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ABSTRACT

Aim: Research publications have been increasing all around the world in every field of knowledge including medical microbiology. The attempt has been made in this paper to describe the growth of medical microbiology research in Pakistan published from 2013 to 2017.

Methodology: Publications on medical microbiology with authorship to Pakistan indexed in the PubMed database were searched. The bibliographical citations of retrieved data were downloaded to examine the year-wise growth, authorship patterns, subject-wise distributions, institutional and country affiliation of the principal author. Microsoft Excel spreadsheet was used for data analysis.

Results: Three hundred and thirty-three documents with an average of 66.6 articles per year published from Pakistan during the projected period. Majority of papers (n=30; 9%) were written on the topic of epidemiology related to medical microbiology. Five-author pattern found to be the preferred collaboration trend. The evaluation of leading author affiliation revealed that 202 papers (60.6%) produced by Pakistani authors, while in remaining 131 (39.3%) papers, the principal authors belonged to 29 different countries of the world. Aga Khan University found a most productive institution with 35 papers. Targeted publications published in 175 different journals of the world, the highest number of articles (n=24; 7.21%) published in Pakistan Journal of Medical Sciences.

Conclusion: High tech research has a direct impact on the health and wellbeing of citizens. The analysis of research publications is important to scale to assess the productivity of a specific field of knowledge. Saudi Arabian researchers are striving well to achieve excellence in dental research by delivering quality education and provision of oral health care services to local community.

Keywords: Microbiology, publications; Pakistan; Biomedical publications

INTRODUCTION

Research involves a creative task in a systematic way to improve the existing reserve of knowledge, find out the clarification of specific problems, formulate new practices and develop new applications of learning (Pervez 2018). The number of research publications has been amplified manifold, especially during the last two decades due to the escalation of financial allocation for research & development and usage of digital technologies (Meo, Almasri & Usmani 2013). Similarly the value of bibliometric appraisal has also been increased. The application of mathematical and statistical calculus of scholarly published material is known as bibliometrics, (Haq & Al Fouzan 2017) this method exposes the different characteristics and attributes of targeted publications. The findings of bibliometric studies help the policy-maker to formulate and revise the course of action. Scholarly publications play a significant role in the economic progress and sustainable development of the country. Whereas continues research in various disciplines of medical sciences improves the quality of life, which is directly linked to the monetary affairs of the nation (Haq, Al Fouzan & Baladi 2017). Research publications in health care have gained high-priority in the current age (Shamim & Shamim, 2009). The results of SJR database (2009) describes that Pakistan stands on 39th position in global research productivity during 2017 with 16897 documents; scored 0.47% of total publications. The United States has exceeded the rest of the world with 626403 (17.71%) documents, followed by China (n=508654; 14.38%) and United Kingdom (n=191830; 5.42%).

Carroll, Butel, Morse & Meitzner (2016) defined, Microbiology, applied to medicine and study of micro-organisms that can affect health is known as Medical Microbiology. This branch of knowledge concerned with the prevention, diagnosis, and treatment of infectious diseases. Medical microbiology further divided into four groups, medical virology, medical bacteriology, medical mycology, and medical protozoology (p.1).

Savitha (2017) examined the Directory of Open Access Journals (DOAJ) and found that 134 e-journals on the subject of microbiology in DOAJ. These journals published from 35 countries, India is on the top with 19 journals followed by the United Kingdom with 17 and Iran with 13 Journals. Bibliometric studies on medical research productivity (Meo, Almasri & Usmani, 2013), neurosurgical research (Shamim, Enam & Kazim 2011) and Zika Virus (Nasir & Ahmed 2018) found in Pakistan. Bibliometric study on Medical Microbiology publications has not been carried out in Pakistan. This paper intends to fill this gap.

The aim of this study is to evaluate the amount of research outcome in the field of Medical Microbiology in Pakistan during the period 2013-2017.

OBJECTIVE OF THE STUDY

The study was carried out to achieve the following objectives:

1. To assess the year-wise growth of research items with an annual growth rate
2. To review the subject-wise distribution of publications to find out the strong and weak area of research
3. To review the authorship pattern and affiliation of the first author
4. To find-out most productive institutes
5. To analysis country wise contribution and research collaboration
6. To calculate source publications/journals.

METHODOLOGY

Required data on the subject of "Medical Microbiology" affiliated with Pakistan has been retrieved from the PubMed/Medline database. PubMed is a free online resource containing over 29 million citations of biomedical literature. It is developed and maintained by U.S. National Library of Medicine. The advanced searching technique has been used in PubMed, typed "Medical Microbiology" in All Field menu, Boolean operator AND appears by default, typed "Pakistan" in the second menu and selects the "Affiliation". Further custom date range from 2013, January 1 to 2017, December 31 has been selected. All targeted citations have been downloaded in Comma-separated value (CSV) file format. Total 349 items retrieved, 16 items have been excluded being publications date of 2018. Total 333 items have been selected to analyze the publication trends.

Limitation of Study

This study is only limited to the results produced by the PubMed database. Institution and country affiliation of the first author was analyzed to find out the productive institutions and country-wise distribution of articles.

RESULTS

Table-1 presents the year-wise progress of publications on the subject of Medical Microbiology with authorship affiliated to Pakistan. Total 333 research items published during the projected period with an average of 66.6 articles per year. A majority of research items (n=110; 33.3%) published during 2017 and lowest number of publications (n=23; 6.90%) appeared in 2013. The average annual growth rate during the period of 2013-2017 has been reported at 31.29. The lowest annual growth rate (6.80) has been recorded during the period of 2016-2017.

Table-1; Year-wise distribution of publications (n=333)

Year	Publications (n)	Percentage	Cumulative number of Publications	Percentage of Total Publications	Annual Growth Rate
2013	23	6.90%	23	6.90%	
2014	39	11.71%	62	18.61%	26.40
2015	65	19.51%	127	38.13%	25.54
2016	96	28.82%	223	66.96%	19.49
2017	110	33.3%	333	100%	6.80
				Average Annual Growth Rate	31.29

All research items have been divided into 38 subjects and *Epidemiology* has been found the most preferred area of research with 30 items followed by *Biochemistry* 26, *Molecular Pathology*, *Genetics* and *Infection Control Department* with 24 research items each. *Oncology* stands on 4th rank with 22 articles and *General Microbiology* on 5th with 21 articles. A sufficient number of articles found on *Clinical Microbiology*, *Genetic Engineering*, *Immunology*, *Pediatrics*, *Bacteriology*, and *Gastroenterology*. *Clinical Biochemistry*, *Clinical Trial*, *Genetic Epidemiology*, *Hepatology*, *Infectious Disease*, *Microscopy*, *Orthodontics*, *Pharmaceutical*, and *Physiology* found to be the least interested area of research with one article each. (Table-2)

Table-2; Subject-wise distribution of publications (n=333)

Rank	Subjects	Articles	Total	Percentage
1	Epidemiology	30	30	9.00%
2	Biochemistry	26	26	7.80%
3	Molecular Pathology, Genetics and Infection Control Department	24 each	72	21.62%
4	Oncology	22	22	6.60%
5	Microbiology	21	21	6.30%
6	Clinical Microbiology and Genetic Engineering	16 each	32	9.60%
7	Immunology	15	15	4.50%
8	Pediatrics	14	14	4.20%
9	Bacteriology	13	13	3.90%
10	Gastroenterology	11	11	3.30%
11	Biotechnology	10	10	3.00%
12	Ethnopharmacology	8	8	2.40%

13	Neonatology and Pathology	7 each	14	4.20%
15	Clinical Virology	6	6	1.80%
16	Hematology and Pharmacology	4 each	8	2.40%
17	Neurology, Pharmacognosy and Soil Microbiology	3 each	9	2.70%
18	Blood Born Disease, Etiology, Food Microbiology, Osteology, Parasitology and Pharmacodynamics,	2 each	12	3.60%
19	Clinical Biochemistry, Clinical Trial, Genetic Epidemiology, Hepatology, Infectious Disease, Microscopy, Orthodontics, Pharmaceutical, and Physiology	1 each	10	3.00%

Figure-1 indicates the authorship pattern on targeted data. The bulk of research work (n=330; 99.1%) has been produced in collaborative research efforts whereas only three articles found by the single author. Five-author pattern found to be favorite (n=55; 16.6%) followed by 10-19 authors (n=47; 14.2%), six-author (n=44; 13.3%) and four-author collaboration (n=33; 10%). Twenty articles (6%) have been written by the joint efforts of 100 or >100 authors.

Figure 1: Authorship Pattern

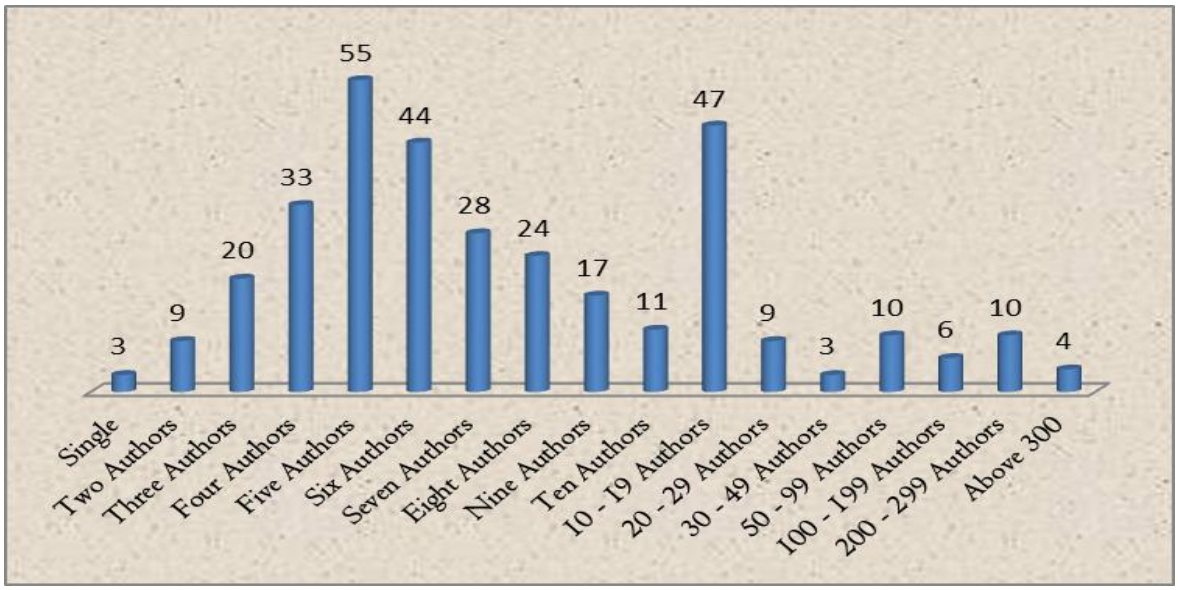

Table-3 explains the intuitional productivity based upon the affiliated address of the first author. The detail examination of publications shows that 177 institutions participated in medical microbiology research in Pakistan. The Aga Khan University, Karachi found to be most productive with 35 research items (10.5%) followed by the

University of Punjab, Lahore with 18 items (5.4%) and Quaid-e-Azam University, Islamabad with 13 (3.9%). There are 113 different intuitions with one publication each.

Table-3: Productive institutions based upon first author affiliation (n=333)

Rank	Institutional affiliation of the principal author	Publications	Total	Percentage
1	The Aga Khan University, Karachi, Pakistan	35	35	10.5%
2	University of the Punjab, Lahore	18	18	5.4%
3	Quaid-i-Azam University, Islamabad, Pakistan	13	13	3.9%
4	Kohat University of Science and Technology, Kohat	11	11	3.3%
5	Government College University, Faisalabad	9	9	2.7%
6	The University of Lahore, Pakistan	8	8	2.4%
7	Army Medical College Pakistan; Dow University of Health Sciences, Pakistan; and University of Peshawar, Pakistan	7 each	21	6.3%
8	Khyber Medical University, Peshawar, Pakistan	6	6	4.5%
9	National University of Sciences and Technology (NUST), Islamabad, Pakistan; Institute for Health Metrics and Evaluation, University of Washington USA; and International Health University of Virginia, Charlottesville, USA	5 each	15	4.5%
10	Baqai Medical University, Karachi Pakistan and King Saud University Riyadh, Saudi Arabia	4 each	8	2.4%
11	10 Institutions	3 each	30	9%
12	13 Institutions	2 each	26	7.8%
13	113 Institutions	1 each	133	40%

Table 4 shows the country-wise research collaboration and contribution. The exploration of country affiliation of first-author found that a large number of papers (n=202; 60.66%) produced by authors belongs to Pakistan. Pakistani authors play their role as a contributor in 131 papers (39.3%), where the leading authors belong to 29 different countries of the world. The researchers belong to the United States stand on the second rank with 35 publications (10.51%) as first-author followed by China, and the United Kingdom. It has been observed that a high ratio of research collaboration with these three countries witness that majority of Pakistani research scholars persuade their higher studies in these countries. Saudi Arabia with 11 publications (3.30%) reach on 5th position, the reason behind this collaboration is that enormous Pakistani medical professionals serving in healthcare set-up of Saudi Arabia. Sixty-six Pakistani institutes

produce 202 articles (60.6%), the share of six productive institutes is 94 publications (28.22%) while other 108 publications produced by 60 institutes. It is observed that out of 66 institutions, 42 institutes produce only one article each.

Table- 4: Country-wise contribution and collaboration (n=333)

Rank	Countries	Articles Published	%
1	Pakistan	202	60.66%
2	United States of America	35	10.51%
3	China	17	5.11%
4	United Kingdome	12	3.60%
5	Saudi Arabia	11	3.30%
6	Germany	7	2.10%
7	France	6	1.80%
8	Belgium	5	1.50%
9	India	4	1.20%
10	Canada, Malaysia and Sweden (3)	3 each	0.90%
11	Australia, Iran, Italy, Japan, Singapore, Sudan and Turkey (7)	2 each	0.60%
12	Iraq, Brazil, Bangladesh, Mali, Netherland, Republic of Korea, South Africa, Switzerland Taiwan, Tanzania, and Uganda (11)	1 each	0.30%

Table 5 reveals that projected research work published in 175 journals of the world. One-fourth of the research (n=86; 25.8%) published in five journals. Pakistan Journal of Medical Sciences found to be the most preferred journal with 24 publications (7.21%), followed by Journal of Pakistan Medical Association (n=22; 6.61%) and Pakistan Journal of Pharmaceutical Sciences (n=18; 5.41%). There are 134 journals where only one article published on the targeted subject.

Table-5: Journal-wise distribution (n=333)

S. No	Name of journals	Article Published	%
1	Pakistan Journal of Medical Sciences	24	7.21%
2	Journal of Pakistan Medical Association	22	6.61%
3	Pakistan Journal of Pharmaceutical Science	18	5.41%

4	Public Library of Science One Journal	14	4.20%
5	Journal of Medical Microbiology	8	2.40%
6	Two Different Journals Published five articles	10	3.00%
7	Six Different Journals Published four articles	24	7.21%
8	Thirteen Different Journals Published three articles	39	11.71%
9	20 Different Journals Published two articles	40	12.01%
10	134 Different Journals Published one article	134	40.24%

DISCUSSION

This study investigates 333 publications on Medical Microbiology retrieved from PubMed Database in authorship affiliated with Pakistan with an average annual growth rate of 31.29. Growing numbers of publications found from 23 in 2003 to 110 during 2017. Researchers find ease to carry out research on epidemiological aspects of medical microbiology (n=30; 9%). Five-Author collaboration found to be preferred pattern with 55 publications. Aga Khan University reveals to be the most productive research organization based upon the affiliated address of first author than by the University of Punjab. The researchers belong to 29 different countries collaborated with Pakistani authors in 131 publications (39.3%). The research collaboration with the United States is on the top, followed by China and the United Kingdom. Pakistan Journal of Medical Sciences found to be uppermost preference.

Pakistan produced 58133 publications in all branches of knowledge from 1996 to 2012 as reflected in the Web of Science database. The share of medical and allied sciences counted 25604 (44.04%), only 1361 publications found on the topic of Immunology and Microbiology (Meo, Almasri & Usmani 2013).

Shamim, Enam & Kazim (2011) analyzed the publications trends on neurosurgical research in Pakistan exposed that only 62 documents found on PubMed database published during 2003 to 2008 with an average of 10.3 articles per year. The highest number of publications (n=23; 37.1%) found on the subspecialty of Neuro-oncology. Most of the papers (n=30; 48.4%) belong to the category of Case report/series and letter to the editor. Majority of publications (n=48; 77.4%) published in Pakistani journals and Journal of College of Physicians and Surgeons of Pakistan published 23 (37%).

A bibliometric research study reported by Nasir & Ahmed (2018) on publications of Zika Virus explored that 3384 articles published globally during 2008 to 2017 in Web of Science indexed journals. United States found to be most productive with 1593 (47.07%) articles, followed by UK, France, and Italy. Plos Neglected Tropical Disease

has been favorite Journal with 122 papers, Diamond Michael S. with 38 papers found most productive authors and Fundacao Oswaldo Guz, Brazil discovered most prolific institute with 187 publications. Pakistani researchers produced only 44 (0.71%) articles on Zika Virus during the projected period.

Vergidis et. al. (2005) analyzed worldwide research growth on Microbiology published from 1995 to 2003 in 74 journals indexed in Web of Science and PubMed databases. Total 89,527 articles identified, had been divided into seven regions. Western Europe and Canada exceeded all other regions with 37,351 (41.7%) publications than by the United States with 26,921 (36.6%).

Roman, Gonzalez-Alcaide & Gutierrez (2016) conducted a bibliometric examination on infectious diseases and microbiology publications produced by Spain during 2000-2013 based upon the data taken from Web of Science. Spanish research produced 149,269 papers, 5.8% share of the global publications and stood on the 6th rank. Most of the research collaboration was done with the United States. Largest numbers of papers published in journal "Enfermedades Infecciosas y Microbiología Clínica".

Singh (2018) carried out a study on Microbiology publications in Sub-Saharan African Countries (SSAC) revealed that 18992 research items, constituted 1.7% of worldwide share, published during 2000 to 2014. Scopus database was used to collect the data. Out of 50 SSAC, 17 countries didn't produce any publication, South Africa is on the top with 6302 publications than by Nigeria with 2766 publications. Keute, V. found a most prolific researcher with 99 publications and Universidade de Sao Paulo acquires top position being most productive institute with 5627 publications. Plos One in a favorite journal with 557 publications. A large area of research (8559) carried out on the topic of Medicine related to Microbiology.

Hosamani & Bagalkoti (2015) examined the Microbiology research in India published during 1999 to 2013 as retrieved from Web of Science database. Total 6,98,726 publications written globally, the share of Indian authors counted 26114 (3.74%). Biotechnology, Applied Microbiology found to be the preferred area of research with 14431 (55.26%) publications and favorite source publications found Bioresource Technology with 1282 publications. Council of Scientific Industrial Research, Delhi found a most productive organization with 3493 research items and Kumar A., emerged as a most dynamic author with 319 publications including 30 H-Index. Majority of international collaboration in Microbiology research was done with United States.

Conclusion

High tech research documents and scholarly publications have a strong impact on the general health and quality of life. Statistical analysis of research publications is important to scale to evaluate the development of a specific branch of knowledge. Medical microbiology research is going through an embryonic phase in Pakistan. This study

highlights that growing trend of publications, research area preference, and international collaboration scenario.

Conflict of Interest: There is no conflict of interest regarding the publication of this study.

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Authors' contribution

Ikram Ul Haq conceived the idea, downloaded the data and wrote the manuscript. Gulnaz Elahi reviewed the relevant literature and classify the bibliographical citations. Iqra Dana analyzed the downloaded data. All authors contributed significantly and critically revised the manuscript before submission.

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