conceal the image of care, studies, research, and continuous medical education.

Over the last few decades, an overwhelming number of papers have revealed that DM is one of the most often diagnosed noninfectious chronic illnesses and ranks top in terms of complications among noncommunicable chronic disorders.<sup>[20,21]</sup> Most noticeably, the incidence of DM has grown substantially as the population has aged.<sup>[22]</sup> Additionally, a substantial body of published research indicates that DM places a significant burden on public health systems and the social economy in rich and developing nations alike.<sup>[23]</sup> Bibliometric and scientometric studies based on literature databases have recently become popular in medical research. Bibliometrics allows academics to use mathematical and statistical approaches to extract crucial literature information to capture research hotspots and frontiers, allowing researchers to focus on their core areas of interest in less time.<sup>[24]</sup> Meanwhile, bibliometrics' theoretical foundation and analytical tools are rapidly evolving. To the best of our knowledge, bibliometrics software covers many functions, from data administration and conversion to matrix generation and display.<sup>[25]</sup> However, in the past three years, bibliometric methodologies have not been used in DM research in KSA. There is only one study that was conducted using data extracted from the Clarivate WOS database for the years from 2000 to 2019.<sup>[21]</sup> A lot of times, the WOS database does not have the most scientific publications for any topic to be looked at. Using the VOSviewer program, we gathered DM-related papers from 2010 to 2021 and investigated research hotspots and frontiers. We intended to discover hotspots and frontiers in time, which calls for further study in the Saudi DM research field using data extracted from the Scopus database.

## Materials and Methods

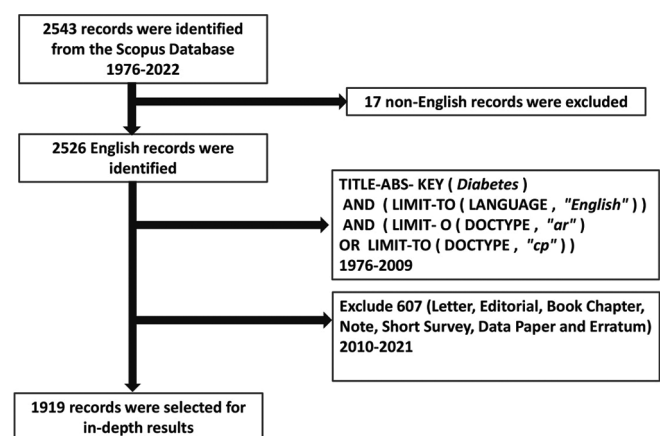
### The Scopus database and search strategy

Scopus is an abstract and citation database created by Elsevier in 2004. Scopus is the only database that brings together comprehensive, highly curated abstract and citation databases with enriched data and connected scholarly literature from a wide range of fields. Scopus has over 36,377 titles (22,794 active titles and 13,583 inactive titles) from 11,678 publishers, with 34,346 peer-reviewed journals in top-level topic disciplines such as

biological sciences, social sciences, physical sciences, and health sciences.<sup>[26,27]</sup> It is divided into three categories: book series, journals, and trade journals. Every year, all journals in the Scopus database are evaluated for sufficient high quality using four different numerical quality measures for each title. We conducted a topical search using the query “Diabetes” AND “KSA” to find documents expressly using the relevant terms. A topical search finds entries that have the same title, abstract, or keywords as the query. There were no time limits when looking for records in the database for all years (1976–2022). On January 5, 2022, the data was retrieved, yielding 2,543 records. This dataset contains 88.4% journal articles, 1.19% proceeding papers, 5.86% reviews, and 4.55% other sorts, such as editorial material, notes, brief surveys, conferences, reviews, and book chapters. The study's data covered the years 2010 through 2021. This study includes journal articles and conference papers, which we will refer to as “articles” throughout the rest of this work. As supplemental information, the full list of articles is available, including the database's article ID, document object identification, and a label indicating whether they matched any of the query terms. Figure 1 depicts the search process and selection criteria. The data was obtained in the form of a tab-delimited text file. These tab characters categorize the text. Using the Excel spreadsheet application, the file was converted to a CSV (comma-separated values) format. This research did not need the permission of an institutional review board since the data being evaluated was already electronically accessible databases.

### Analysis

VOSviewer is a software application that assists in constructing and visualizing bibliometric networks. These networks can be created around journals, researchers, or individual articles and can be based on citations, bibliographic coupling, cocitation, or coauthorship relationships. Additionally, VOSviewer has text mining capabilities that enable co-occurrence networks to create and visualize significant phrases taken from a corpus of scientific literature. The VOSviewer was developed by the University of Leiden's Centre for Science and Technology Studies to interact with bibliographic formats such as Web of Science files, Scopus

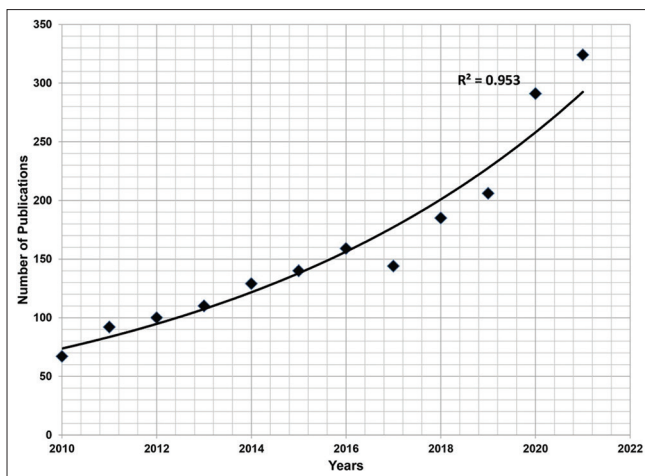


**Figure 1:** Selection criterion for data extraction from the Scopus database

files, PubMed files, RIS files, and Crossref JSON files.<sup>[28,29]</sup> For DM research in KSA, topics are constructed through the clustering of a direct citation network. These networks are formed by simply connecting two academic articles when one of them cites the other. Direct citation networks are well-known for surfacing taxonomies of research fields and assisting in the identification of research fronts. They perform optimally when the time window for analysis is extended, as is the case with bibliometrics research. As a result, this is the approach taken in this article, although other types of networks may be used to accomplish different goals. For example, cocitation networks aid in identifying fundamental and foundational research, while bibliographic coupling networks are advantageous when time is limited.<sup>[30,31]</sup>

## Results

Scientific research in diabetes in KSA began with the publication of the first research paper in 1976. Since then, and until writing this paper, about 2,543 research papers have been published as observed in The Scopus database. One thousand nine hundred nineteen of them were published from 2010 to 2021, representing 75.46%, and we note that the rate of increase in the number is constant [Figure 2]. The regression coefficient is 0.953. Figure 2 shows the number of scientific papers ( $n = 1919$ ) where the increase was observed in all years except in 2017, where a slight decrease occurred, but an estimated increase occurred in the following years. The year 2022 was not included in this study in order to preserve the year as an analytical unit from which useful conclusions can be drawn. As shown in Table 1, Saudi researchers have published various types of research papers, but most of them (88.54%) are journal papers. King Saud University has the most publications, followed by King Abdulaziz University, King Saud bin Abdulaziz University for Health Sciences, and Ministry of Health KSA. One hundred fifty-nine researchers participated in diabetes research, where we found that 37% of them have published more than ten scientific papers, and ten of them have published more than 20 scientific papers.



**Figure 2:** Annual production of articles. Correlation analysis was performed between the number of articles and years (2010–2021)

Al-Daghri, N.M. (King Saud University), Robert, A.A (Prince Sultan Military Medical City), and Alokail, M.S. (King Saud University) are the top-publishing authors with 62, 36, and 34 papers, respectively. Chrousos, G.P. (National and Kapodistrian University of Athens) is a top-publishing international author. However, all his research was published at King Saud University. Twenty-seven scientific fields participated in DM research, where researchers from medicine contributed 59.7%. Biochemistry, Genetics and Molecular Biology, Pharmacology, Toxicology and Pharmaceuticals and Nursing contributed 21.1%, while the rest of the scientific fields contributed by 19.1%. Surprisingly, researchers from Engineering, Chemical Engineering, Physics and Astronomy, Business, Management and Accounting, Computer Science, Mathematics, Veterinary Sciences, Energy, Decision Sciences, Earth and Planetary Sciences, Agricultural and Biological Sciences published on DM. Eighty-three countries contributed to the published DM research from the KSA. KSA produced the majority of them with 89.42%. Egypt ( $n = 209$ ), the USA ( $n = 192$ ), the UK ( $n = 141$ ), the UAE ( $n = 73$ ), Australia ( $n = 53$ ), Canada ( $n = 50$ ), India ( $n = 48$ ), and Malaysia ( $n = 38$ ) are the most collaborative countries in Saudi diabetic research. In total, 757 (39.44%) research received financial support from 159 supporting bodies inside and outside KSA. King Saud University is the top-funding agency with 30.78% (233/757). In total, 15.72% of the articles were sponsored by King Abdulaziz University, King Abdulaziz City for Science and Technology, King Faisal University, and Prince Sattam bin Abdulaziz University [Table 2].

## Citation analysis and impact of Saudi diabetic research

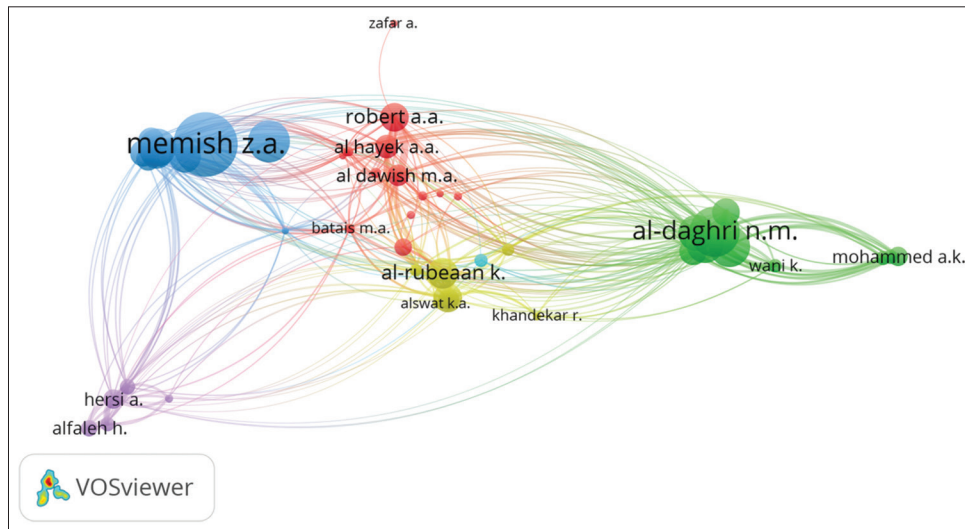
Seven thousand seven hundred sixty-one researchers cited Saudi DM papers. Six hundred seventeen of them have three papers, while 207 have three, 46 have 10, 11 have 20, and only 3 have more than 30 scientific papers. Citation analysis was done for influential authors with more than ten scientific papers using the VOSviewer software [Figure 3]. The most frequently cited researcher is Memish, Z. A. (King Saud Medical City, Ministry of Health, KSA), as shown in Table 3. However, he is not the most published researcher. Al-Daghri, N.M. (King Saud University) is the most published researcher with the highest total

**Table 1: Types of documents extracted from the Scopus database**

Document Type	1976-2022	
	<i>n</i>	Percentage
Article	2233	88.40
Review	148	5.86
Letter	62	2.45
Conference Paper	30	1.19
Editorial	23	0.91
Note	17	0.67
Short Survey	10	0.40
Conference Review	3	0.12
Total	2543	100

**Table 2: Number of research projects (2010-2021)**

Funding agency	Country	Funded Projects
King Saud University	KSA	233
King Abdulaziz University	KSA	45
King Abdulaziz City for Science and Technology	KSA	40
King Faisal University	KSA	17
Prince Sattam bin Abdulaziz University	KSA	17
King Abdullah International Medical Research Center	KSA	15
King Fahad Medical City	KSA	14
National Plan for Science, Technology and Innovation	KSA	14
Majmaah University	KSA	12
National Institutes of Health	USA	11
Department of Sport and Recreation	Australia	9
Princess Nourah Bint Abdulrahman University	KSA	9
Taif University	KSA	9
University of Tabuk	KSA	9
King Faisal Specialist Hospital and Research Centre	KSA	8
Merck	Germany	8
AstraZeneca	USA	7
Ministry of Health, Consumption and Social Welfare,	Spain	7
King Khalid University	KSA	6
Ministry of Health	KSA	6
National Institute of Diabetes and Digestive and Kidney Diseases	US	6
Novo Nordisk	Denmark	6
Qassim University	KSA	6



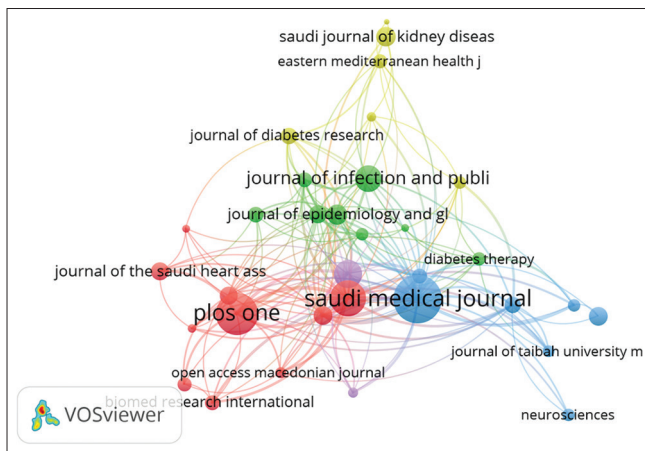
**Figure 3:** Visualization mapping of citations for authors having more than ten documents using VOSviewer revealed the six clusters with 381 links and a total link strength of 2,166. Nodes represent the number of citations

correlation strength (698). Visualization mapping of citations for authors having more than ten documents using VOSviewer revealed the six clusters with 381 links and a total link strength of 2166. Cluster 1 (Red) consisted of 14 authors, with Robert, A.A., affiliated with the Diabetes Treatment Center, Prince Sultan Military Medical City, Riyadh, KSA, being the top-cited author in this cluster with a total link strength of 183. Cluster 2 (Green) consisted of ten authors, with Al-Daghri, N.M. (King Saud University) being the most prolific with 1388 citations and a total link strength of 401. Nine researchers formed the third cluster (Blue) with Memish, Z.A. (King Saud Medical City) as

the top-cited author and remarkable total link strength. Clusters four, five, and six consisted of seven, seven, and one author, respectively.

Citation analysis showed that 1506 (78.47%) of the total documents had been cited at least once. Eight hundred ninety-one scientific papers had a minimum of five citations. While the papers that got 10, 15, 20, 30, and 50 citations are 558, 366, 267, 160, and 64, respectively. A visualization map was created using scientific papers that have been cited more than 50 times. Only 27 of them have been assembled into eight clusters. The

top-cited article was published by Zheng, Y. (2018; Nature; Global aetiology and epidemiology of type 2 DM and its complications). Assiri, A. published the second top-cited article (2013; The Lancet; Epidemiological, demographic, and clinical characteristics of 47 cases of Middle East respiratory syndrome coronavirus disease from KSA: a descriptive study). Citation analysis revealed that 736 journals had been cited once. Seventy-four journals have been cited five times. Thirty-three articles with a minimum number of ten citations were mapped. Five clusters were gathered with 170 links between them and a total strength of 352. Clusters consisted of 10, 8, 7, 6, and 2 journals [Figure 4]. The top-cited one is the Saudi Medical Journal, with 1214 citations and a total link strength of 87. Plos One, Annals of Saudi Medicine, and Diabetes Research and Clinical Practice were cited 945, 679, and 423 times, respectively.



**Figure 4:** Visualization mapping of citations for source having more than 50 citations using VOSviewer. Nodes represent the number of citations

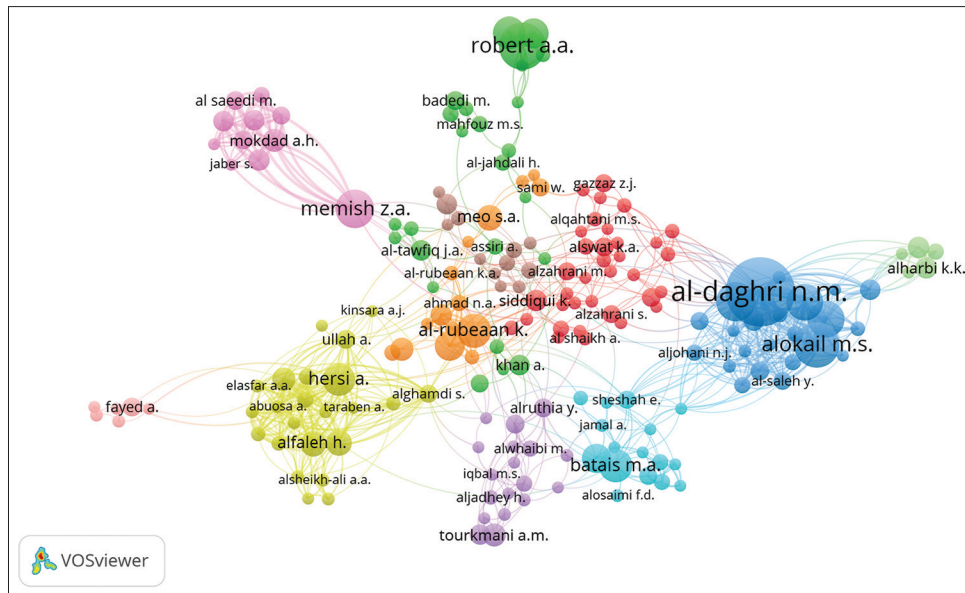
The Ministry of Health, King Saud University, Prince Sultan Military Medical City, and King Saud Bin Abdulaziz University for Health Sciences are the top-cited organizations. Of course, KSA is the highest cited ( $n = 16892$ ), followed by the USA ( $n = 5658$ ), UK ( $n = 3498$ ), Egypt ( $n = 1982$ ), China ( $n = 1567$ ), the UAE ( $n = 1388$ ), Australia ( $n = 1213$ ), and Canada ( $n = 1186$ ).

**National and international collaboration: analysis of coauthorship**

Coauthorship is one indicator that signposts the effectiveness of national and international cooperation. As observed, there are 7,761 authors who we found have published research on DM in KSA. We found 1,521 authors who have participated in research involving at least two people. Research in which more than five authors participated was conducted, in which 189 authors participated. One hundred eighty-nine authors were mapped into 11 clusters using VOSviewer with 837 links and a total link strength of 2731. The most collaborative authors in these 11 clusters [Figure 5] were Siddiqui, K. (KSU), Robert, A.A. (KSU), Al-Daghri, N.M. (KSU), Hersi, A. (KSU), AlRuthia, Y. (KSU), Batais, M.A. (KSU), Youssef, A.M (KSU), Tuomilehto, J. (KSU), Memish, Z.A. (King Saud Medical City, Ministry of Health), Fayed, A. (Princess Nourah bint Abdulrahman University), and Alharbi, FK (KSU). As shown in Figure 5, Al-Daghri, N.M. (KSU), is the most collaborative author. In total, 5553 national and international organizations participated in DM research in KSA. King Fahd General Hospital has a distinguished research collaboration network. From the analysis of the visualization map, we note that all this cooperation is with national bodies, whether universities or hospitals. High Institute of Public Health, Alexandria University had research cooperation with some research bodies in the KSA. Sheikh

**Table 3: Top-cited authors**

Author	Affiliation	Documents	Citations	Total Link Strength	Citation/document
Al-Daghri N.M.	King Saud University	62	1388	698	22.39
Robert A.A.	Prince Sultan Military Medical City	36	543	321	15.08
Alokail M.S.	King Saud University	34	976	435	28.71
Sabico S.	King Saud University	28	513	225	18.32
Memish Z.A.	King Saud Medical City	27	2055	263	76.11
Al-Attas O.S.	King Saud University	25	816	353	32.64
Alkharfy K.M.	King Saud University	25	797	366	31.88
Al-Rubeaan K.	Sultan Bin Abdulaziz Humanitarian City	23	602	219	26.17
Batais M.A.	King Saud University	22	94	149	4.27
Al Dawish M.A.	Prince Sultan Military Medical City	21	337	314	16.05
Hersi A.	King Saud University	21	288	379	13.71
Youssef A.M.	King Saud University	19	533	203	28.05
Al Hayek A.A.	Prince Sultan Military Medical City	19	390	193	20.53
Almigbal T.H.	King Saud University	18	49	102	2.72
Meo S.A.	King Saud University	15	250	43	16.67
Alfaleh H.	King Saud University	15	217	293	14.47
Alhabib K.F.	King Saud University	15	205	371	13.67
Mokdad A.H.	University of Washington	13	876	213	67.38
Kashour T.	King Fahd Medical City	13	178	283	13.69
Tourkmani A.M.	Prince Sultan Medical City	13	95	57	7.31
Khandekar R.	King Khaled Eye Specialist Hospital	13	76	42	5.85



**Figure 5:** Visualization mapping of coauthorship for authors with minimum number of five documents using VOSviewer. Nodes represent the number of documents

Khalifa Medical City and Rashid Hospital (UAE) performed some research projects with their Saudi collaborators. One hundred fourteen countries contributed to KSA's DM research. Twenty-six countries reached the ten-document threshold as the minimum number of documents. These countries were clustered according to their links and total link strength. Cluster one (Red) involved Australia, Canada, Finland, Iran, Iraq, Sudan, Sweden, and the USA. Cluster 2 (green) consisted of France, Germany, Greece, Italy, Jordan, Lebanon, and the UK. Arabian countries were gathered in cluster 3 (blue), including Bahrain, Kuwait, Oman, Qatar, the UAE, and Yemen. KSA, Malaysia, Pakistan, and India are assembled in the fourth cluster (yellow). Surprisingly, Egypt stood alone in its entirety (Cluster 5). It can be said that the countries that work the best with KSA on DM research are the USA, Egypt, the UAE, the UK, Kuwait, Bahrain, Qatar, and Bahrain [Figure 6].

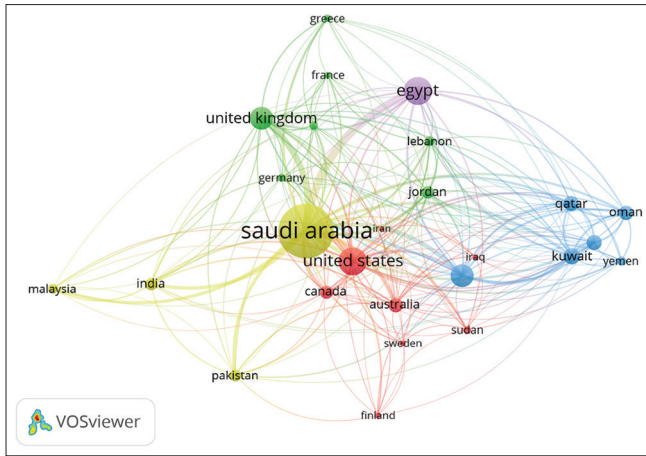
### Co-occurrence of authors' and all keywords

The co-occurring terms are indicative of research hotspots in the study area. As shown in Figure 7, a simplified co-occurring keyword network was obtained with the normalization strength algorithm on VOSviewer. Visualization of authors' keywords ( $n = 3376$ ) with a minimum number of five revealed that 155 keywords created by authors were classified into eleven clusters. The densities of nodes indicate keywords, and the size of each node corresponds to the frequency with which keywords co-occur. Common keywords such as KSA and diabetes were removed to allow the emergence of others. "Obesity" was enabled with the largest frequency of 83, followed by "prevalence" (76), "covid-19" (74), "risk factors" (69), "hypertension" (52), "knowledge" (45), "mortality" (37), and "hba1c" (33). The most centralizing keywords are "hypertension," "risk factors," "obesity," and "prevalence," with links of 57, 55, 53, and 52, respectively. All keywords (research themes) were 11,759. One

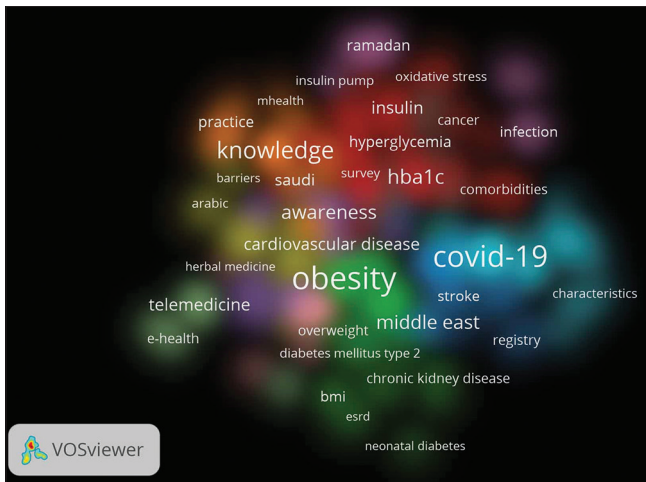
hundred seventy-seven keywords had an occurrence of more than 50 and were gathered into five clusters with 14,558 links and 282,422 as total link strength [Figure 8]. These five clusters represent the research themes of DM in KSA. Cluster 1 consisted of 59 keywords, with adult "male" and "female" being the most centric ones, with a total link strength of more than 22,000. Fifty-one keywords formed the second cluster with "controlled study," "body mass," "glucose blood level," "hemoglobin a1c," "major clinical study," and "non-insulin-dependent diabetes." Keywords ( $n = 48$ ) associated with questionnaire-based cross-sectional studies huddled in the third cluster. Research on DM in children and teenagers was centralized in the fourth group. Gender difference and risk factors as research themes were grouped in the fifth cluster.

### Cocitation and bibliographic coupling

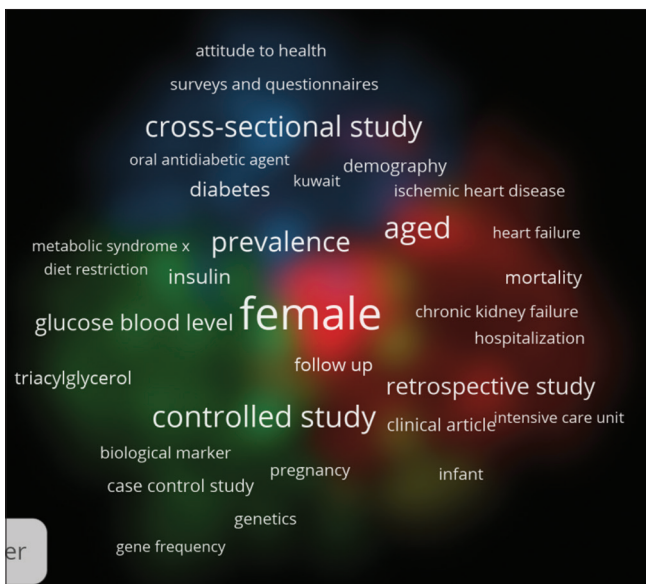
Cocitation was performed for authors, documents, and sources. VOSviewer was used to show and analyze 61,387 articles ranging from 2010 to 2021. The top 56 most cocited or occurring items from each cluster were chosen, and their document cocitation network is presented in Figure 9. The biggest group of linked papers consists of 48 items divided into seven clusters, each having 196 linkages and a total link strength of 337. These nodes and connections, respectively, indicate cited references and cocitation relationships from the gathered articles. With 26 citations and total link strength of 41, Al-Nozha, M.M., (2004) is the most-cited article. Table 4 shows the most frequently cocited sources. Cocitations of journals revealed that Diabetes Care is the top journal in terms of cocitations with 2220 citations and total link strength of 19,283, followed by The New England Journal of Medicine, The Lancet, Saudi Medical Journal, Plos One, Circulation, Annals of Saudi Medicine, and Diabetologia. Memish, Z.A. scored the highest cocitation ( $n = 343$ ), while Al-Nozha, M.M. had the highest total link strength (6,582).



**Figure 6:** Network visualization mapping of coauthorship for countries with minimum number of ten documents using VOSviewer. Nodes represent total link strength



**Figure 7:** VOSviewer was used to obtain density visualization of authors' keywords with minimum number of five



**Figure 8:** VOSviewer was used to obtain density visualization of all's keywords with minimum number of 50

Bibliographic coupling analysis based on association strength for documents revealed that Al Dawish M.A. (2016; Diabetes mellitus in KSA: A review of the recent literature) had the highest total link strength (67). Bibliographic coupling analysis of published articles revealed that the most influential publication belonged to Aldawish, M.S. (2016; Diabetes Mellitus in KSA: A Review of the Recent Literature) published in Current diabetes Reviews. Saudi Medical Journal is the top one based on bibliographic coupling analysis.

## Discussion

The current study provided a bibliometric overview of the intellectual structure, diffusion of knowledge, emerging literature, and impact of collaboration in research about DM in KSA. Scopus database was used to extract scientific papers published from 2010 to 2021 to search for titles and abstracts published in English. This citation's classical investigation and assessment of scientific output include applying research to clinical and medical practice. Because study results are scattered among several publications and not presented systematically, physicians often complain that their knowledge of published research is either partial or lacking. This makes interpreting the published scientific data more challenging. Systematized amalgamations of all types of clinical and basic research conducted in a particular topic or subjective area are often used to overcome the aforementioned challenges in bibliometric studies.<sup>[32-34]</sup>

A bibliometric analysis is a method of determining the current status of research on a given subject from a cross-sectional perspective. It is a statistical and quantitative study aimed at determining the academic influence and features of publications on a certain research topic, which might help researchers build their plans to solve health concerns.<sup>[35]</sup> Many researchers have looked at DM research throughout the globe, which includes improvements in a variety of fields and subspecialties. A bibliometric analysis on DM research was undertaken in KSA, though. This research, however, was completed two years ago.<sup>[21]</sup> It is also well understood that bibliometric studies must be conducted regularly to re-evaluate research and elicit data. Our study will aid in identifying the quality of work, discoveries, and trends in DM in KSA. One of the key causes contributing to this dangerous trend, which includes an unhealthy diet, lack of exercise, overweight, and obesity, is a change in lifestyle. Many socioeconomic changes have occurred in KSA during the previous few decades, including an increase in the number of diabetic cases in urban areas compared to rural areas. As a result of the development, there were notable changes in the population's lifestyle. Reduced intake of fruits and vegetables were seen, as well as increased consumption of junk food and sugar-sweetened and carbonated beverages. Simultaneously, technological improvements such as autos, elevators, and escalators led to a decrease in physical activity and, presumably, to the growth of DM. As a result of this analytic investigation, academic institutions and funding organizations will be able to evaluate the quality and productivity of individual scholars'

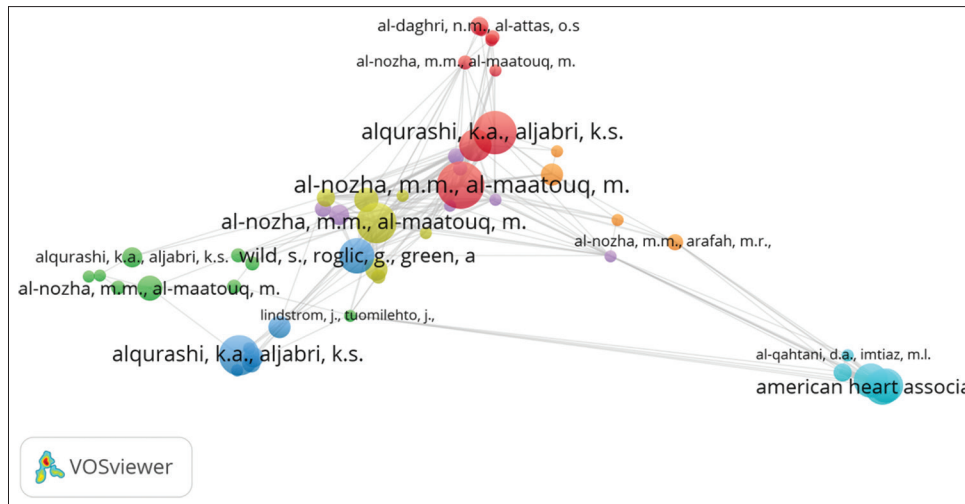


Figure 9: Network visualization of cocitation of 48 documents with minimum five cocitations

Table 4: Cocitation analysis

Cocited reference	Journal	Authors	Year	Citations	Total link strength
Diabetes mellitus in KSA	Saudi Medical Journal	Al-Nozha, M.M., Al-Maatouq, M.A., Al-Mazrou, Y.Y., Al-Harathi, S.S., Arafah, M.R., Khalil, M.Z.	2004	26	41
Prevalence of diabetes mellitus in a Saudi community	Annals of Saudi Medicine	Alqurashi, K.A., Aljabri, K.S., Bokhari, S.A.	2011	23	36
Diabetes mellitus in KSA	Saudi Medical Journal	Al-Nozha, M.M., Al-Maatouq, M.A., Al-Mazrou, Y.Y.,	2004	21	31
Prevalence of diabetes mellitus in a Saudi community	Annals of Saudi Medicine	Alqurashi, K.A., Aljabri, K.S., Bokhari, S.A.,	2011	21	8
Global prevalence of diabetes: estimates for the year 2000 and projections for 2030	Diabetes care	Wild, S., Roglic, G., Green, A., Sicree, R., King, H.	2004	18	28
Epidemiology, clinical and complications profile of diabetes in KSA: a review	Annals of Saudi Medicine	Elhadd, T.A., Al-Amoudi, A.A., Alzahrani, A.S.	2007	16	33
Diabetes mellitus in KSA	Saudi Medical Journal	Al-Nozha, M.M., Al-Maatouq, M.A., Al-Mazrou, Y.Y., Al-Harathi, S.S., Arafah, M.R., Khalil, M.Z., Khan, N.B., Al-Mobeireek, A.	2004	12	8
Prevalence of diabetes mellitus in rural KSA	Diabetes Care	Fatani, H.H., Mira, S.A., El-Zubier, A.G.	1987	11	36
Global prevalence of diabetes: estimates for the year 2000 and projections for 2030	Diabetes Care	Wild, S., Roglic, G., Green, A., Sicree, R., King, H.	2004	10	9
Diabetes mellitus type 2 and other chronic noncommunicable diseases in the central region, KSA (Riyadh cohort 2): a decade of an epidemic	BMC Medicine	Al-Daghri, N.M., Al-Attas, O.S., Alokail, M.S., Alkharfy, K.M., Yousef, M., Sabico, S.L.	2011	10	8

research. Furthermore, the significant level of interest in this topic means that future research prospects will be enhanced.<sup>[8,20,36,37]</sup>

From 2010 to 2021, 1,919 documents were published, representing 75.46% of total research output since 1976, and the pace of rising is quite significant. This can be explained by the fact that the research authorities in KSA have begun to realize the importance of DM and the expansion of its prevalence in society. As well as the government’s policy to support research and enable universities to establish distinguished research laboratories and to appoint experts in this field. All years saw a rise, except for 2017, which had a minor decline. This decline could be linked to the financial crisis that swept the world in 2016.<sup>[38]</sup> In DM research, 159 researchers were involved, of whom 37% have

published more than ten scientific publications, and ten have written more than 20. They are Al-Daghri NM (King Saud University), Robert AA (Prince Sultan Military Medical City), and Alokail MS (King Saud University). The previous results show that the top three productive authors are Tuomilehto J, Abu El-Asrar AM, and Al-Daghri NM. Al-Daghri NM<sup>[21]</sup> is affiliated with Department of Biochemistry, College of Science, KSU. His expertise is in diabetes, hypertension, insulin resistance, metabolism, molecular biology, and glucose metabolism.<sup>[39]</sup>

Diabetes research included 27 scientific domains, with medicine contributing 59.7%. Other scientific domains contributed 40.3%. A multidisciplinary research roadmap for chronic disease management has been encouraged before.<sup>[40]</sup> Machine



learning, big data analysis, telemedicine manufacturing of a miniature insulin administration device, medical ontology, and mobile educational system are among the research themes from nonmedical background.<sup>[36,37,41-47]</sup> Transdisciplinary cooperation is critical in bridging the gap between scientific discovery and the implementation of evidence-based DM prevention and treatment strategies.<sup>[48,49]</sup> We investigated patterns of cooperation of Saudi scientists on a national and international scale. The published DM research from KSA included 83 nations. KSA produced 89.42% of them. The most collaborating country in Saudi diabetic research is Egypt ( $n = 209$ ), the US ( $n = 192$ ), the UK ( $n = 141$ ), the UAE ( $n = 73$ ), Australia ( $n = 53$ ), Canada ( $n = 50$ ), India ( $n = 48$ ), and Malaysia ( $n = 38$ ). Coauthorship is one measure of national and international cooperation's efficacy. As previously stated, 7,761 authors have published research on DM in KSA. VOSviewer mapped 189 authors into 11 clusters with 837 linkages and a total link strength of 2731. Al-Daghri, N.M. (KSU) is the most collaborative author. Diabetes research in KSA included 5,553 national and international institutions. King Fahd General Hospital has an impressive research network. The visualization map shows that this collaboration is with national entities, whether universities or hospitals. Patients with diabetes have a variety of biological, psychological, and social requirements that a team must treat specialists from many disciplines. Multidisciplinary cooperation, which refers to cooperative work done by specialists from several disciplines that engage around a single patient, has become crucial in this regard for improving therapeutic results.<sup>[50]</sup> The High Institute of Public Health of Alexandria University collaborated with Saudi research institutions. In total, 141 nations aided KSA's DM research. These countries were grouped based on their overall connection strength. The best collaborators with KSA in DM's research were the US, Egypt, the UAE, the UK, Kuwait, Bahrain, Qatar, and Bahrain. A comparable study on DM research in Middle Eastern nations found similar author cooperation tendencies, with the UK, the USA, and Germany as significant contributors.<sup>[51]</sup>

Characterizing knowledge structure, the history of study subjects, and the birth of themes have long been essential components of information science. Citation analysis is a quantitative approach for evaluating the status of referrals to resources using complete bibliographic information. Citation analysis is a quantitative approach to evaluating the status of referrals to resources using complete bibliographic information.<sup>[52,53]</sup> Memish, Z.A. (King Saud Medical City, Ministry of Health, KSA) is the most-cited researcher, but he is not the most published. Al-Daghri, N.M. (King Saud University) has the most publications. While the total number of citations is an important indicator of an article's impact and importance, it can be misleading in older articles that have had more time to be cited as each year passes.<sup>[54]</sup> In total, 1506 (78.47%) of the total papers have been referenced. Seven hundred thirty-six journals were referenced once in the citation analysis. The Saudi Medical Journal has the most citations (1,214) and the strongest links (87). Diabetes Research and Clinical Practice was mentioned 945 times, while Plos One was quoted

679 times. Organizations like the Ministry of Health and King Saud University for Health Sciences are often referenced. Most cited is KSA (16,892), followed by the USA (5,658), UK (3,498) Egypt (1,982), China (1,567), UAE (1,388), Australia (1,213), and Canada (1,286) in that order.

The co-occurring phrases reflect the study's research hotspots.<sup>[55]</sup> Authors' keywords ( $n = 3,376$ ) were visualized in 11 clusters, with a minimum of five. The current extracted author's keywords as the most important topics in DM research (obesity, prevalence, COVID-19, risk factors, hypertension, knowledge, mortality, and hba1c). Key terms with the highest centralization are "hypertension," "risk factors," "obesity," and "prevalence." There were 11,759 keywords. Five groupings were extracted in this study and reflected KSA DM research topics. "Male" and "female" were the most central keywords in cluster one. "non-insulin-dependent DM," "controlled study," "body mass glucose blood level," "hemoglobin a1c," "major clinical study" are the main keywords in the second cluster. The third cluster included questionnaire-based cross-sectional study keywords. The fourth group focused on diabetes in children and adolescents. The sixth cluster included gender differences and risk variables. Cword analysis has the ability to optimally map research fronts, detecting developing fields, filtering smaller subfields, and classifying the domain's conceptual structure.<sup>[25]</sup>

Each bibliometric technique has its own set of advantages and disadvantages. Combining diverse methodologies and their ancillary functions to generate a full literature map, so offering better findings and promoting deeper understandings, has, thus, become a trend in the bibliometric landscape.<sup>[56]</sup> In this study, the author intends to fill a void in the literature that has not yet been fully explored by utilizing and combining three distinct bibliometric methods, namely cocitation, bibliographic coupling, and cword, to complementarily capture and connect the bibliographic information to rigorously and holistically explore the constantly changing subject of DM and renew our knowledge. Cocitation was performed for authors, documents, and sources. VOSviewer was used to construct clusters and analyze 61,387 articles ranging from 2010 to 2021. Depending on their placement on the map, the clusters might be regarded as the most significant or promising research clusters.<sup>[57]</sup> The top 56 most cocited or occurring items from each cluster were chosen, and their document cocitation network was presented. With 26 citations and total link strength of 41, Al-Nozha, M.M., (2004) is the most-cited article. Table 4 shows the most frequently mentioned references. Cocitations of journals revealed that Diabetes Care is the top journal in terms of cocitations, followed by The New England Journal of Medicine. Memish, Z.A. scored the highest cocitation ( $n = 343$ ), while Al-Nozha, M.M. had the highest total link strength (6,582). Bibliographic coupling analysis based on association strength for documents revealed that Al Dawish M.A. (2016; Diabetes mellitus in KSA: A review of the recent literature) had the highest total link strength (67). Saudi Medical Journal is the top one based on bibliographic coupling analysis. These micro

and macrolevels of analysis help decision makers and policy advisers to direct research on DM.

There are certain limitations to the current study. Even though the authors did all they could to avoid inaccuracies, false-positive and false-negative results are conceivable. Furthermore, the use of Scopus to retrieve documents may have resulted in the loss of some publications published in unindexed journals in non-English speaking countries. Future research may draw on a broader set of data sources to guarantee that no studies are overlooked. Additionally, keywords may be classified and employed by other analytical approaches, such as correspondence analysis, to get further insight and uncover new patterns in DM. Finally, a review based on the number of citations over a lengthy period of time cannot disclose the impact of freshly published research. Thus, breaking down the study period into subperiods may aid in determining how prominent research topics alter and evolve through time in DM.

## Conclusion

Diabetes is one of the most serious global health problems, affecting millions of individuals throughout the globe. The six Gulf Cooperation Council nations, including KSA, have the highest DM incidence in the MENA area.<sup>[58]</sup> A holistic map on this issue is required in order to get a complete scientific framework that aids in the prediction of future research orientations in the area of DM. Through various methods, this study conducts a bibliometric analysis of research connected to DM in order to investigate the scientific structures and linkages between the basic articles on this subject. The cocitation analysis, like the bibliographic coupling analysis, was used to discover the most important publications, journals, authors, clusters, and networks. There were 1,919 documents published. Researchers from several disciplines were involved in DM research. In total, 37% of them have published 10 or more scholarly articles. Al-Daghri, New Mexico (King Saud University) is the leader. Seven hundred fifty-seven (39.44%) research projects got financing from 159 domestic and foreign sources. Z.A. Memish is the most referenced author. Saudi Medical Journal has the greatest number of citations (1,214). Al-Daghri, New Mexico (KSU) is the most collaborative. One hundred forty-one nations supported diabetes research in Saudi Arabia. With Saudi Arabia, the Egyptian Supreme Institute of Public Health has the greatest scientific partnership. Authors' and all keyword analyses pointed to a dense knowledge structure. The New England Journal of Medicine has 2,220 cocitations and a total link strength of 19,283, followed by the Diabetes Care Journal. These methodologies were integrated to offer an overview of the intellectual structure of DM research, allowing academics to position their efforts in this region and explore new research avenues in the future. This study is the first of its kind on the bibliometric analysis of diabetes research in KSA. This study benefited from the huge volume of studies and will add a lot of information that primary care physicians can benefit from.

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## Authors' contribution

SIA, MMET, and YK conceived the research, gathered, entered, and analyzed the data; prepared the report; and submit it. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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## Conflict of interest

There are no conflicts of interest.

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