REVIEW ARTICLE

Bibliometric Evaluation of Dental Research Productivity and Assessment of Influencing Factors in Pakistan

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ABSTRACT

Objective: This study aimed to evaluate the dental research productivity of Pakistan-based authors and assess the factors that can influence their performances.

Methods: The bibliometric analysis was carried out to examine dental research contributed by Pakistani authors from 1993 to 2022. The bibliographic details of all the relevant published articles on dentistry were extracted from the Scopus database. The search strategy was built using pertinent keywords connected with different Boolean Operators. After applying the inclusion/exclusion criteria, 2859 articles were included in the final analysis. Micro-soft Excel and VOS viewer software were used to analyze the data.

Results: Overall, Pakistan contributed 0.72 percent of the global dental research, however in the last five years, this ratio reached 1.56 percent. A slow research progress was recorded in the first 15 years, whereas exceptional growth was found in the last five years of study. The research impact analysis showed that the selected articles were cited with an average of 7.68 citations per article. Moreover, dental research co-authored with international authors had a higher citation impact than nationally collaborated or single-authored articles. The highest number of articles were found on *Dental Education*, followed by *Oral Pathology/Medicine* and *Dental Public Health*, however, the articles on *Periodontics* gained the highest citation impact. Most of the articles were published in locally published journals, and Saudi Arabia was found to be a vital partner in dental research.

Conclusion: The research activities increased over time, and dental research with international collaboration had a better impact.

Keywords: *Academics; Bibliometric Database; Dentistry; Developing Countries; Pakistan; Research Activity.*

Introduction

Academic and clinical research require a lot of effort and consistency, whereby educators and institutions must strategize the curricula, develop programs, and conduct activities such that both undergraduate and postgraduate students are engaged towards a research-oriented approach.[1,2] The innovative advances in operating techniques and contributions to dentistry revolutionized oral health therapy and greatly extended life expectancy.[3] As a far-reaching consequence, the research activities aim to improve the standards of oral health care provided to patients. Both preventive and curative dental treatments aim to improve patients' quality of life.[4]

According to the United Nations, nearly forty-five countries worldwide have been classified as least developed. Most African nations fall within the low-income category according to the World Bank's criteria, while South Asian countries are classified as lower-middle-income. Predominantly, all the research and data analysis on oral health and disease is concentrated in high-income countries.[5]

According to the United Nations, Pakistan is classified as a lower-middle-income country. A healthy community can significantly contribute to the nation's progress.[6] Numerous universities, dental

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colleges, dental hospitals, and oral health research facilities in Pakistan are involved in dental research. Ever since the restructuring of the higher education system in Pakistan, research publications have become mandatory for promotion and upgradation.[7] This altered the mindset and provided an innovative insight. An extraordinary growth in research activities has been observed over the last two decades.[8]

Being the fifth most populous country in the world, the share in global research has been unsatisfactory.[9] Haq[10] reported that only 731 papers on medical sciences were produced by Pakistan in 2001, reaching 6685 in 2020. Furthermore, the study deduced that more than one-third (27%) of the total research in Pakistan was conducted in medical sciences, however, the ratio of dental research was nominal.

Literature also revealed the trend of subject-wise publication related to dentistry in Pakistan and reported the scarce situation, thereby creating a substantial knowledge gap.[11,12,13,14] This limited output not only underscores the uneven distribution of scholarly focus but also reveals significant gaps in evidence-based resources necessary for advancing academic inquiry. Consequently, the lack of comprehensive and balanced research creates a substantial knowledge gap that warrants urgent attention from researchers, academicians, and policymakers alike. Though, bibliometric studies evaluated the research output in dentistry, and reported that globally dental research makes limited contributions in biomedical sciences.[15,16] It is essential to highlight Pakistan-based dental research through quantitative analysis. To the best of the author's knowledge, no quantitative study to date has documented the global contribution of dental research originating from Pakistan.

Therefore, this study aimed to do a comprehensive bibliometric analysis of Pakistan-based dental research published in the Scopus-indexed journals and addressed the methodological gap. The study is based on the research questions, including (i) what was the contribution of Pakistan to global dental research, and how did dental research and its metrics progress from 1993 to 2022? (ii) What was the proportion of research collaboration at national and international levels? (iii) Which were the preferred patterns of authorship and what were the most favorite and the least researched areas of dental research in Pakistan? (iv) Which were the most frequently used sources of publications, and which were the most research collaborative countries to Pakistan in dentistry?

Methodology

This study employed a bibliometric method to evaluate research progress in dentistry produced by Pakistan over 30 years, from January 1, 1993, to December 31, 2022. The study examined the data obtained from the Scopus database.

The study used these keywords: dentistry, dental, orthodontic*, prosthodontic*, periodontic*, pedodontic*, oral surgery, maxillofacial surgery, restorative dentistry, endodontic*, oral hygiene, and oral health. These keywords were used by Alonaizan et. al.[17] to analyze Saudi Arabia's research output in dentistry. Further, only original research articles and reviews were selected from the filter of the document type, and all the other types of documents were excluded. Pakistan was selected from the country/territory filter. Microsoft Excel (Microsoft 365, Microsoft, USA) and VOSviewer software (*version* 1.6.20) were used to analyze the data.

Results

The initial search query generated 398,624 articles (articles and reviews only) on various dental specialties published between January 1, 1993, and December 31, 2022. However, after selecting Pakistan from the country/territory filter, only 2,859 articles were left (Figure 1). From 1993 to 2022, Pakistan subsidized 0.72 percent of the world's dental research. The periodic distribution revealed that from 2018 to 2022, Pakistani authors contributed 1.56% of the global dental research (Table I).

Progress was plodding (n=120; 4.19%) during the first 15 years (1993 to 2007), however, in the next 10 years (2008 to 2017), the growth of dental research appeared to be picking up, and more than one-third of the articles (n=972; 34%) were published. A phenomenal growth (n=1767; 61.81%) was recorded over the past five years (2018 to 2022). The articles published between 2008 and 2012 had the highest citation impact (12.60 citations/article), whereas overall, all the articles gained an average of 7.68 citations per article (Figure 2).

The analysis (Table II) of national and international research collaboration showed that Pakistani authors produced more than two-thirds of articles by collaborating at the national level. In contrast, almost one-third of the articles were the outcome of international research collaborations. Over time, the proportion of international collaboration increased, and from 2018 to 2022, 37 % of articles were co-authored with international authors. A sharp contrast in citation impact between national and international collaboration was found. The articles produced with international collaboration gained an average of 14.10 citations per article compared to those produced nationally, which received 4.62 citations per article (Table II).

The analysis of authorship patterns revealed that 97% of the articles were written by a collaboration of two or more authors, and the six-author pattern was found to be most proffered, followed by three-author patterns (Figure 3). The nine-author pattern gained the highest citation impact (14.25 cites/article), and the six-author pattern gained the lowest citation impact (4.86 cites/article). The average number of authors per article was 3.18 during the first 15 years (1993-2007), while this ratio increased to 4.15 authors per article in the next 10 years (2008-2017), and the highest proportion, an average of 6.10 authors per article, was found during the last five years of study (2018-2022).

The subject dispersion of dental research exposed that apart from miscellaneous articles that were related to more than one dental specialty or minutely related to dentistry, the highest number of articles were written on the topic of *Dental Education* (468), followed by *Oral Medicine/Oral Pathology* (330) and *Dental Public Health* (312). *Pediatric Dentistry* (47) and *Oral & Maxillofacial Radiology* (38) had the lowest number of articles. The articles on *Periodontics* had the highest citation impact, followed by Restorative Dentistry. The ratio of citable articles is expected to be higher in these two dental specialties. The articles on *Pediatric Dentistry* had the lowest citation impact (Figure 4 & Table III).

Twelve of the top 15 most preferred sources of publications are being published from Pakistan, and 57% (n=1632) of the total articles were published in these top 15 journals. The highest number of articles was published in *Medical Forum Monthly,* followed by the *Pakistan Journal of Medical and Health Sciences*. The top six journals published more than 100 articles each. *The European Journal of Dentistry* was found to be the most preferred international source of publication. Among the top 15 sources, Photodiagnosis and Photodynamic Therapy had the highest citation impact (24.03 citations/article), followed by the *European Journal of Dentistry* and the *Pakistan Journal of Medical Sciences*. *Journal of Islamic International Medical College* and *Medical Forum Monthly* received the lowest citation impact.

The examination of international research collaboration exposed that Saudi Arabia surpassed the rest of the world with 527 articles co-authored with Pakistan. Malaysia came in second with 152 articles, followed by the United Kingdom and the United States with 139 and 122 articles, respectively. Amongst the top 15 collaborating countries, the dental research co-authored with Canada gained the highest citation impact with an average of 30.81 citations per article, followed by Italy (29.72 citations per article) and the United Kingdom (22.33 citations per article). The research articles jointly written with India had the lowest citation impact (Figure 5 & Table 5).

Table I: Contribution of Pakistan in the Global Dental Research

Intervals	Total dental articles at the Global level	The share of Pakistan in dental articles	%
1993-1997	35803	8	0.02
1998-2002	39964	35	0.09
2003-2007	50705	77	0.15
2008-2012	71359	303	0.42
2013-2017	87449	669	0.77
2018-2022	113344	1,767	1.56
Total	398624	2859	0.72

Table II: Comparison of National and International Collaboration in Dental Research

	Total			National Collaboration			International Collaboration		
Intervals	TP	TC	CI	TP	TC	CI	TP	TC	CI
1993-1997	8	59	7.38	4	22	5.50	4	37	9.25
1998-2002	35	390	11.14	24	130	5.42	11	260	23.64
2003-2007	77	811	10.53	65	624	9.60	12	187	15.58
2008-2012	303	3819	12.60	247	2,165	8.77	56	1654	29.54
2013-2017	669	7289	10.90	491	2,825	5.75	178	4464	25.08
2018-2022	1767	9584	5.42	1106	3,182	2.88	661	6402	9.69
Total	2859	21952	7.68	1937	8948	4.62	922	13004	14.10

TP: Total Publications; TC: Total Citations: CI: Citation Impact

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Table III: Distribution of Articles, Citable Articles, Citations and Citations Impact by Dental Sub-Categories of Dentistry

Dental Sub-Categories	Total Articles	Percentage of citable Articles	Total Citations	Citation Impact
Dental Education	468	61.11	3258	6.96
Oral Medicine/Oral Pathology	330	67.58	3013	9.13
Dental Public Health	312	58.65	1962	6.29
Orthodontics	266	56.02	1235	4.64
Restorative Dentistry	220	69.09	2609	11.86
Periodontics	215	73.49	3004	13.97
Endodontics	186	63.44	1143	6.15
Oral and Maxillofacial Surgery	162	51.85	709	4.38
Prosthodontics	145	57.93	956	6.59
Pediatric Dentistry	47	57.45	192	4.09
Oral and Maxillofacial Radiology	38	68.42	299	7.87
Miscellaneous	470	52.34	3572	7.60

Table IV: Top 15 Most Frequently Used Sources of Publications

S. No.	Name of Journal	Total Articles	Total Citations	Citation Impact
1	Medical Forum Monthly	332	52	0.16
2	Pakistan Journal of Medical and Health Sciences	290	200	0.69
4	Journal of the Pakistan Medical Association	199	967	4.86
3	Journal of the College of Physicians and Surgeons Pakistan	183	1196	6.54
5	Pakistan Armed Forces Medical Journal	150	69	0.46
6	Journal of Ayub Medical College Abbottabad JAMC	103	393	3.82
7	Pakistan Journal of Medical Sciences	88	1474	16.75
8	Rawal Medical Journal	58	23	0.40
9	Journal of the Liaquat University of Medical and Health Sciences	56	49	0.88
10	European Journal of Dentistry	32	708	22.13
11	Photodiagnosis and Photodynamic Therapy	32	769	24.03
12	Biomed Research International	30	204	6.80
13	Journal of Postgraduate Medical Institute	29	58	2.00
14	Journal of Medical Sciences Peshawar	25	12	0.48
15	Journal of Islamic International Medical College	25	1	0.04

Discussion

Research in dentistry encounters particular difficulties in developing nations, such as a lack of funding, poor infrastructure, and regulatory barriers.[18] It later affected the quality, quantity, and extent of research due to a shortage of finances and resources.[19] At an institutional level, research orientation and competence gain accreditations and attract talented students. It opens a channel through which innovative progress and impactful research for societal progress can be generated.[20, 21] As educational institutions bear the responsibility of laying the foundation, delving into prospective research work both as a student and academician is the only way to support society as a whole.[22]

Concerning Pakistan, the first dental college, de'Montmorency College of Dentistry, was established in 1934 in Lahore. Later, public-sector

Table V: Frequency of Articles its Impact Co-Authored with Top 15 Countries

S. No.	Country's Name	Total Publications	Total Citations	Citations Impact
1.	Saudi Arabia	527	6829	12.96
2.	Malaysia	152	1157	7.61
3.	United Kingdom	139	3104	22.33
4.	United States	122	2069	16.96
5.	China	56	1142	20.39
6.	India	55	234	4.25
7.	Germany	34	449	13.21
8.	United Arab Emirates	34	342	10.06
9.	Australia	32	548	17.13
10.	Canada	31	955	30.81
11.	Egypt	25	424	16.96
12.	Italy	25	743	29.72
13.	Thailand	19	332	17.47
14.	Sweden	17	320	18.82
15.	Oman	16	321	20.06

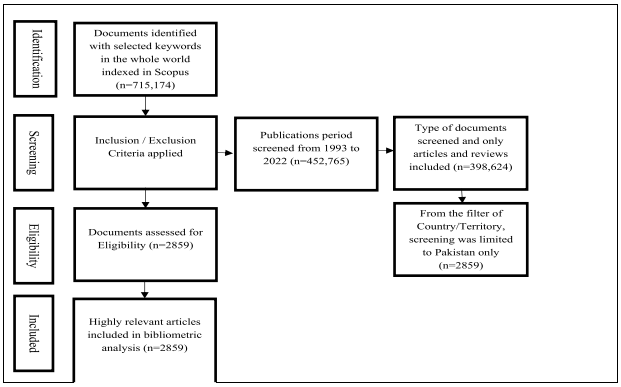

Figure 1: Screening Process of Articles on Scopus Database

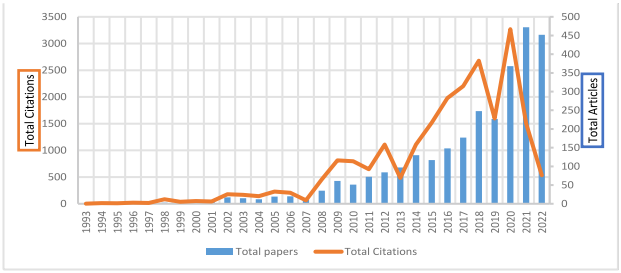

Figure 2: Distribution of Articles and Citations by years

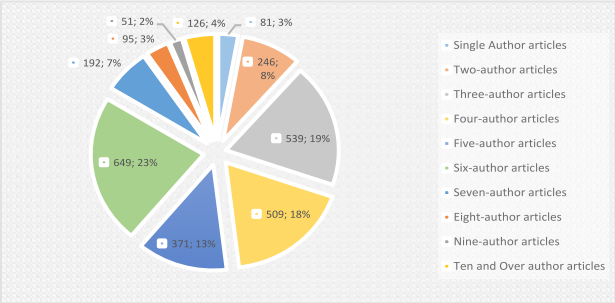

Figure 3: Distribution of Articles by Authorship Pattern

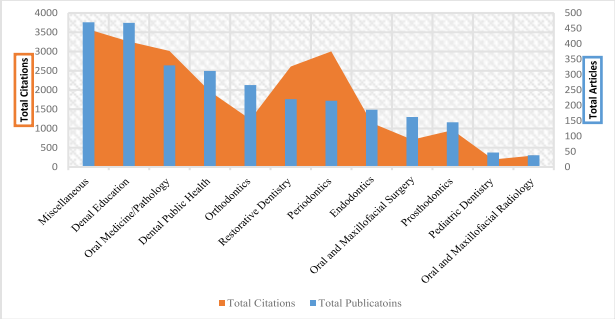

Figure 4: Distribution of Articles and Citations by Sub-Categories of Dentistry

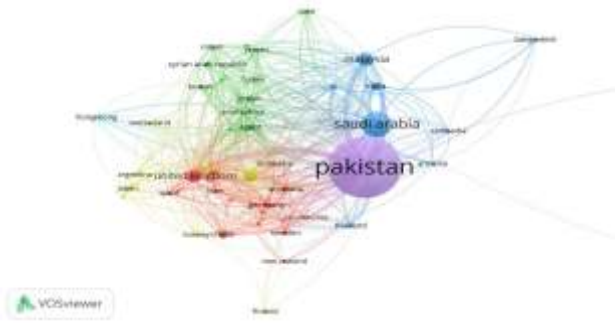

Figure 5: Co-Occurrence Network of Countries

medical colleges at Hyderabad, Peshawar, Multan, and Quetta commenced their dental sections in 1963, 1964, 1974, and 1985, respectively, while the first private dental college started at Baqai Medical University in 1992.[19] Currently, 18 public sector dental colleges/sections and 43 private dental colleges/sections are recognized by the Pakistan Medical & Dental Council (PM&DC).

According to the present study, it is unfortunate that Pakistan's research production in dentistry is minuscule (0.72%) compared to global output. The quantity of publications at national and international levels is highly unsatisfactory, indicating the conventional non-research-based approach despite an upward trend (1.56%) over the past few years (2018-2022). This stands in contrast to other Middle Eastern, Arab, and African countries, where Saudi Arabia contributes almost 3.63% of global dental research,[23] and Brazil, Egypt, Malaysia, and Iraq are also major contributors.[24-26]

There is a concerning issue that Pakistan is trailing behind its neighboring countries. Iran produces substantially more dental research, as indexed in PubMed, despite having a far lower population than Pakistan.[15] India, being a populous country, still produces an average output in terms of research articles; however, the trend is on the rise, and currently, it is contributing almost 1.21% in dental research around the world.[27]

Since the first dental article was published in 1902, the trend towards dental research was stagnant till the late 1950s, after which both article publications and citations increased significantly. Another interesting finding is that research follows certain dynamics, such as economic stability and resource availability.[28] Therefore, the highest contribution towards dental research comes from Scandinavian countries, with Sweden on top; next is the United Kingdom, followed by New Zealand, Israel, Australia, Canada, Germany, Belgium, and the USA; however, the most cited articles come from the United States (US).[29] There is only marginal participation by underdeveloped countries. Developed countries like the US, the United Kingdom (UK), China, Japan, etc., have successfully devised a functional system to engage in research with a focus on addressing and overcoming upcoming challenges.[30] In an attempt to innovate the latest and safest methods of treatment, nations have worked together to fight the odds[31].

Moreover, in developed countries, the research is more coherent with contemporary treatment modalities and futuristic approaches in utilizing artificial intelligence and robotics for diagnosis and treatment planning.[29] Although it is to the advantage of humankind for a small population, in the larger context, all the low- and lower-middle-income countries shall be brought at par with high-income countries in terms of both at the best level. For developing countries, matters are more complex regarding human resource development, infrastructure provision, specifying target areas of concern, generating a loop of finance and collaboration, dealing with the process of patency and publications, and creating a vicious research cycle.[32]

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Since the advent of the internet and consequential globalization, all fields have been moving fast towards the internationalization of efforts. Similarly, in dental research, scientists work collaboratively at inter-university and interdepartmental levels to broaden the impact of their studies. In the Pakistani research scenario, about one-third (32.24%) of articles were the results of international research collaboration. These articles gained 14.10 citations per article compared to the articles that collaborated nationally or single author that received an average of 4.62 citations per article. Likewise, it was studied in Saudi Arabia that international collaboration significantly increases publications in international journals as well as citations for an article.[17] Another relevant example is that of India working in close association with Australia in all fields of dentistry, with a special focus on research, which gave exponential upward growth for India and a more stable output for Australia as well.[33] In fact, collaborative research in terms of bilateral, trilateral, and quadrilateral papers has become so prevalent that a Collaborative Category Normalised Citation Impact (Collab-CNCI) was developed to ensure transparency among the authors for citation scores.[34] Another key factor is access to indexed journals for researchers and academicians. Issues like findability, reusability, interoperability, and accessibility pose critical problems for authors and researchers. According to a study, compliance with the FAIR principles is only 32.6%, with data sharing being more plausible in open-access journals than in non-open-access journals.[35] Presumed Predatory journals, high article processing charges, and non-acceptance of students' articles are also issues that hinder greater productivity.[36]

Based on the author's perspective, involving multiple co-authors, especially foreign colleagues, in an article has numerous benefits, such as a greater target audience, broader demographic data collection, quicker ethical issues resolution, sharing the processing charges, faster data analysis, strategic cross-checking, and better peer review. One may have to share the ownership; however, responsibilities are also divided. Although interactive hassles or disinterested participants can cause unnecessary delays, teamwork can resolve issues.[37]

There was an increase in citations and publications overall from 2017 to 2020 as the Pakistan Higher Education Commission (HEC) started multiple dentistry-related post-graduation in both public and private sectors, encouraged students to go abroad for the same, and extended fellowship programs by the College of Physicians and Surgeons Pakistan, along with an extension for current students. As per the current data, around 1000+ dentists have Fellowships from the College of Physicians and Surgeons, Pakistan, which is expected to increase with time. Subsequently, the research productivity will increase. Many private and public sector institutes offer PhD, MPhil, and MDS programs in clinical and basic sciences. The authors do not have exact data about currently enrolled postgraduate students.

In recent times, almost all technical expertise has shifted towards utilizing artificial intelligence (AI) to perform tasks and projects efficiently, as is the case in dentistry and dental research.[38] As a proficient game-changer, AI has emerged as the most researched domain worldwide, be it data analysis or digitalization of clinical skills. Moreover, 3-D printing technology, stem cell regeneration, and tele-dentistry have also gained immense attention.[39] However, this present study found that periodontology is the most citable topic in Pakistan. Ever since the focus of dental treatment has shifted from curative to preventive, periodontology has become a center of attention for clinicians, academicians, and researchers altogether. The probable cause can be poor oral hygiene conditions and low access to technological advancements in the masses. However, the trend varies in other countries; for example, in Saudi Arabia, the most developed field is implant dentistry in research, and restorative dentistry is the most funded field. A study showed that the trend of dental research focused more on implants, tissue engineering, and bioactive restorative materials.[40]

Another research indicates the direct relationship between political stability, economic development, and financial proficiency with research productivity.[41] It can partially explain the low output from Pakistan, and oral & dental research is not a priority in the health policy, subsequently affecting the research foci. Therefore, it is a dire need of the

hour to focus more on contemporary research fields in basic and clinical sciences. Undergraduate and postgraduate programs shall encompass research and publications as an obligatory part of their courses. The authorities must undertake individual and collective projects, with inter-departmental and inter-institutional collaboration. Academicians and journals should ensure high-impact publications and cater to a larger target population that can contribute to increased citations. It was observed in the present study that the majority of articles published in international journals have been co-authored with Saudi Arabia. A possible explanation could be based on the fact that a large number of dentists have migrated to Saudi Arabia and the Middle East for professional purposes. While working there, they maintained working relations with their colleagues in Pakistan and managed to get publications in international journals.

Nevertheless, it was observed that the overall citation impact for these articles was much lower than that of articles that were published with Canadian collaboration. The reason could be that Canada is a developed country, and the state-of-the-art facilities and interdepartmental collaborations resulted in a much higher citation impact for asmaller number of articles. Co-authorship with Malaysian institutes has also increased, and this may be due to the fact that many Pakistani dentists have recently opted for Malaysian universities for postgraduate studies and developed their research collaborations.

In last decade, many Pakistani dentists obtained postgraduate degrees, especially master's level, from the UK, Malaysia, Hong Kong, and the USA. However, very few pursued it for the doctoral program. One possible reason could be limited financial resources and the availability of scholarships. Higher Education Commission (HEC) Pakistan initiated many programs to provide international and indigenous scholarships, funding, and grant opportunities. Furthermore, Fulbright, Commonwealth, Deutscher Akademischer Austauschdienst (DAAD), Third World Association of Science (TWAS) PhD Fellowships, US-Pakistan Knowledge Corridor, Faculty Development Program, etc., scholarships are also available, which should be explored to enhance the research culture. These scholarships do not directly cater to clinical dentistry programs; however, one can apply in basic science subjects.

Recently, several dental and medical institutes, including Khyber Medical University, Peshawar, National University of Medical Sciences, Rawalpindi, Shifa Tameer-e-Milat University, Islamabad, Jinnah Sindh Medical University, Karachi, and Baqai Medical University, Karachi, are offering doctoral programs in dental subjects. However, they are still in the infancy stage. Some Pakistan-based universities, such as the National University of Science & Technology and COMSATS University Islamabad, have developed their research laboratories and provided services to other institutes. It has been observed that dentists recently joined their PhD program in basic sciences such as biomaterials, nanotechnology, biotechnology, molecular sciences, etc., which will eventually help to promote further research in the field of dentistry. As discussed earlier, research in dentistry is not a priority at a national level; still, a few dental institutes (such as Dow Dental College) have developed their research laboratories; however, they are still scarce. It is recommended that dental institutes utilize indigenous resources, develop their research laboratories, and encourage their faculty to indulge in research activities. It has been observed that the Pakistan-based dental journals are not Scopus-indexed. Therefore, the articles published in those articles were not included. The editorial boards and administration of national journals should try to index their journals in globally accepted databases like Scopus, Web of Science, and PubMed.

The study has some limitations; only one database, Scopus, has been used to extract the publication data on dentistry produced by authors affiliated with Pakistan. Web of Science, PubMed, and Google Scholar results could produce different research outputs. The citation metrics were also collected from Scopus; the ratio of metrics on other databases would be different. Some data may not be added to this study because many Pakistani journals, especially two dental journals, i.e, The Journal of Pakistan Dental Association and Pakistan Oral and Dental Journal, are not indexed in Scopus.

The findings indicated that all stakeholders, including HEC, PM&DC, institution administrators, and other

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healthcare policymakers, need to revisit research policies to raise faculty research growth. Support from financial sources, provision of modern high-tech technology, professional growth, and collaboration with researchers from talent-rich countries are required to achieve high-impact research. The results of this study may be helpful to dental practitioners, researchers, and academicians who wish to evaluate the patterns of dental research in Pakistan. Some convenient conclusions can be drawn from this research, such as that this study has the potential to identify influential topics and collaborative countries, which can support making decisions about future prospects. The dental community of Pakistan might benefit from recognizing top research trends and identifying gaps.

Conclusion

Pakistan's contribution to overall global production is insignificant (0.72%), despite a rising trend toward research output, particularly over the past five years. The citation index is higher with international collabroators compared to national collaborators. The highest number of publications is related to Dental Education; however, the percentage of citable articles is for Periodontology. Most of the articles were published in collaboration with Saudi institutes/authors.

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CONFLICT OF INTEREST

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon request.