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Evaluation of research productivity in Diabetes research from Pakistan: A bibliometric analysis (2001-2021)

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Despite the persistent and mounting issue of diabetes, literature appraising its research progression, particularly from low- and middle-income countries is scarce. This study aimed to evaluate the diabetes-related research performance from Pakistan (2001-2021). Data were retrieved from the Web of Science (WoS) and "Bibliometrix" package in R was used for extensive bibliometric analysis. Pakistan was ranked 27th with 2062 articles (1% of global contribution) from 504 sources and 7796 authors. Overall, an upward trend was observed, with the majority being published within the last 5 years. Two authors had > 50 publications, 4 authors showed an h-index of ≥ 10, and 3 authors had ≥ 1000 citations. Around 80.7% of the articles had corresponding authors from Pakistan and most of them had single-country publications. The USA, China, and Saudi Arabia also made notable contributions. Dow University of Health Sciences and Aga Khan University were leading affiliations. The leading funding sources were mostly from Western countries except for the Higher Education Commission of Pakistan. Leading authors and affiliations showed both the public and private sector representation but mostly from Karachi with established local and intra-regional collaborative trends that need to be sustained and expanded across the country. Among the top 10 sources, half were in the ESCI category and 6 were local journals from Pakistan. Study findings suggest encouragement and support for publishing more in higher impact factor and quality journals and emphasize the need to explore possible solutions to foster a consistent and quality research culture in resource-constrained settings

Keywords: Diabetes Mellitus, Research, Pakistan, Bibliometrics

INTRODUCTION

Diabetes Mellitus is one of the major persistent and mounting public health threats distressing both mortality and morbidity along with its socio-economic impact. Diabetes mellitus is characterized by abnormal glucose metabolism and if this disease is not managed properly it can lead to various complications such as retinopathy, nephropathy, and neuropathy among others. Diabetes is one of the top 10 causes of global mortality with an increase in prevalence across the world including in developing as well as developed countries in recent decades (Alam, Asghar, et al. 2014, Wang, Gao, et al. 2017, Lin, Xu et al. 2020). The International Diabetes Federation (IDF) anticipated the global prevalence of diabetes in 2017 to be >450 million reaching around > 6%of the global population(Khan, Hashim, et al. 2020), and in 2045 the prevalence of diabetes will rise by 693 million (Cho, Shaw, et al. 2018). Diabetics have 2-3 folds increased all-cause mortality (Yang, Yu et al. 2019). Additionally, diabetics are at increased risk of mortality from other co-morbid conditions such as cancer, cardiovascular disease, chronic kidney and liver diseases, infections, and stroke (Policardo, Seghieri, et al. 2015, Bragg, Holmes et al. 2017).

Between 2000 and 2019, the increase in global age-standardized diabetes mortality rate was 3% while it reached 13% for the lower and middle-income countries (WHO 2022). Some regions like island nations in the Pacific Ocean have a higher prevalence of diabetes than others. In the last two decades, Countries from the Southeast Asia region such as Indonesia, Malaysia, Thailand, and Vietnam, have increased through the ranks. Due to its large population size, China has 88.5 million people with type 2 diabetes, followed by India and the United States with 65.9 million and 28.9 million people with diabetes respectively(Khan, Hashim, et al. 2020). From 2010 to 2030, diabetes in the adult population is predicted to increase by 69% in developing countries, compared to 20% in developed nations (Ogurtsova, da Rocha Fernandes, et al. 2017). Both males and females have seen an increase in diabetes mellitus incident cases over the recent decades(Khan, Hashim, et al. 2020, Liu,

Ren, et al. 2020). Most of the patients with diabetes are under the age of 64 years in developing nations, as opposed to developed nations where the majority of patients are older (Akhtar, Nasir, et al. 2019).

In Pakistan, a developing country, diabetes prevalence is also rapidly increasing. Diabetes and its associated risk factors prevalence have been the subject of numerous research studies but estimates of the prevalence of diabetes vary greatly from study to study. According to one study, diabetes prevalence in Pakistan is very high, reported from 7.6 % to 11% in 2011, with an expected rise by 2030 to 15%, with the provincial pattern of diabetes prevalence as Punjab (30.2%), Sindh (32.3%), Baluchistan (29.5%), and Khyber Pakhtunkhwa (13.2%), According to the National Diabetes Survey of Pakistan (NDSP 2016-17), diabetes affects 26.3% of Pakistanis. If current trends continue, Pakistan will soon have the highest prevalence of diabetes in the world. This concerning situation poses a challenge for Pakistani healthcare professionals and policymakers (Hussain and Ali 2016). Based on the rise in diabetes prevalence in Pakistan, the estimated economic burden of only outpatient diabetic care clinics will surpass Rs. 71 billion in a single year. This is 80% more than the recent fiscal year's total budget which was Rs.40 billion (Iqbal 2015, Basit, Fawwad, et al. 2019). Diabetes control and prevention is a major task and challenge for healthcare professionals and national policymakers in the healthcare system. Diabetes' economic burden, in terms of mortality and morbidity, will consume a significant portion of the health budget in an already strained healthcare system with inadequate funds and resources. The development of society and the economy is hampered by poverty as a cause of diabetes complications(Hussain and Ali 2016).

Unfortunately, the Government of Pakistan has not given medical research or research, in general, a high priority. Although, the global influence of Pakistan's research is on the rise(Iqbal 2015). Despite this growth, it is challenging to evaluate the existing situation and determine trends and performance to make better plans and investments for the future. To address this expanding health problem, it may be challenging to evaluate diabetes-related research and publication trends in Pakistan. Bibliometrics is a useful scientific tool for such required appraisals utilizing both qualitative and quantitative parameters (Abramo and D'Angelo 2011). This study aimed to evaluate the diabetes-related research progress from Pakistan indexed in the Web of Science (WoS) in the last 2 decades, using a variety of widely used bibliometric indicators. This evaluation of research trends and performance could support policy and decision-makers in making decisions that will allow strategic changes to be implemented.

MATERIALS AND METHODS

This bibliometric study explored diabetes-related publications from Pakistan. With a population of more than 230 million, Pakistan is considered to be a lower-middle-income nation by the World Bank. With a $348.26 billion GDP, it spends around 3% of that amount on healthcare (World Bank 2021).

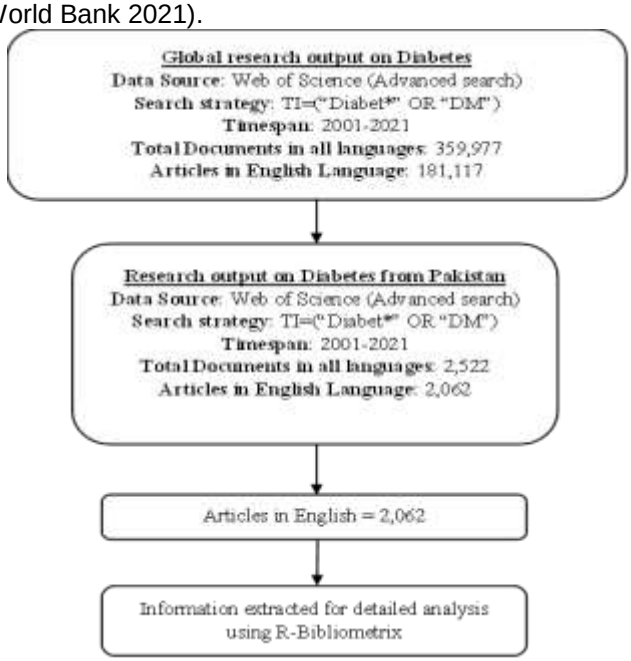

Figure 1: Global and Pakistan research output on Diabetes (2001-2021)

There are many databases available for academics and researchers, including EBSCO, ProQuest, PubMed, Scopus, and others. The Web of Science (WoS), a commonly used credible database, was chosen to identify pertinent publications together with the appropriate criteria, search subjects, and literature-identified keywords. Furthermore, WoS is more suitable to compare the research yield of diverse affiliations, authors, and locations (Jelercic, Lingard, et al. 2010, Ronda-Pupo, Díaz-Contreras et al. 2015, Gazzaz, Butt et al. 2020). It includes a search across pertinent research records in addition to including around 1.9 billion searchable cited references from over 171 million records (WoS 2022). An extensive variety of variables were used to assess the quality and quantities of publications and provide a critical picture of Pakistan's contribution to diabetes research at the local and worldwide levels. The King Abdul Aziz University's digital and online tools were used to access information (KAU). In this work, scientometric techniques were employed to guarantee the accuracy of the data at both the first stages of extraction and subsequent processing. For the examination of all published publications in WoS between 2001 and 2021 that had a clear focus on diabetes, the employed search strategy was: Title (TI) = ("Diabet*" OR "DM") AND Country (CU) = Pakistan, Timeframe: 2001–2021. All English-language articles (a total of 2062) were included for the in-depth analysis of this study, as shown in Figure 1. The investigation was done on November 11, 2021. To

guarantee consistency and check the process, the author (AAM) independently looked up and abstracted the relevant data twice on the same day to avoid any discrepancy. Data in the plain text files from WoS were retrieved. Later the "Bibliometrix" package in R was used for extensive bibliometric analysis(Aria and Cuccurullo 2017). The extracted data were analyzed using a variety of bibliometric measures, including affiliations, authors, citations, countries, documents, sources, and collaborative networks.

RESULTS

The total number of articles published in the English language and indexed in WoS with “Diabet*” OR “DM” in titles from 2001 to 2021 was 181,117 from 205 countries and 7,056 sources. Among countries, the USA, China, the United Kingdom, Japan, and India collectively contributed around 60%: 28%, 13.6%, 7.3%, 6.7% & 4.8% respectively while the top 10 countries collectively contributed more than 2/3rd (around 80%). Articles were associated with 236 WoS subject categories and 148 research areas led by Endocrinology Metabolism (31.7%), Medicine General Internal (8.4%), and Pharmacology Pharmacy (7%). Around 4% of documents (n=4,720) showed any group authors while the authors' appearances were > 100,000. Around 90,302 (49.9%) of these articles were in the open access category and 56.4 % (n= 76,464) showed any funding source. When explored for this study scope, the contribution from Pakistan was 2,062 articles in English and indexed in WoS with “Diabet*” OR “DM” in titles from 2001 to 2022 representing around 1.1% of the global productivity and ranked 27th

Table 1: Summary table

Description	2001-2011	2012-2021	2001-2021
Sources (Journals, Books, etc.)	89	461	504
Articles	190	1872	2062
Article average age	14.2	4.83	4.7
Average citations per article	35.07	10.59	12.82
References	4610	41615	45156
Article Contents			
Keywords Plus (ID)	565	2675	2889
Author's Keywords (DE)	441	3876	4126
Authors			
Authors	768	7424	7796
Authors of single-authored articles	2	10	12
Authors Collaboration			
Single-authored articles	2	13	15
Co-authors per article	5.48	7.67	7.47
International co-authorships %	31.58	32.44	32.44

A summary of the study scope articles from Pakistan (2001 - 2021) in English is shown in Table 1 with 2062 articles from 504 sources with 190 and 1870 articles published from 2001-2011 and 2012-2022, respectively. The total number of author’s was7796 while the single-authored articles were 15. In the year 2022, at the time of data extraction around 226 articles were published from Pakistan and these were not included in the detailed analysis. Articles in the open access category from Pakistan were around 37% (765).

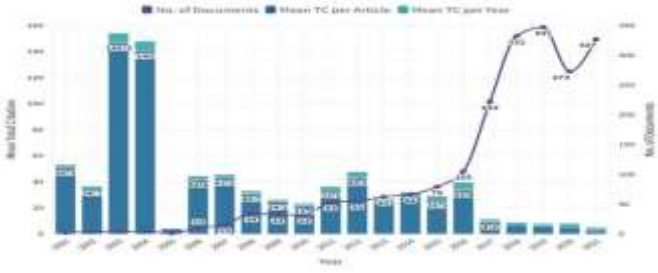

Figure 2: Year-wise articles productivity and mean total citations

Figure 2 shows the year-wise articles' productivity and mean total citations having the highest publications in the year 2019 (n=347) and the minimum in 2001 (n=2). Initial years (2001-2011) contributed 190 (9.2%) articles while the last 10 years (2012-2021) contributed 1872 (90.8%).

Table 2: Top 20 most productive authors with authors’ impact:

Authors	Articles	FA	CA	h_index	TC
BASIT A	67	10	11	19	2481
FAWWAD A	65	9	20	14	792
ALI A	39	8	10	8	313
KHAN A	38	7	6	9	931
AHMAD M	33	5	6	9	447
KHAN MA	31	7	5	9	312
AHMAD S	29	7	5	8	184
HUSSAIN M	27	11	12	5	143
HUSSAIN S	26	6	5	7	124
ALI M	25	5	2	7	150
RIAZ M	25	6	8	9	246
AHMED S	23	2	2	6	161
AHMEDANI MY	23	7	11	9	324
KHAN S	23	5	5	7	146
AHMAD A	22	4	4	7	226
KHAN M	22	6	3	4	186
AKASH MSH	21	10	14	13	1222
ALI S	21	3	3	6	115
RIAZ S	21	8	6	8	283
REHMAN K	20	7	1	13	1194

FA - First author, CA - Corresponding author, TC – Total citations

Table 2 shares the top authors' productivity and impact with 5 authors showing>30 and 2 authors having > 50 publications namely; Basit A (67), and Fawwad A (65). Four authors showed an h-index of ≥ 10, led by the same 2 most productive authors. Three authors had ≥ 1000 citations. From a total of 99 authors' countries other than Pakistan, the USA, the United Kingdom & China were leading with 938, 497 & 355 articles respectively. For total citations per country, Pakistan, the United Kingdom, the USA, and China were leading with 11628, 4821, 3994 & 1019 respectively.

Table 3: Top 10 countries with Corresponding authors

Country	Articles	SCP	MCP	Freq	MCP Ratio
PAKISTAN	1665	1383	282	0.807	0.169
USA	60	0	60	0.029	1
CHINA	59	0	59	0.029	1
SAUDI ARABIA	55	2	53	0.027	0.964
UNITED KINGDOM	35	0	35	0.017	1
INDIA	28	3	25	0.014	0.893
MALAYSIA	21	0	21	0.01	1
U ARAB EMIRATES	15	1	14	0.007	0.933
GERMANY	14	0	14	0.007	1
KOREA	14	0	14	0.007	1

Table 3 shows the leading corresponding authors which were from 41 countries in total with 1665 (80.7%) of the articles from Pakistan followed by 60, 59, and 55 from the USA, China, and Saudi Arabia respectively, as shown in Table 3. Around 83% of the corresponding authors from Pakistan, published single-country publications.

Table 4: Top 10 affiliations and funding organizations

Top 10 affiliations	Articles
Dow University of Health Sciences	149
Aga Khan University	125
University of Karachi	124
Baqai Medical University	116
Comsats University Islamabad	93
Government College University Faisalabad	90
University of Lahore	90
University of Punjab	89
University of Agriculture Faisalabad	87
National University of Sciences Technology Pakistan	75
Top 10 funding Organizations	
Higher Education Commission of Pakistan	123
National Institutes of Health - USA	47
United States Department of Health Human Services	47
European Commission	30
NIH National Institute of Diabetes Digestive Kidney Diseases	26
National Heart Lung Blood Institute - USA	24
Medical Research Council - UK	22
UK Research Innovation	22
Wellcome Trust	20
British Heart Foundation	19

Altogether, around 2776 affiliations contributed to producing 2062 publications in the study scope. Table 4 shows the top 4 affiliations contributed with > 100 articles each namely; Dow University of Health Sciences, Aga Khan University, University of Karachi, and Baqai Medical University with 149, 125, 124, and 116 articles respectively. The leading funding source from Pakistan was the Higher Education Commission of Pakistan followed by the National Institutes of Health and the United States Department of Health Human Services from the USA. General Internal Medicine (34.2%), Pharmacology-Pharmacy (12.7%), Chemistry Medicinal (11.2%), and Endocrinology-Metabolism (10.9%) were the most common WoScategories and a similar trend was observed in research areas. For the Web of Science indexing around 38.1% of articles were in Emerging Sources Citation Index (ESCI) category.

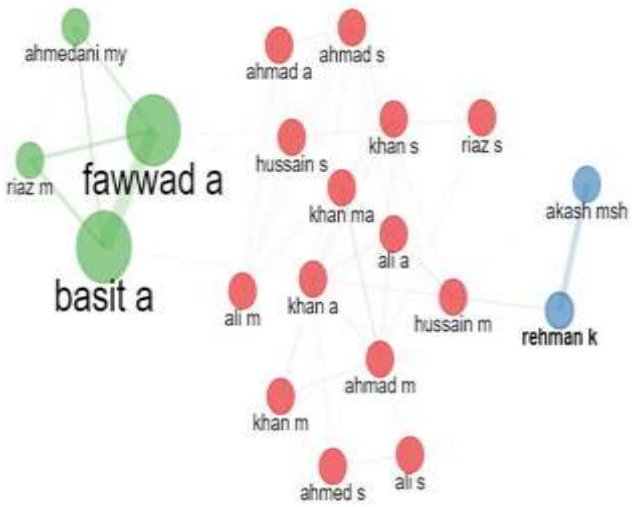

Figure 3: Top 20 Authors' Collaboration Network

Figure 3 shows the top 20 authors' collaboration network with 3 main clusters shown in green, red, and blue.

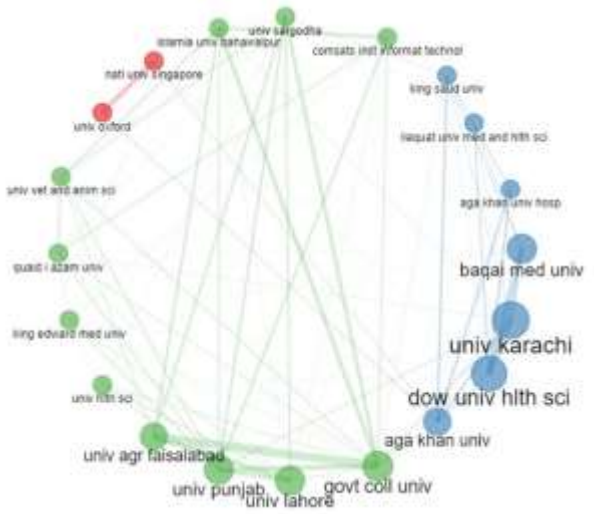

Figure 4: Top 20 Affiliations Collaboration Network

Similarly, 3 main clusters were also observed for the top 20 affiliations collaboration network as shown in Figure 4.

Table 4: Top 10 highly cited publications

Document	Year	Local Citations	Global Citations	LC/GC Ratio (%)
SHERA AS, 2007, DIABETES RES CLIN PR	2007	77	177	43.50
BASIT A, 2018, BMJ OPEN	2018	37	95	38.95
AAMIR AH, 2019 , BMJ OPEN	2019	33	81	40.74
SALTI I, 2004, DIABETES CARE	2004	21	450	4.67
SHERA AS, 2010 , PRIM CARE DIABETES	2010	21	61	34.43
KHOWAJA LA, 2007, BMC HEALTH SERV RES	2007	16	73	21.92
ZHOU B, 2016, LANCET	2016	15	1737	0.86
KOONER JS, 2011, NAT GENET	2011	14	381	3.67
MORRIS AP , 2012, NAT GENET	2012	14	1341	1.04
JAFAR TH, 2004, DIABETIC MED	2004	12	58	20.69

IC - Internal Citation (Citations within study selected documents), GC - Global Citation (Citation in Web of Science)

Most of the highly cited publications shown in Table 4 were published between 2004 to 2012. Two of the articles published in BMJ Open (each in 2018 and 2019) showed relatively more citations. Among sources, two showed > 1000 citations including 'Diabetes Care' followed by 'Diabetes RES CLIN PR' with 3360 and 1012 citations respectively. From 504 total sources, the 'Indo American Journal of Pharmaceutical Sciences', was foremost with 233 articles followed by the 'Pakistan Journal of Medical Health Sciences', 'Pakistan Journal of Medical Sciences' and 'Journal of the Pakistan Medical Association' with 176, 132, and 118 articles. The year-wise progress of the 10 most productive sources is shown in Figure 4 with relatively increased contributions of diabetes-related publications in recent years.

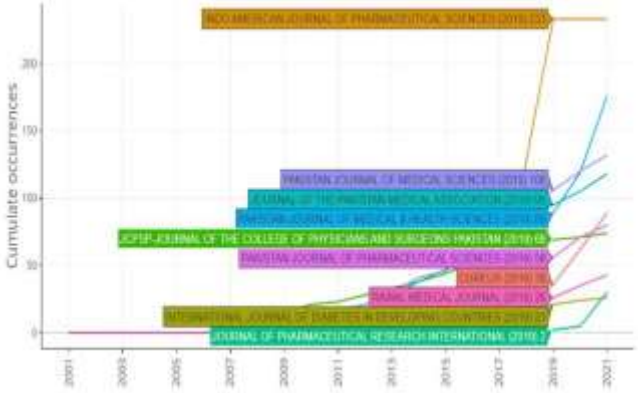

Figure 4: Year-wise progress of the 10 most productive sources

In total, 4126 keywords were used. Tree map in Figure 5 shows that 'Diabetes Mellitus', 'Diabetes', and 'Type 2 Diabetes Mellitus', were the most frequently used keywords.

Figure 5: Treemap of keywords

DISCUSSION

Healthcare research has become increasingly important in recent years due to the growing awareness of the importance of health and the need for evidence-based health care. Diabetes research is also ongoing, and the field is constantly evolving. On research trends and performance, literature is scarce from the region including Pakistan. To the author's best knowledge, this is the first bibliometric study assessing diabetes research from Pakistan. The current study provides a comprehensive overview of publications on diabetes from Pakistan. This will help plan targeted diabetes research priorities and avoid unnecessary use of Pakistan's already limited resources. Findings would benefit academicians, physicians, and researchers, but also the policymakers

and other key stakeholders from the region including Pakistan to recognize recent trends, identify relevant desirable future research ideas and provide better-informed decisions.

In general, Pakistan was ranked 27th and had around 1% (n=2062) of diabetes-related global research productivity mainly led by Western and developed countries. Similar trends have also been observed in many such health-related studies (Abdullah, Humayun, et al. 2022, Rodzlan Hasani, Hanis, et al. 2022, Yin, Wang, et al. 2022). Among neighboring countries, India (n= 8,683) and Iran (n= 4,491) were the leading countries from the region with global ranking and percentages at 4th(4.8%), and 18th(2.5%) respectively. The sources for the study scope accounted for about 7% of all global sources. Articles in the open access category from Pakistan were 37% which was much lower than 59% of the global open access figures and highlights the limitation for less developed countries like Pakistan. Notably, these relative findings necessitate more exploration and efforts for essential improvements.

A gradual increase in productivity was observed from 2006 to 2016 followed by a spike from 2017 with around 2/3rd of the contribution from the last 5 years (2017-2021). Presumably, a continuous prioritization of relevant research and the allocation of adequate resources are essential for better preparation and addressing future challenges.

The study found that the same two authors Basit A and Fawwad A were leading the productivity as well as the impact. The authors Fawwad A and Basit A. Notably, the top authors showed collaborative trends with the same 2 most productive authors found in one cluster and demonstrated the highest level of collaboration and represented the same affiliation of Baqai Medical University. Most of the other top 20 authors also showed collaborating trends and were found in another cluster. As corresponding or first author, the contribution of Basit A, Ali M, and Ali S were relatively low as compared to other prolific top authors, while Fawwad A, Hussain M, and Akash MSH showed high contributions as corresponding and/or first author.

According to the study, > 2/3rd of the corresponding authors were from Pakistan followed by authors from the USA, China, and Saudi Arabia. The same countries were observed for leading total citations per country. Similar trends were also found for these countries to be major contributors in another bibliometric study on diabetes from Saudi Arabia (Gazzaz, Butt, et al. 2020). The majority of the Pakistani corresponding authors published the single country publications advocating the need to emphasize international collaborations with more multi-country publications including feasible neighboring countries with similar settings.

Findings related to the most frequently used keywords were led by; Pakistan, diabetes mellitus, diabetes, and type 2 diabetes mellitus. Additionally, the study findings demonstrated the evolution of varied issues and interdisciplinary aspects related to diabetes and its complications covering diabetic retinopathy, hypertension, and insulin resistance among others yet no specific field-specific pattern or dominance was observed that could be due to limited research and relevant literature from the region. It also emphasizes the significance of continuously observing the relevant research context in a multifacetedly expanding field.

Leading affiliations showed contributions from both the public and private sector top-ranked organizations from the country. Dow University of Health Sciences, Agha Khan University, University of Karachi, and Baqai Medical University were the major organizational contributors. It was interesting to observe that all of these organizations were from the same city Karachi. While other leading institutes from other regions including the most populous province of Punjab and federal territory Islamabad showed relatively fewer contributions. Affiliations collaboration networks also showed similar intra-organizational and intra-regional collaboration trends. Perhaps more inter-regional collaborations can be considered in the future.

The journal 'Indo American Journal of Pharmaceutical Sciences', from India, was the leading source. Interestingly, it contributed only from 2017-2019 and didn't show any contribution before or after this timeframe. Six out of the top 10 sources were local journals showing relatively major contributing sources for top authors with relatively more productivity observed in the last 5 years while 3 journals in the top 10 were from India. Exploring whether local and external reputable journals reflect similar trends for other prevalent diseases in the region would be a valuable avenue of inquiry.

In terms of the Journal Impact Factor (JIF) Quartile among the top ten productive sources, half were in the Emerging Sources Citation Index (ESCI) category with 2 journals each from Pakistan and India while Cureus was the only journal among the top sources that represented the developed world (the USA) and was also in ESCI category. Only the 'Pakistan Journal of Medical Sciences' had > 2 impact factor and was in the Q3 category. The rest of the top sources were found in the Q4 category. Notably, around 1/4th of the total articles in the study scope were published in Emerging Sources Citation Index (ESCI) category. Possibly, these changes can be related to the reality of exclusion or discontinuation of a leading source in our study findings at one end and the inclusion of a few new local journals being indexed in WoS in the ESCI category in recent years. In contrast, most of the highly cited documents were from high-impact factor journals. Open-access journals, with or without publication charges, are found to have a positive correlation with journal impact factors and H-indexes (Ghane, Niazmand, et al. 2020). It is suggested that researchers, from Pakistan, should also be encouraged to publish their research in higher quartile (Q1 and Q2) journals. Our

findings also correlate with such health-related studies from other regions outside of Western countries (Baeesa, Maghrabi, et al. 2017, Almarghoub and Al-Qattan 2019).

Pakistan's Higher Education Commission was the leading and rare local funding organization, followed by mostly foreign funding organizations from developed countries led by the USA. These results imply the absence of local funding sources in Pakistan, which may have restricted more research that could have been done. Limited resources such as the lack of capable and motivated researchers, unavailability of advanced research laboratories, inadequate funding, and fewer local quality journals could have hindered the development of local quality research culture. Furthermore, publication charges for most of the high-quality open-access journal range from 1500-5000 dollars per publication which can be an additional barrier to publishing in quality journals.

Moreover, exploring the trends in local as well as high-quality journals may reveal unique insights and perspectives that are not adequately captured in the global literature. Therefore, future studies could consider a broader range of publications, diseases, and/or regions, including those that may not be indexed on major databases like the Web of Science. Such efforts can help to bridge the gaps in knowledge and research capacity between high- and low-income countries and contribute to the development of more effective and context-specific strategies for disease prevention and management.

A possible explanation for the limited research output from middle-income and lower-middle-income countries like Pakistan can be that the present study relied solely on a search of the Web of Science, which does not index many journals published in these countries. Thus, the study's reliance on data solely from WoS may also limit its scope and applicability. To supplement the study, metadata from additional sources and time frames could be leveraged to provide a more comprehensive perspective on the subject. Furthermore, the paucity of available literature in the study's context and region posed a challenge to making meaningful comparisons with other regions and periods.

CONCLUSION

This study informed that Pakistan contributed to around 1% of global diabetes research and was ranked 27th. In general, there was an upward trend in the number of publications in diabetes research, with the majority being published within the past 5 years. A significant proportion of the corresponding authors were from Pakistan, and the majority of the publications were single-country collaborations. The USA, China, and Saudi Arabia also made notable contributions, in terms of corresponding authors and total citations per country. Leading affiliations showed contributions from both the public and private sector top-ranked organizations from the country but mostly from Karachi. Top authors and affiliations showed established local collaborative trends that need to be sustained, expanded, and supported across the country. Other than HEC, the possibility of more local funding sources needs to be considered. Half of the top sources were in the ESCI category. Six of the top 10 sources were local journals from Pakistan with only one in the Q3 category suggesting encouragement and support for publishing more in higher impact factor and quality journals. These findings call for attention and emphasize the need to explore possible solutions to foster a consistent and quality research culture and support resource-constrained settings.

CONFLICT OF INTEREST

The authors declared that the present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Author AAM was the sole author involved in the study conception, design, data collection, analysis, writing, reviewing, and approval of the final version of the manuscript.

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