Review Article

A Bibliometric Study of Infectious Diseases Research in Pakistan (2000-2020): A Call for Increased Productivity

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Abstract

Background: Despite numerous developments, infectious diseases remain a complex public health threat and this situation is worst in low-income countries. Pakistan has enormous rising burden of infectious diseases and is further challenged by recent COVID-19. Research trends and performance provide foundation for disease counter measures. However, limited literature from the region has explored the evolutionary process of infectious disease literature.

Objective: This bibliometric study aimed to evaluate the credible literature on infectious diseases from Pakistan.

Methods: This was a descriptive exploratory study. All types of publications from 2000 to 2020 were extracted from the Web of Science in the subject category of infectious diseases from Pakistan. Later, "R-Bibliometrix" package was used for detailed analysis using a comprehensive range of indicators.

Results: Pakistan was ranked 52nd with 1298 documents from 100 sources, representing 0.38% of global share. Authors were from 117 countries led by USA and UK. Recent decade contributed 84% of documents. Articles (65.1 %) were the most common publication type. Aga Khan University and Hospital were major contributors. The Higher Education Commission (HEC) of Pakistan was the only major funding source from Pakistan. Journal 'International Journal of Infectious Diseases' was the leading and consistent source over time. None of the local journals was found to be a major contributor.

Conclusion: Contribution from Pakistan was found to be much lower than its burden of infectious diseases and expected scholarly magnitude. A prioritized response and increased productivity from research community is recommended.

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Introduction

The battle between infectious organisms and humans is going on since the beginning of life. Despite medical and technological advances over the last many decades, infectious diseases (IDs) are still considered as the leading cause of illness and mortality worldwide. Globalization with all its benefits has also facilitated the spread of these infectious agents to different parts of the world.[1] A noticeable increase in total number of outbreaks has been observed in the last few decades.[2] Yearly, around 25% of 60 million deaths occurring worldwide are caused by infectious diseases.[3] In addition, recent COVID-19 (nCoV) pandemic has become a new complex global and regional challenge that has led to > 7,690,708 confirmed cases and 427,630 deaths till date encompassing 216 countries worldwide.[4] World Health Organization (WHO) has published blueprint lists of diseases with great public health threat due to their epidemic potentials and that need to be considered for research and development attention. The most recent list is dominated by infectious diseases, particularly led by viruses such as COVID-19, Crimean-Congo hemorrhagic fever, Ebola, Middle East respiratory syndrome coronavirus (MERS-CoV), Severe Acute Respiratory Syndrome (SARS) and Zika.[5]

The burden of infectious diseases is highest amongst developing countries particularly in Southeast Asia by virtue of its distinct geography, climatic conditions, favorable environment for vectors, population, and country-specific health economics of the region.[6] In the year 2018, 1.5 million deaths were caused by Tuberculosis (TB), measles killed 140,000 people mostly in African and Asian countries, malaria caused 405,000 deaths (with 94% of deaths occurring in African countries), influenza led to 650,000 deaths per year and diarrheal diseases prevented approx. 525,000 children per year to reach till the age of 5.[7] Moreover, infectious diseases pose various social and economic risks to further complex the issue.[8] It is said that on current trends, the 'double burden' of infectious diseases in low- and middle-income countries will remain a double burden for next decades.[9]

Pakistan being no exception, has enormous burden of infectious diseases and the trend is on the rise.[10] It is estimated that 8-9 million people in Pakistan are infected with Hepatitis C which increases the risk of chronic liver disease (CLD) and cancer. Diagnosed cases of TB are 620,000 and every year around 410,000 are newly infected and approx. 59000 die from the disease. Each year malaria shows 500,000 cases that are mostly in rural districts of Baluchistan. HIV/AIDS prevalence is below 1% in general population of the country but is epidemic amongst injecting drug abusers and transgender sex workers. Poliomyelitis remains endemic; rabies causes 5000 deaths/year and dengue outbreaks are also challenging.[11] Furthermore, COVID-19 rise in Pakistan is alarming and has already led to 139, 230 confirmed cases with > 2632 deaths.[4]

In Pakistan, epidemic outbreaks are difficult to detect due to insufficient public health data and absence of automated surveillance systems.[12] Major barriers to detect epidemic outbreaks in Pakistan are insufficient public health data and ineffective ID surveillance system, that have also led to failure in achieving Millennium Development Goals (MDGs) in health.[13] Baseline comprehensive estimates of the burden of infectious diseases is needed for effective planning and prioritizing of the limited public health resources in such resource limited settings. Research which is thought to be the cornerstone of evidence-based medical practice could effectively provide the data with trends. But unfortunately there is growing concern that developing countries have not been using the vast research potential offered by their health care services.[14] The number of medical schools have increased in the country but the number of researchers have declined.[15] Research trends and output provide foundation for disease control, prevention and therapeutic measures.[16] However, despite significance and its magnitude of impact from epidemics to pandemic over the last few decades, there is limited literature from the region that explored the development and evolutionary process of the relevant literature in the subject of infectious diseases. Perhaps, it is essential to understand the progress of scientific knowledge on infectious diseases to assist in making need-based and better-informed decision making. Bibliometrics is a gateway to evaluate such proceedings and fill the knowledge gap.[17, 18] To fill this knowledge gap, this bibliometric study aimed to evaluate the credible literature on infectious diseases from Pakistan using a comprehensive range of indicators.

Methods

This was a descriptive exploratory study. Amongst several available databases for scholars such as; Scopus, PubMed, EBSCO, Science Direct among others. Web of Science (WoS), a Clarivate Analytics (Formerly Thomson Reuters) maintained platform, was purposefully used for this study. It is considered as the most precise, credible and comprehensive source for scientific exploration and appraisal. It is also assumed to be more appropriate to evaluate the research output of different regions, authors or organizations.[19,20] It encompasses search across salient search databases, disciplines and document types along with more than one billion searchable cited references.[21]

This study planned to use a wide range of indicators that measure quantity and quality of the publications and provide a critical picture of national and international contribution to literature related to infectious diseases from Pakistan. King Abdul Aziz University (KAU) online library and digital resources were used to access information. This research was conducted using scientometric techniques with efforts made to assure quality of data at both initial extraction and later processing phases. The research analyzed all published documents in a Web of Science category (WC) - 'Infectious Diseases' during 2000 – 2020. The following search strategy was used in advance search: WC=Infectious Diseases Refined by: AD (Address)= Pakistan, Timespan: 2000–2019. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI. No language limitation was imposed.

All 1298 documents were identified and extracted. Later 24 documents showing > 50 authors were excluded to avoid bias while all remaining publications (total = 1274) were included for further detailed analysis (also shown in Table 1). Data was extracted from WoS in plain text files and later bibliometric analysis at source level, author level and at document level were performed using R "Bibliometrix" package[22]. Search was conducted on 7th June, 2020 and two researchers (NSB and AAM) independently searched and abstracted required information to verify the process. The information of retrieved documents was analyzed using various bibliometric metrices such as; journals, publication year, authors, indices, citation reports, affiliations, countries and keywords, among the few and various data presentation tools were planned accordingly.

Results

Total number of documents indexed in 'Infectious Diseases' (WOSC) from 2000 to 2020 were 339,334 from 261 sources. Among total 220 countries, the USA, England, France, Spain and Germany were major contributors with 34%, 11.2%, 7.3%, 5 % & 4.8%, documents respectively. Articles (65.3%) were found to be the leading document type followed by meeting abstracts, letters and reviews. Total number of authors appearances was > 100,000 while total number of group authors found were 11083 with > 96% of documents not showing any groups. Around 39 % documents showed any funding source and 50.3% (170,937) were in open access category. Documents were found to be related to 44 and 48 Research areas and WoS categories other than infectious diseases, when explored for this study objective.

Table 1: *Summary Table*

Description	2000-2020	2000-2020*
Documents	1274	24
Sources (Journals, Books, etc.)	100	9
Average years from publication	6.24	2.33
Average citations per documents	16.56	49.96
Average citations per year per doc	2.049	11.91
References	27073	917
Document Contents		
Keywords Plus (ID)	2590	0
Author's Keywords (DE)	2148	54
Authors	4718	4744
Author Appearances	8862	6593
Authors of single-authored documents	49	0
Authors of multi-authored documents	4669	4744
Authors Collaboration		
Single-authored documents	56	0
Documents per Author	0.27	0.005
Authors per Document	3.7	198
Co-Authors per Documents	6.96	275
Collaboration Index	3.83	198
Document Types		
Articles	821	24
Editorials	24	0
Letters/Correspondences	131	0
Reviews	72	0
Others	226	0

 * Excluded from further detail analysis

Summary of the study is shown in Table 1 with 1274 documents published from Pakistan (2000-2020) extracted from WoS with 100 sources (38.3% of total sources). Pakistan was 52nd in terms of contribution with 1298 documents representing around 0.38% of global share. Regarding the type of publications being indexed from Pakistan, the most common publication type in the Infectious Diseases (WOSC) was articles representing around 65.1% followed by meeting abstracts (16.8%), letters (10.1%) and reviews (5.5%). Around 40% documents showed any funding source and 64% documents were in open access category. Annual growth rate was 7.67%. Documents were found to be related to 21 Research areas and 21 WoS categories other than infectious diseases. Total number of authors appearances was 8862 while total number of authors was 4718. There were 56 (4.4%) single authored documents with 49 authors.

Figure 1 shows year wise publications and mean total citations with maximum documents in 2018 (159).

Figure 1: *Year Wise Distribution of Documents and Mean Total Citations*

Table 2 shows 20 most productive authors with authors' impact. Findings showed 6 authors having ⩾ 35 publications with 2 authors having ⩾ 40 publications namely; HASAN R (54), KHAN A (41), BHUTTA ZA (38), ZAIDI AKM (38), ALI A (37) and JABEEN K (36). Two authors; BHUTTA ZA and ZAIDI AKM showed ⩾ 3000 total citations and H-index of ⩾ 20.

In infectious diseases research, Pakistan collaborated with authors from 117 countries. Corresponding authors were found to be from 47 countries. Around 633 (59.3%) of corresponding authors were from Pakistan. Top three contributive countries other than Pakistan as corresponding authors were; USA, UK and China with 123, 60 & 48 documents respectively.

Similar trend was observed for total citations per country with 7604, 5027 and 3038 from Pakistan, USA and United Kingdom respectively. Around 68% of Pakistani corresponding authors published single country publications.

Table 2: *Table 2: Top 20 Most Productive Authors with Authors' Impact*

Author	PY start	No. of Documents	% as FA	% as CA	AF	h-index	TC
Hasan R	2002	54	5.6	31.5	8.9	17	1000
Khan A	2007	41	36.6	9.8	8.8	13	379
Bhutta Za	2005	38	13.2	42.1	5.1	20	3107
Zaidi Akm	2008	38	7.9	21.1	5.0	22	3059
Ali A	2007	37	18.9	24.3	6.8	13	525
Jabeen K	2006	36	22.2	22.2	6.2	12	618
Khan Ma	2000	30	13.3	6.7	5.9	8	230
Zafar A	2004	30	13.3	16.7	4.1	14	660
Shakoor S	2009	27	40.7	18.5	5.0	9	273
Alam Mm	2007	25	36.0	20.0	3.2	11	541
Ali S	2000	24	20.8	12.5	3.9	9	261
Idrees M	2008	23	8.7	47.8	4.1	10	433
Ahmed S	2007	22	13.6	22.7	4.3	7	268
Beg Ma	2003	22	13.6	54.5	3.9	10	405
Raza A	2001	22	22.7	13.6	4.1	9	226
Alim	2005	19	21.1	5.3	2.8	8	270
Khane	2000	20	20.0	25.0	4.0	10	251
Hasan Z	2008	19	15.8	42.1	2.5	10	462
Qureshi S	2013	19	0.0	0.0	1.7	10	561
Sharif S	2007	19	0.0	0.0	2.1	9	509
Irfan S	2008	18	27.8	33.3	2.9	7	1944

PY - Publication year, FA - First author, CA - Corresponding author, AF - Articles Fractionalized, TC – Total citations

Table 3 shows Top 10 most frequent affiliations and funding sources. Altogether, around 1563 organizations contributed to produce 1274 publications in study scope. Collaborative index was 3.83. Aga Khan Univ, Aga Khan Univ Hosp and Quaid I Azam Univ, were the leading contributors. United States Department of Health Human Services, Higher Education Commission of Pakistan and National Institutes of Health NIH USA, were the leading funding sources.

Figure 2a shows top 50 Authors Collaboration Network with major clusters. A three-field plot for top 20 most productive countries, authors and organizations is shown in figure 2 shows. Pakistan, USA and United Kingdom were relatively major contributing countries for top authors while Aga Khan Univ and Aga Khan Univ Hosp were the major organizational

Table 3: *Top 10 Most Frequent Affiliations and Funding Sources*

| Affiliations	Freq.	Funding Organizations	Freq.
Aga Khan Univ	415	United States Department of Health Human Services	73
Aga Khan Univ Hosp	114	Higher Education Commission of Pakistan	65
Quaid I Azam Univ	78	National Institutes of Health NIH USA	65
Univ Punjab	77	Gates Foundation	60
Dow Univ Hlth Sci	61	United States Agency for International Development USAID	28
Univ Vet and Anim Sci	61	NIH Fogarty International Center FIC	22
Ctr Dis Control and Prevent	55	National Natural Science Foundation of China	21
Natl Inst Hlth	55	World Health Organization	21
Univ Agr Faisalabad	43	Wellcome Trust	18
London Sch Hyg and Trop Med	42	Medical Research Council UK MRC	17

contributors.
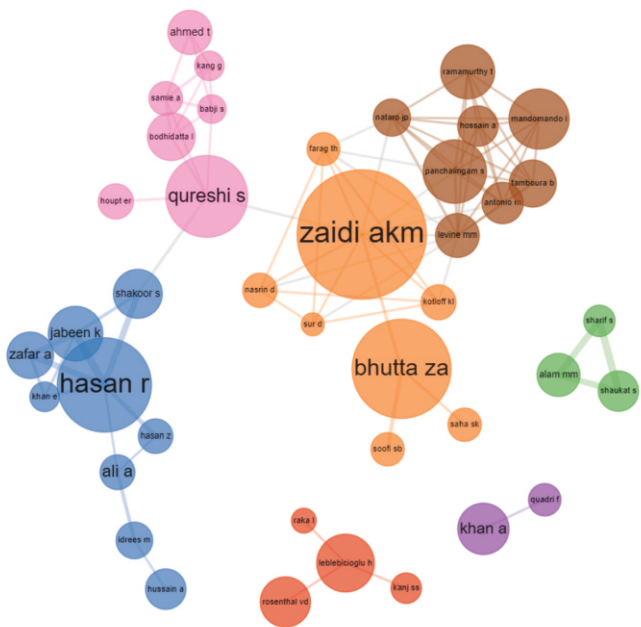
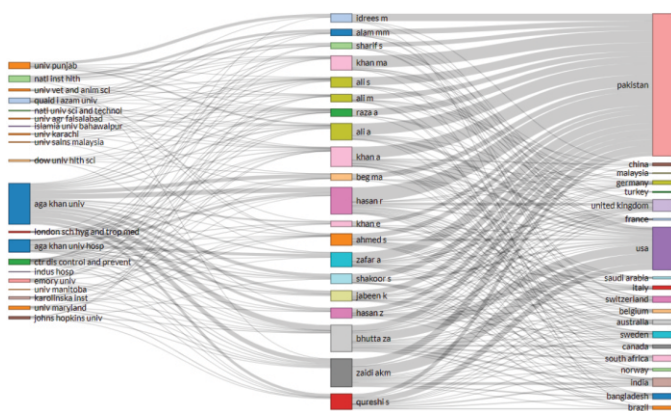**Figure 2a:** *Top 50 Authors Collaboration Network*

Figure 2b: *Three Field Plot for top 20 most Productive Country, Author and Organization*

Based on publication output from Pakistan, highly cited papers were also evaluated, and top 20 cited documents are shown in table 5. Two (2) documents showed > 1000 global citations. Sources; LANCET INFECT DIS and CLIN INFECT DIS, were leading. Ten (50%) of these 20 documents were published in last 10 years (2010-2019). Two references were cited ≥20 times namely; 'TAMURA K, 2011, MOL BIOL

Table 4: *Top 20 Highly Cited Documents*

Document	Year	*IC	*GC
Kumarasamy Kk, 2010, Lancet Infect Dis	2010	13	1662
Laxminarayan R, 2013, Lancet Infect Dis	2013	9	1453
Okeke In, 2005, Lancet Infect Dis-A	2005	10	392
Musher Dm, 2005, Clin Infect Dis	2005	0	363
Lockhart Sr, 2017, Clin Infect Dis	2017	3	331
Stanaway Jd, 2016, Lancet Infect Dis	2016	1	289
Rosenthal Vd, 2012, Am J Infect Control	2012	4	257
Rosenthal Vd, 2010, Am J Infect Control	2010	2	245
Kapoor A, 2009, J Infect Dis	2009	0	219
Ali Sa, 2009, Int J Infect Dis	2009	8	199
Graham Sm, 2012, J Infect Dis	2012	1	188
Kotloff Kl, 2012, Clin Infect Dis	2012	5	158
Okeke In, 2005, Lancet Infect Dis	2005	6	155
Idrees M, 2008, Bmc Infect Dis	2008	8	153
Zaidi Akm, 2009, Pediatr Infect Dis J	2009	5	153
Hassan A, 2011, Braz J Infect Dis	2011	0	139
Ochiai Rl, 2005, Emerg Infect Dis	2005	0	138
Thaver D, 2009, Pediatr Infect Dis J	2009	2	136
Liu J, 2014, Lancet Infect Dis	2014	0	135
Smego Ra, 2003, Clin Infect Dis	2003	0	131

EVOL, V28, P2731' and 'CRUMP JA, 2004, B WORLD HEALTH ORGAN, V82, P346', with frequency of 25 and 20 respectively.

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

Science), TC: Total Citations

Total number of sources were 100 with 'International Journal of Infectious Diseases', as the leading sources having 208 (16%) of total documents followed by 'Journal of Infection in Developing Countries' and International Journal of Tuberculosis and Lung Disease' with 74 and 69 documents respectively. Figure 3 shows year wise growth of 10 most productive sources.
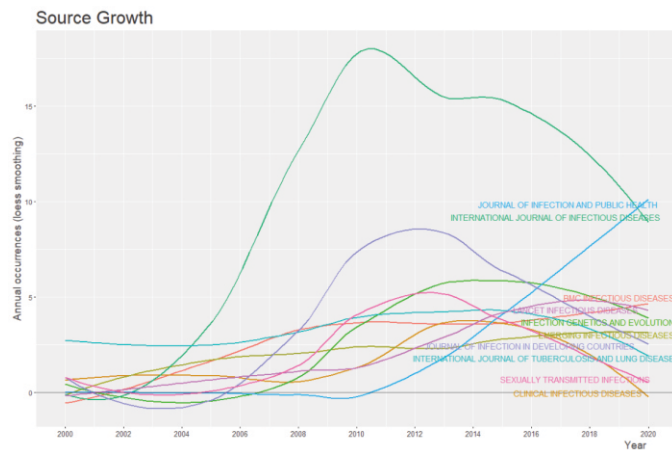

Figure 3: *Year Wise Growth of 10 most Productive Sources*

In total, 2148 Keywords and 2590 Keywords Plus (ID) were used. Trend of key words by year is shown in figure 4 with Pakistan, Tuberculosis, Epidemiology, Resistance and Surveillance, as the most frequent keywords.
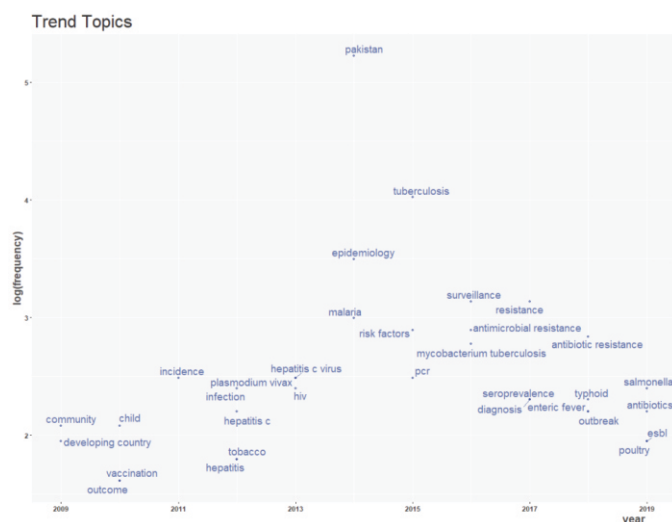

Figure 4b: *Trend of Key Words by Year*

Discussion
Current study provides a comprehensive overview of infectious diseases related publications from Pakistan. Study findings try to fill the knowledge gap and enhance academic advancement but may also assist in planning of focused prioritized interventions along with avoidance of unnecessary waste in terms of resources for infectious diseases in Pakistan.

This study provides a macroscopic overview with baseline information on infectious diseases related research output from Pakistan. A bibliometric analysis was conducted on documents published in WC - infectious diseases over the last two decades (2000-2019) from Pakistan using WoS as source of data. Overall, Pakistan was ranked 52nd with around 0.38% of global contribution on the subject. Presumably, contribution from Pakistan was found to be much lower than its population, burden of infectious diseases and scholarly magnitude. Perhaps, prioritized response and productivity is required from research community. From the region, India, Iran and Bangladesh were ranked 14th, 29th and 53rd with 9941, 2929 and 1243 documents respectively. Sources of these documents were around 38.3% of total sources in study scope while open access category documents were 64% from Pakistan, relatively higher than 50% among total on the study scope globally. Generally, increasing trend in terms of numbers of publications was observed over the years with majority published in last 10 years (84%). Resemblance was observed in global, regional and Pakistan in terms of document types trends and distribution with articles as the most frequent document type followed by meeting abstracts, letters and reviews.

Largely, similar identifications and trends of top authors were observed in terms of productivity, impact, international collaborations and organizational affiliations with few exceptions. Findings showed 6 authors having $\geq$ 35 publications lead by Hasan R, Khan A and Bhutta ZA. Two authors; Bhutta ZA and Zaidi AKM showed relatively higher impact in terms of h-index and total citations. Findings suggest that in infectious disease research, Pakistan collaborated with authors from 117 countries comprising more than half of the countries contributing globally on the subject. Nearly 60% of the corresponding authors were from Pakistan showing vital contributions in publications. Surprisingly, more than 2/3rd of these Pakistani corresponding authors,

published single country publications that probably suggests putting more efforts for more multi-country publications. USA, UK and China contributed with more corresponding authors, other than Pakistan. These countries were also found to be major contributors in another bibliometric study on infectious diseases and microbiology.[23] In addition, similar trend was observed for total citations per country. Almost all the top authors showed start publication year in previous decade (2000-2009) except Qureshi S, who had start publication year in last 10 years (2013). This probably shows the trend of established contributing authors from previous decade.

Around 1563 institutes contributed to produce 1274 publications in study scope. Obvious major contributors in terms of affiliations and top authors were Aga Khan University and Aga Khan University Hospital and are among the top ranked institutes from the region. They were followed by Quaid I Azam University and University of Punjab as the leading local contributors. Two institutes from the USA; National Institutes of Health (NIH) and Center for Disease Control and Prevention (CDC), and one from UK; London School of Hygiene & Tropical Medicine, were most frequent foreign affiliations, collectively representing around 30% of top ten affiliations. This finding is probably more attributed to multi (country and organizational) affiliations of top authors along with their inter and intra group collaborations as found in top authors' collaboration network.

Notably, 90% of top funding sources were from outside Pakistan led by United States Department of Health Human Services, National Institutes of Health (NIH) USA and Gates Foundation. The Higher Education Commission (HEC) of Pakistan was found to be the only major funding source on the subject from Pakistan. These findings probably suggest the non-availability of local funding sources that might have restricted more research output. In addition, apparently, the top and established authors' foreign affiliations seem to be the major link of more foreign funding from established institutes in the developed world. It also suggests that other well reputed local universities need to prioritize, invest and contribute more on infectious disease research. Immunology, Microbiology and Public Environmental Occupational Health, were most common other research areas and similar trend was observed in contributions from other WCs showing range from basics to applied and laboratory to population.

Half of the 20 top cited documents were published in each of the last two decades showing continuity and possibility of higher citations in future from the recent decade (2010-2020) publications. Leading sources were 'Lancet Infect Dis' and 'Clin Infect Dis', representing half of these top cited documents. The 'International Journal of Infectious Diseases' was found to be the leading source with relatively consistent contributions over the last two decades. Most of these leading sources showed relative declined contributions from Pakistan in recent decade except 'Journal of Infection and Public Health' that showed rise.

Findings related to keywords showed; Pakistan, Tuberculosis, Epidemiology, Resistance and Surveillance, as the most frequent keywords. This verifies the validity of study search strategy with focus on infectious diseases in Pakistan. Moreover, relatively diverse but complex trend of topics was observed in last 2 decades showing the evolution of more publications in various infectious disease related issues covering Tuberculosis, Hepatitis, Typhoid and malaria among others. These findings suggest more focus on prevalent infectious disease issues in Pakistan along with its public health aspects. Furthermore, despite being highly affected by recent COVID-19 and unprecedented global post issue research productivity[24], Pakistan has contributed only 65(0.7 %) documents out of 8929 total documents published in WoS on COVID-19 (nCoV) till date. This finding also shows the lack of expected research community response and productivity from Pakistan. Remarkably, no local journal was found to be among major contributors that suggests local relevant stakeholders to prioritize the issue. It would also be interesting to explore if local well reputed journals have same trends for other prevalent diseases in the region.

Analysis was based on data extracted from only one database (WoS) that may limit the generalizability of findings to the subject global research productivity. Besides, continuous changes and updates in WoS may show different publications data to be analyzed depending upon date of search. Most of the journals are not included in one subject category mainly due to overlap in terms of their scope. However, WoS has made around 250 subject categories and subsequently each journal and published document receives all subject categories given to the parent journal. 'infectious diseases' is one of such category in WoS with 131 journals. Moreover, scarce available literature in study context also limited the comparison with other regions and timespan.

Conclusion

Contribution from Pakistan was found to be much lower than its burden of infectious diseases and expected scholarly magnitude. Overall, similar trends of top authors were observed in terms of productivity, impact, affiliations and collaborations with few exceptions. Mostly, increasing trend in terms of numbers of publications was observed over the years with majority published in recent decade. Most of the top authors showed multiple and international affiliations. Majority of the funding sources were from outside Pakistan. None of the local journals was found to be a major contributor. A prioritized response and increased productivity from research community is recommended. The bibliometric findings of this study can benefit relevant stakeholders and particularly researchers to better understand the performance and trends of infectious disease related research from Pakistan and plan with better informed decisions with the help of these findings.

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