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Trends in Pharmaceutical Scholarly Communications from India, China and United States: A Comparative Study

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ABSTRACT

The present study throws light on the scholarly communication of three leading countries in the field of pharmaceutical research as reflected in SCOPUS database during 1998-2017. In terms of publication output, United States with two leading Asian countries, China and India leads with 40.54 per cent share of the global research publication share in pharmaceutical sciences. The global outcome of scholarly communication in the field of pharmaceutical research is 1395221. The study mainly focuses both on qualitative and quantitative research growth of United States, China and India in terms of output of scholarly communication, citation impact, relative research effort, common sources used for publications and research collaboration. The growth pattern of three leading countries is highly chaotic. The relative research effort of India and China increased during 2008-2017 while in United States, it was decreased. Bioorganic and Medicinal Chemistry, Tetrahedron Letters and Tetrahedron are the common source of communication in these three countries. All the three countries show the positive shift in international collaboration during 1998-2002 to 2012-2017 in pharmaceutical research.

Keywords: Pharmaceutical research; Activity index; Transformative activity index; h-Index; Impact factor; Scientometrics.

1. INTRODUCTION

The main purpose of any research is discovery, invention, research and development for the benefit of mankind. The main aim of pharmaceutical research is invention of new drugs to eradicate illness from the society. The pharmaceutical research is a boon for the mankind. An exponential growth in pharmaceutical research has been found during the last four decades. From drug discovery to its successful therapeutic outcomes, pharmaceutical field involves many disciplines such as chemistry, biology, pharmaceutics and biotechnology[1]. The impact of pharmaceutical research is directly related to cure the lives of human beings and animals from various diseases. Scientometrics plays a vital role in the assessment of scholarly communication. It is a technique which is used to analyse both the quantity and quality of scholarly communications using various scientometric indicators. The assessment of scholarly communication is a challenging task.

Olmeda-Gomez[2], et al., accessed the Pharmacology research output of world as indexed in Scopus database. In terms of quantitative and qualitative research, North America and Western Europe leads in Pharmacology research. However, North Africa leads in receiving citation from foreign countries other than domestic citations. Sweileh[3], et al., analysed scholarly communication of community pharmacy of 13 Middle Eastern Arab (MEA) countries during the period 2003-2012 and indexed in Scopus database. Kingdom of Saudi Arabia topped the list. Middle Eastern countries carried out international research collaboration with Malaysia, Pakistan, UK, Australia, Finland, New Zealand, India and USA. Ding[4], et al., assessed the pharmacology research output of China and other top 10 representative countries. China's research output and share has shown a steady increase over the research period that is during 2001 to 2011. During the period, other western countries have not shown significant difference in terms of bibliometric indicators as their research has reached its peak ten years ago. Alhaider[5], et al. made a qualitative and quantitative assessment of research of Saudi Arabia in the field of pharmaceutical sciences as indexed in SCOPUS database. Saudi Arabia research growth increased during the research period of 2001-2010 in terms of publications with annual average growth rate of 14.2 per cent. Saudi Arabia published a largest share with Egypt in terms of international collaboration followed by USA, India and UK. Mulimani and Hadagali[6] analysed the research growth of BRICS countries in the field of pharmacy and pharmacology as indexed in Web of Science, a multidisciplinary bibliographic database during 2001to 2016 using various scientometric indicators. China has shown a significant growth during the period of study and may be a strong competitor for developed countries like USA in terms of research output. Verma and Shukla[7] analysed the research trend of information literacy of selected countries in terms of annual growth rate, compound annual growth rate, doubling time, most prolific authors and found that maximum

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publications are in 2016 and United States is the maximum contributor with 5770 publication followed by United Kingdom with 1028 publications. Roy[8] evaluated the growth rate, pattern of authorship and collaboration trend and most prolific researchers in the field of biological sciences during 1901-1947 and found that growth rate was very slow due to inadequate research institutes in early decade. Das, et al[9] analysed the scholarly communications of pharmaceutical research in India during 1998-2017 to access the quality of research in terms of total publication, total citation received, prolific authors and institutions and found out their relative citation index in global context and the unexplored area of research in pharmaceutical science for research grants. Hugar and Chaman[10] evaluated the pharmaceutical research using Web of Science database during 2013-2017 and found that highest numbers of publications were found during 2016. USA leads with 30.2 per cent and National Science Foundation of China is the first funding agency with 4.6 per cent of funding.

Basing on the above literature we found that no such comparison has been made till now which compared the scholarly output and impact of two Asian developing countries i.e. India and China with developed countries like United States in the last two decade. The present study is an attempt in that direction to find out the annual growth rate and citation pattern of the United States, India and China during 1998-2017 and the preferred source of communication and their collaboration patterns.

2. OBJECTIVES

The main objectives of the study are as follows.

- To find out research trends of India, China and United States, the three leading countries in the field of Pharmaceutical sciences and their share in the world output
- To examine the pattern of growth of the India, China and United States
- To find out the relative research effort of these countries using activity index
- To examine the impact of the research output using citations received by published papers
- To identify the sources of communication in pharmaceutical research used by these countries
- To analyse the pattern of collaboration of these countries.

3. MATERIALS AND METHODS

The study is based on scholarly communication output of pharmaceutical research during the last two decades i.e.1998 to 2017 by India, China and United States as reflected in Scopus database. Scopus is the largest abstracting and citation database of Elsevier. A basic search strategy used was - Affil (India) and Doctype (*ar* or *re*) and Pub year > *1997* and Pub year < *2018* and (limit-to (subarea , *"phar"*)). The data for other countries followed the similar search strategy. The citation and bibliographic information extracted was saved in MS Excel-2007 for the purpose of analysis. For accessing the quantity and impact of publications, following bibliometric indicators are used:

- Total number of publications (TNP) for measuring the productivity of different countries
- Total no of citation (TNC) to measure the impact of output
- Citation per paper (CPP) to normalise the variation in output of different countries
- h-Index to rate the impact of research.

Activity Index (AI) has been used to normalise the output data, as the absolute research output is affected by the size of the country as well as the size of subfield. The measure was first suggested by Frame[11] and later elaborated by Schubert &

Table 1. Publication share of top 10 productive countries during 1998-2017

Rank	Country	TNP	Share (%)	h-index
1	United States	292901	21	560
2	China	159801	11.5	224
3	India	113012	8.1	233
4	Japan	93669	6.7	254
5	UK	71838	5.2	366
6	Germany	65405	4.7	314
7	Italy	50979	3.7	251
8	France	45586	3.3	279
9	South Korea	35434	2.5	187
10	Spain	34271	2.5	215
	Top 10 country share	962896	69.2	
	world	1395221		

Table 2. Preferred Language of three leading countries in pharmaceutical research

Country	English	Chinese	German	Spanish	Japanese	Others	Total
India	112979	1	3	58	6	68	*113115
China	108220	50968	36	1	120	505	*159850
United States	292157	263	197	109	105	171	*293002

*some scholarly communication published in dual language.

Table 3. Preferred communicating documents of the three leading countries

Document type	India	Per cent	China	Per cent	United states	Per cent
Article	103402	91.5	149347	93.5	236393	80.7
Review	9588	8.5	10390	6.5	56477	19.3
	112990	100	159737	100	292870	100

Table 4. Yearly distribution of publication output of India, China and United States in pharmaceutical research

Year	India		China		United States	
	TNP	% of Growth	TNP	% of Growth	TNP	% of Growth
1998	1470	0	1224	0	10936	0
1999	1669	13.54	1605	31.13	11345	3.8
2000	1543	-7.5	1823	13.58	11237	-0.95
2001	1657	7.39	1864	2.25	11155	-0.73
2002	2067	24.74	2126	14.06	11840	6.14
2003	2280	10.3	2876	35.28	11961	1.02
2004	2458	7.81	3532	22.81	13090	9.44
2005	2757	12.16	4666	32.11	13570	3.67
2006	3235	17.34	5670	21.52	14036	3.43
2007	3675	13.6	6473	14.16	15168	8.06
2008	4245	15.51	7948	22.79	15571	2.66
2009	5636	32.77	8662	8.98	15586	0.1
2010	7855	39.37	9343	7.29	16149	3.61
2011	10349	31.75	11226	20.15	16899	4.64
2012	10525	1.7	11924	6.22	17614	4.23
2013	10410	-1.09	13680	14.73	17537	-0.44
2014	10708	2.86	16250	18.79	17752	1.23
2015	10533	-1.63	15047	-7.4	17576	-0.99
2016	12005	13.98	16424	9.15	17209	-2.09
2017	7935	-33.9	17438	5.81	16670	-3.13
Total	113012		159801		292901	
CAGR	8.8		14.21		2.13	

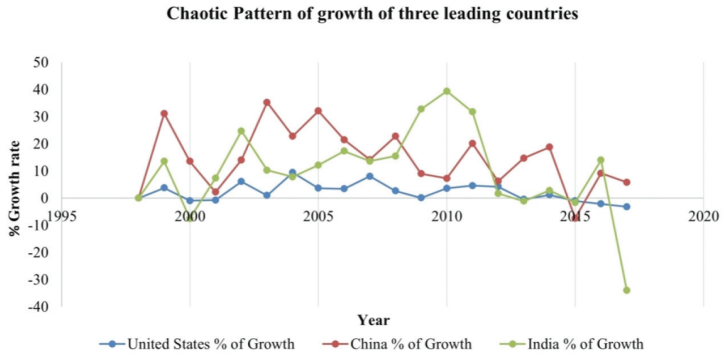

Figure 1. Growth rate of pharmaceutical research of India, China and United States.

Burn[13]. The measure has been used by Garg & Padhi[12], Kumar & Garg[14] & Mulimani & Hadagali[6]. AI is the ratio of the country's share of the world's publication output in the given field to the country's share of the world's publication output in all science fields, expressed as percentage. AI=100 indicates that a country's research effort in the given field corresponds precisely to world average. AI>100 reflects higher than average effort and AI<100 indicates lower than the average effort by the country. The whole period of research output of India, China and United States has been divided into four block of 5 year each for the study of relative research.

Journal impact factor is used for measuring the journal impact; Higher the Journal impact factor, the better the impact of the journal. The TNP and TNC were calculated directly from the downloaded data. CPP is the average number of citation papers obtained (TNC/TNP). For calculating the h-index, a list of publication was taken and sorted from the highly cited to low cited. The documents were matched until the number of publications matched with the number of citations.

The per cent of growth = End Value - First value / First value ×100

The compound annual growth rate (CAGR) is calculated by taking the n^{th} root of the total percentage growth rate, where n is the number of years taken for the study -

CAGR = [Ending Value/Beginning Value) $^{1/n}$*-1]*

4. RESULTS

4.1 Publication Share by Leading Countries during 1998-2017

The top 10 countries published 962,869 publications constituting about 69 per cent global share which covers two third of pharmaceutical research. United States leads in pharmaceutical research with 292901 publication with 21 per cent global share followed by China (159801, 11.5 %) and India (113012, 8.1 %). The value of average h-index was 288. Among all the countries listed in Table 1 only United States, UK and Germany had higher value of h-index than the average. It was highest for United States (560) followed by UK (366) and Germany (314).

4.2 Preferred Language of Three Leading Countries

The most preferred language for publication of scholarly communication is English for all the three countries. United States publishes mostly in English language (292157) followed by India (112979), China (108220). Chinese Language is mostly preferred by China (50968) followed by United States (263) and India (1). United States also preferred German Language (197), followed by China (36) and India (3). United States scholarly communication published in Spanish Language (109), Japanese Language (105) and other 19 language (171). China published in Spanish Language (1), Japanese Language (120) and other 5 language (505). India published in Spanish Language (58), Japanese Language (6) and other 9 language (68) as shown in Table 2.

4.3 Preferred Communicating Documents

It has been noticed that an appropriate selective outlet may play an important role in the visibility influence which has great impact over the research article. During the research period as we took only article and review for the study, more than 90

Table 5. Publication output and AI of three leading countries in pharmaceutical research

Year	India		China		United States		Total
	TNP	AI	TNP	AI	TNP	AI	TNP
1998-2002	8406	55	8642	42	56513	149	73561
2003-2007	14405	68	23217	79	67825	124	105447
2008-2012	38610	115	49103	104	81819	93	169532
2013-2017	51591	118	78839	130	86744	77	217174
Total	113012		159801		292901		565714

(AI rounded to the nearest whole number)

Table 6. Citation impact of three leading countries in pharmaceutical research

Country	TNP (%)	TNC (%)	CPP
India	113012(20)	1287849(10.86)	11.40
China	159801(28)	1822827(15.38)	11.41
United States	292901(52)	8740619(73.75)	29.84
Total	565714	11851295	17.55

Table 7. Citation profile of three leading countries in pharmaceutical research

Citation Range	India (%)	China (%)	United States (%)
0	27871(24.7)	35200 (22)	19990 (6.8)
1-3	29730(26.3)	38842(24.3)	37299(12.7)
4-9	22726(20.1)	33452(21)	62808(21.5)
>9	32687(28.9)	52207(32.7)	172804(59)
Total	113012	159801	292901

per cent researchers of India and China preferred to publish their research articles rather than review article. However, the researchers of United States preferred 80.7 per cent as articles and 19.3 per cent as review articles as shown in Table 3.

4.4 Yearly Distribution of Publication Output

During the research period the pattern of scholarly communication and the annual rate of growth of the three leading countries are as represented in Table 4. India shows a rising trend of Pharmaceutical research output during 2004-2016 with little deviation and a decline has been observed from 2017. The research performance of United States in the year 2014 reached its peak and with little deviation and slowly decreased from 2015. But in case of pharmaceutical research in China, it shows continuous growth and with little fluctuation and during the year 2017, it crossed the research output of United States and become assumed to be a great competitor of United States in terms of pharmaceutical research soon. The annual growth rate is highly inconsistence and has fluctuated during the research period for all the three countries because pattern of growth is highly chaotic as shown in Fig.1. Among all the three countries, China has the highest value of CAGR (14.21) followed by India (8.80) and United States (2.1)

4.5 Relative Research Effort of Three Leading Countries

The research output of the India, China and United States from 1998-2017 (20 yrs.) has been presented in four blocks of 5 year each in Table 5. Activity Index (AI) has been used to calculate the relative research effort of these countries. The calculation of AI for India, China and United States for the block year 1998-2002 has been illustrated as follows.

For India AI= {(8406/73561)/ (113012/565714)} ×100=55

For china AI= {(8642/73561)/ (159801/565714)} ×100=42 and

For United states AI= {(56513/73561)/ (292901/565714)} ×100=149

Likewise, we calculated the value of AI for three countries for other three blocks. It indicates that AI of United States has declined considerably during the last two blocks (2008-2017); whereas that of India and China has increased considerably in last two block in Table 5.

4.6 Citation Impact of Three Leading Countries

The three leading countries together produced 565,714 paper. These papers received 11,851,295 citation with an average of 17.55 citation per paper during the research period. In terms of total citations United States received 8,740,619(73.75 %) of total citation followed by China with (1822827, 15.38 %) and India with (1287849, 10.86 %) as shown in Table 6. Also, the value of CPP was highest for United States. The value of CPP for India and China was almost equal.

4.7 Pattern of Citations

The overall pharmaceutical research output was classified according to the citation range from 1 to >9. During the research period, a larger portion (45.55 %) received citation more than 9. Almost 21 per cent publications received 4 to 9 citation. The share of publications not cited is lowest for the United States. However, the share of not cited publications for India and China did not differ considerably.

4.8 Top 20 Preferred Journals of India, China and United States

Journals are the primary source of information as they help researchers to communicate the finding of their research in a faster and effective way. Out of Top 20 preferred journals

Table 8. Top 20 preferred journal of India in pharmaceutical Research

JOURNALS	TNP	H-INDEX	IF (2016)	COUNTRY
Tetrahedron Letters	4976	99	2.193	United Kingdom
International Journal of Pharmacy and Pharmaceutical Sciences	4946	38	0	India
Research Journal of Pharmaceutical Biological and Chemical Sciences	4183	18	0	India
Asian Journal of Pharmaceutical and Clinical Research	3185	26	0	India
Journal of The Indian Chemical Society	2846	25	0	India
Indian Journal Of Chemistry Section B Organic and Medicinal Chemistry	2698	39	0	India
International Journal of Pharmaceutical Sciences Review and Research	2666	24	0	India
Indian Journal of Pharmaceutical Sciences	2340	48	0	India
Indian Drugs	2274	28	0	India
Research Journal of Pharmacy and Technology	2231	8	0	India
International Journal of Pharmacy and Technology	2037	14	0	India
International Journal of Pharmtech Research	1904	40	0	India
Journal of Chemical and Pharmaceutical Research	1754	23	0	India
Der Pharmacia Lettrer	1731	14	0	United States
Tetrahedron	1616	80	2.651	United Kingdom
Journal of Chemical and Pharmaceutical Sciences	1571	7	0	India
Bioorganic and Medicinal Chemistry Letters	1497	71	0	United Kingdom
European Journal of Medicinal Chemistry	1496	96	4.519	Netherlands
Journal of Environmental Biology	1496	38	0.697	India
Oriental Journal of Chemistry	1426	13	0	India

from each country of the three leading countries, Tetrahedron Letters, Bioorganic and Medicinal Chemistry Letters and Tetrahedron are the 3 most common journals of the three leading countries preferred by the researchers to communicate their research findings. Tetrahedron Letters is the first preferred journal of India with 4976 publication published from United Kingdom followed by International Journal of Pharmacy and Pharmaceutical Sciences (4946) and Research Journal of Pharmaceutical Bioorganic and Chemical Sciences (4183) which were published from India. Zhongguo Zhongyao Zazhi is the 1st preferred journal of China with 8151 followed by Chinese Pharmaceutical Journal (6811) and Chinese Pharmacological Bulletin (6774) published from China where as 1st preferred journal of United States is Bioorganic and Medicinal Chemistry Letters with 9748 publication followed by Tetrahedron Letters (7360) published from United Kingdom and Journal of Medicinal Chemistry (6700) published from United States.

Table 8, Table 9 and Table 10 presents the top 20 most preferred journals by the scholars in the field of pharmaceutical sciences from India, China and United States. These Tables also gives the TNP, h-Index, IF Values (2016) and Country of its publisher.

4.9 Share of Collaborative Papers in the National Output

United States had 36.86 per cent papers in international collaboration followed by China with 22.28 per cent and India with 12.74 per cent during the research period 1998 to 2017. All the three countries had shown a positive shift in collaborative pattern during 1998-2002 to 2012-2017. United States registered the largest shift in international collaboration with 38 per cent and both India and china had registered with a shift of 6 per cent.

5. CONCLUSIONS

The three leading countries with 565714 publications scored 41 per cent of the global publication which is more than one third of the global pharmaceutical research. In terms of quality and quantity, United States leads in the world. In terms of quantity, India is in 3rd position in pharmaceutical research

Table 9. Top 20 preferred journal of China in pharmaceutical research

JOURNALS	TNP	H- INDEX	IF (2016)	COUNTRY
Zhongguo Zhongyao Zazhi	8151	24	0	China
Chinese Pharmaceutical Journal	6811	16	0	China
Chinese Pharmacological Bulletin	6774	15	0	China
Chinese Traditional and Herbal Drugs	5935	13	0	China
Chinese Journal of New Drugs	5134	9	0	China
Yaoxue Xuebao	4364	27	0	China
Tetrahedron Letters	3642	86	2.193	United Kingdom
Acta Pharmacologica Sinica	3352	70	3.223	China
Tetrahedron	3162	77	2.651	United Kingdom
Chinese Journal of Antibiotics	2849	10	0	China
Journal of Jilin University Medicine Edition	2719	5	0	China
Bioorganic and Medicinal Chemistry Letters	2454	65	0	United Kingdom
Journal of Ethenopharmacology	2174	79	2.981	Netherlands
Chinese Journal of Pharmacology And Toxicology	2007	11	0	China
Journal of Chemical and Pharmaceutical Research	1996	11	0	India
Environmental Pollution	1984	111	5.099	United Kingdom
Journal of China Pharmaceutical University	1927	13	0	China
Journal of Asian Natural Products Research	1907	34	0	United Kingdom
Journal Of Pharmaceutical And Biomedical Analysis	1726	68	0	Netherlands
Molecules	1693	46	2.861	Switzerland

and in terms of quality is in the 7th position with h-index 233 and China is in 2nd position in terms quantity and in terms of quality, it is in the 8th position with h-index 224.The publication growth rate of China is growing very fast and had crossed the publication growth of United States in 2017 and is assumed to be a great competitor of United States soon in pharmaceutical research. Interestingly, the Citation growth of China is not remarkable as the publication growth. The Publication inflation may be the reason for publication growth[15]. In pharmaceutical research, China with the highest publication growth rate 14.21 is emerging as the leading country among the three leading countries. During 1998-2007, the relative research effort of United States is higher than the average, while relative research effort of both China and India shows lower than the average effort in pharmaceutical sciences. During 2008-2017, the relative research effort of both China and India is higher than the average. While the relative research effort of United States shows lower than the average effort. United States has shown a negative shift in their publication activity while both India and China have shown a positive shift. Only 14.68 per cent did not receive any citation in pharmaceutical research which may be because the paper published in the year 2017 will have only one year citation window. Citation is a quality indicator, United States with 29.84 citations per paper. Citation per paper of both India and china is 11.4 which indicate that the in term of publication growth, citation growth of China is not remarkable. China preferred to publish one third of its scholarly communication in domestic language where as both United States and India preferred English language for their publication. Top three preferred journals of China published in domestic journals whereas both United States and India preferred to publish in foreign journals. All the three leading countries have shown a positive shift in the pattern of international collaborative research during the research period. As stated in NSTMIS report on R& D statistics[16], for the year 2014-2015, United States and China have allocated more than 2 per cent of their GDP for R&D (NSTMIS, 2017-2018) while India invested 0.69 per cent of its GDP for R&D. The research expenditure of India should be increased as well as international collaborative work should be praised for new research in pharmaceutical sciences. To eradicate diseases from world, the research in pharmaceutical science should be continued with a motivation to save life and reduce suffering.

Table 10. Top 20 preferred journal of United States in pharmaceutical research

JOURNALS	TNP	H- INDEX	IF (2016)	COUNTRY
Bioorganic and Medicinal Chemistry Letters	9748	105	0	United Kingdom
Tetrahedron Letters	7360	111	2.193	United Kingdom
Journal of Medicinal Chemistry	6700	189	6.259	United States
Antimicrobial Agents and Chemotherapy	6353	173	4.302	United States
Journal of Pharmacology and Experimental Therapeutics	5963	183	0	United States
Alcoholism Clinical and Experimental Research	3638	130	0	United States
Drug and Alcohol Dependence	3597	134	3.222	Netherlands
Bioorganic and Medicinal Chemistry	3568	95	0	United Kingdom
Psychopharmacology	3565	151	3.308	Germany
Toxicological Sciences	3560	153	4.081	United Kingdom
Molecular Pharmacology	3189	148	3.922	United States
Journal of Pharmaceutical Sciences	2989	122	2.713	United States
Neuropsychopharmacology	2953	185	6.403	United Kingdom
American Journal of Health System Pharmacy	2915	80	0	United States
Tetrahedron	2848	123	2.651	United Kingdom
Drug Metabolism and Disposition	2740	130	4.242	United States
European Journal of Pharmacology	2661	106	2.896	Netherlands
Toxicology and Applied Pharmacology	2587	122	3.791	United States
Chemical Research in Toxicology	2525	119	3.278	United States
Biochemical Pharmacology	2508	126	4.581	Netherlands

Table 11. Share of collaborative papers in the national output

Country	Total papers			Total collaborative papers			Shift 1998-2002 to 2012-2017
	1998-2017	1998-2002	2012-2017	1998-2017 (%)	1998-2002 (%)	2012-2017 (%)	
India	113012	8406	51591	14394 (12.74)	766 (9)	7791 (15)	6
China	159801	8642	78839	35397 (22.28)	1787 (21)	21403 (27)	6
United States	292901	56513	86744	107976 (36.86)	12622 (22)	51668 (60)	38

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