

Pharmacy and Pharmacology Research in the BRICS Countries: A Scientometric Analysis

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Abstract

The present study deals with the scientometric analysis of the BRICS countries' research output in the area of pharmacy and pharmacology on the basis of publications as indexed in the Web of Science, a multidisciplinary database. The parameters used for the analysis of the research output include authorship and collaboration pattern, citation distribution, publication activity, Relative Growth Rate and Doubling Time. The study reveals that China has exhibited a significant increase in its publication activity during the period. The reason may be that China's rise in its Research and Development (R&D) expenditure and the practice of utilitarian governance is at institutional as well as at national level.

Keywords

Activity Index; Publication Efficiency Index; Relative Growth Rate; Doubling Time; Authorship Pattern; Scientometric

Introduction

Any country's economic growth depends upon the research spending of the particular nation (Blanco et al., 2016). Recently, there is an exponential increase in the research spending by the Pharmaceutical industry (Congressional Budget Office, 2006). The research output in the form of inventions, such as new drugs for curing a particular disease, will be of greater help to the mankind. The research in the field of pharmacy and pharmacology will have direct impact on the quality of the lives of people (EFPIA, 2017). Pharmacology is originated from the Greek word 'pharmacon' which means drug, and logos signifies discourse or science. Hence, Pharmacology is the study of drugs in detail. Drug is derived from the French term 'Drogue' which means dry herb. According to WHO (1996) - "Drug is any substance or product that is used or is intended to be used to modify or explore physiological systems or pathological states for the benefit of the recipient".

Pharmacology includes all aspects about drugs especially safe dosage for therapeutic purposes. Pharmacy is both an art and science of compounding and dispensing drugs. Pharmacy also involves formulating a suitable dosage of drugs for administering to human beings or animals. A drug can be either therapeutic or poisonous depending on the dosage. Toxicology is the study of poisonous effects of drugs and other chemicals on the human beings. Pharmaceutical industries manufacture particular drugs in large scales to supply for public through the pharmacy. The analysis of such studies is important in order to know the status of the field. Many bibliometric studies have been conducted so far, in order to assess the pharmacy and pharmacology publications output of the individual nation and the world. The previous studies which are highly pertinent to the present study have been reviewed.

Olmeda-Gomez et al. (2012) analyse the scientific output of the world in the field of Pharmacology as reflected in the Scopus database. The study identified the North America and the Western Europe as the leading regions in terms of quantity of Pharmacology scientific output and impact of the output. However, the North Africa occupied the first place in terms of receiving high number of citations from foreign countries other than domestic citations. Sweileh et al. (2014) emphasize on the Community Pharmacy research output of the thirteen Middle Eastern Arab (MEA) countries. The study has revealed that the Kingdom of Saudi Arabia is in lead among the MEA countries in terms of Pharmacy based research publications. Malaysia, Pakistan, UK and Australia were the countries with which the Middle Eastern countries worked in the international collaboration.

Ding et al. (2013) ascertain the research performance of China and other ten representative countries in the field of Pharmacology. The inferences drawn from the study include; the China's publication output and its world publication share has shown a steady increase over the period from 2001 to 2011. The other western countries have not shown much difference in the value of

bibliometric indices over the years which suggests that their research has reached its plateau a decade ago. Ahmed et al. (2016) assess the India's research output in the field of Clinical Pharmacology for the period from 2005 to 2014. The study points out that the Publication output of India and the world showed an upward trend during the period and the United States of America and the United Kingdom had the highest world publication share. Nasir et al. (2015) conduct a study to analyse the Pharmacology research output of the Pakistan. The study reported that Pakistan lags behind the other developed countries in terms of quantity and quality of Pharmacology research publications and Pakistan occupies the thirteenth position among the top hundred productive Asian countries.

Based on the literature search conducted it was found that no studies have been conducted so far to assess and compare the pharmacy and pharmacology publication output of the BRICS nations in particular, and their impact among the scientific communities. Therefore, there is a need to conduct this study. The acronym 'BRICS' refers to the association of the five emerging national economies viz., Brazil, Russia, India, China and South Africa. The first BRIC summit was held in the year 2009. Initially it was BRIC, until the South Africa joined the association in the year 2010. As the BRICS countries being the world's major emerging economies which account for 42.58% of the world's total population, it is important to analyse the research output of these countries in order to gain understanding of their publication activity in a specific field.

Objectives

The main objective of the study is to carry out an analysis of pharmacy and pharmacology research output of the BRICS nations for the period from 2001 to 2016. The specific objectives of the study are to:

1. ascertain the research productivity of the BRICS countries in the area of pharmacy and pharmacology;
2. study the publication activity and shift in the research trend in the BRICS countries ;
3. analyse the citation profile and compare the citation trend among the BRICS countries;
4. find out the Relative Growth Rate and Doubling Time of the pharmacy and pharmacology research output in the BRICS countries ;
5. explore the impact of pharmacy and pharmacology research output of the BRICS countries using citation-based indicators; and
6. assess the authorship and collaboration pattern of the BRICS countries in the field of pharmacy and pharmacology.

Materials and Methods

The Clarivate's [Web of Science](#), a multidisciplinary database was chosen as the source for the study. The data for the study was retrieved from the Web of Science core collection and the year-

wise publication output of the BRICS countries from 2001 to 2016 was downloaded during December, 2017. The downloaded data was tabulated and analyzed using various qualitative and quantitative indicators. The quantitative indicators were used to assess the scientific output, and qualitative indicators were used to assess the impact of the publication output. The string used while searching the database was SU=(pharmacy and pharmacology) AND CU=(Brazil) PY=(2001-2016). The same string was used for retrieving the publication data of Russia, India, China and South Africa by replacing the specific country name in the string.

Results

China and India have secured second and eighth rank globally with 9.02 and 4.23 percent global publications' share respectively. Brazil, Russia and South Africa have secured thirteenth, twenty seventh and thirty eight global rank with 2.33, 0.75 and 0.49 percent global publications' share respectively. There is a noticeable difference between the global share of the top 27 productive countries which vary between 0.49 and 27.80 percent. The United States stands first contributing 27.80 percent of the global publications' share. China stands second with 9.02 percent global share. The countries which secured global rank between 3 and 22, has also shown noticeable difference in their proportion of global publication share varying between 1.02 and 8.64 percent. The global publication share of the BRICS countries all together during the period from 2001 to 2016 was 16.83 percent. The other details are presented in Tables 1 and 2.

Table 1. Global Publications' share and world rank of top productive countries

Country	Total Publications	World Publications Share	Country	Total Publications	World Publications Share
World	822233		Switzerland	15324	1.86
USA	228629	27.80	Belgium	13273	1.61
China	74210	9.02	Turkey	12524	1.52
Japan	71057	8.64	Sweden	12405	1.50
Germany	56122	6.82	Taiwan	11807	1.43
England	53901	6.55	Poland	11673	1.41
Italy	43123	5.24	Iran	9797	1.19
France	38354	4.66	Denmark	8465	1.02
India	34802	4.23	Austria	7098	0.86
South Korea	27368	3.32	Egypt	7059	0.85
Spain	27072	3.29	Scotland	6805	0.82
Canada	26738	3.25	Greece	6698	0.81
Netherlands	19672	2.39	Russia	6171	0.75
Brazil	19161	2.33	South Africa	4067	0.49
Australia	17919	2.17			

Table 2. Year-wise distribution of publications and Activity Index of the BRICS Countries

Year	Publication output and Activity Index (2001-2016)					
	World	Russia	India	China	South Africa	Brazil
2001	31085	145 (62.15)	586 (44.54)	770 (27.45)	135 (87.80)	375 (51.76)
2002	35840	181 (67.29)	687 (45.29)	898 (27.76)	106 (59.79)	503 (60.22)
2003	37871	187 (65.79)	797 (49.72)	1189 (34.79)	117 (62.46)	527 (59.71)
2004	43356	248 (76.22)	1016 (55.36)	1442 (36.85)	162 (75.54)	741 (73.33)
2005	42897	532 (165.24)	1040 (57.28)	1906 (49.23)	165 (77.76)	775 (77.52)
2006	49032	265 (72.01)	1345 (64.81)	3552 (80.26)	176 (72.57)	864 (75.61)
2007	50197	291 (77.24)	1606 (75.59)	2880 (63.57)	181 (72.90)	1018 (87.02)
2008	54072	338 (83.29)	2850 (124.53)	3616 (74.09)	273 (102.07)	1379 (109.43)
2009	54394	403 (98.72)	2621(113.84)	4281 (87.20)	233 (86.60)	1426 (112.49)
2010	55621	385 (92.23)	2831 (120.25)	4839 (96.39)	282 (102.50)	1396 (107.70)
2011	59917	508 (112.97)	3020 (119.08)	5766 (106.62)	332 (112.02)	1552 (111.15)
2012	60383	486 (107.24)	3042 (119.02)	6505 (119.36)	321 (107.48)	1725 (122.58)
2013	63092	471 (99.47)	3894 (145.82)	7996 (140.42)	332 (106.39)	1653 (112.42)
2014	61620	539 (116.55)	3402 (130.44)	8332 (149.82)	393 (128.94)	1732 (120.61)
2015	61674	567 (122.50)	2877 (110.21)	9547 (171.51)	420 (137.68)	1688 (117.51)
2016	61182	625 (136.11)	3188 (123.11)	10691 (193.61)	439 (145.06)	1807 (126.73)
2001-2016	822233	6171	34802	74210	4067	19161
%	-	4.46	25.14	53.62	2.94	13.84
CAGR	4.62	10.23	11.95	19.17	8.18	11.05

CAGR - Compound Annual Growth Rate

The year-wise activity Index of the BRICS countries was calculated using the formula as suggested by Price (1981) and is presented in the table 2. The research efforts of China were lower than the world's average for the period 2001 to 2010, picked up from the year 2011, and the research effort of China was higher than the world's average for the period 2011 to 2016. India's research efforts were lesser than the world's average efforts during the period from 2001 to 2007, whereas, the country's research efforts were higher than that of the world's average from the year 2008 to 2016. Brazil's research efforts were lesser than the world's average during the years 2001 to 2007, and the research efforts were higher than the world's average during the years 2008 to 2016. Among the BRICS, except India, all the other four nations' research performance reached its peak in the year 2016. Whereas, India's research performance was highest in the year 2013 and it gradually decreased for the years 2014, 2015 and 2016.

Among the BRICS nations, China leads with 74,210 (53.62%) publications, followed by India with 34,802 (25.14%) publications, Brazil with 19,161 (13.84 %) publications, Russia with 6,171 (4.46%) publications and South Africa with 4,067 (2.94 %) publications ranked second to fifth respectively. China had the highest rate of publication growth (19.17), followed by India with the growth rate of 11.95, Brazil with the growth rate of 11.05, Russia and Brazil with the growth rate of 10.23 and 8.18 respectively. The Compound Annual Growth Rate (CAGR) values indicate that there is a great disparity between the growth rate of the BRICS countries and China is emerging as the leading country with the highest publication growth rate.

Table 3. Citation Profile of the BRICS Countries

Citations Range	Brazil	Russia	India	China	South Africa	Total (%)
0	3,333	2219	6486	11,522	823	24383 (17.62)
1	1536	663	2771	6142	282	11394 (8.23)
2	1225	500	2300	5243	248	9516 (6.88)
3	1024	337	2092	4687	236	8376 (6.05)
4	958	279	1783	4093	172	7285 (5.26)
5	907	202	1563	3660	176	6508 (4.70)
6-10	3111	629	5487	12975	586	22788 (16.46)
11-100	6889	1301	11817	25311	1480	46798 (33.81)
101-500	176	39	488	567	63	1333 (0.96)
501-1000	2	2	13	9	1	27 (0.02)
>1000	0	0	2	1	0	3 (0.002)
Total	19161	6171	34802	74210	4067	138411

The overall publications output was classified according to the citations range from 1 to >1000. It can be interpreted from the data given in the table that during the period, the large proportion of papers (33.81percent) received citations within the range of 1 to 100, followed by, the 16.46 percent papers received citations within the range of 6 to 10. Whereas, 0.96 percent of publications received citations within the range of 101 to 500. The least proportion of publications, 0.02 percent and 0.002 percent received citations within the range of 500 to 1000 and >1000 respectively. Overall, 17.62 percent of the BRICS publications output did not receive any citations.

Table 4. Citation impact of the BRICS countries in the field of pharmacy and pharmacology

Country	TNP (%)	TNC (%)	CPP	PNC (%)	PEI	h -Index
Brazil	19161 (13.84)	252084 (14.30)	13.16	17.39	1.03	121
Russia	6171 (4.46)	51449 (2.92)	8.34	35.96	0.65	79
India	34802 (25.14)	491169 (27.87)	14.11	18.64	1.11	170
China	74210 (53.62)	906787 (51.45)	12.22	15.53	0.96	167
South Africa	4067 (2.94)	61101 (3.47)	15.02	20.24	1.18	92
Total	138411	1762590	12.73			

TNP-Total no of publications; TNC-Total no. of citations; CPP-Citation per paper; PNC-Publications not cited; PEI-Publication efficiency index

The publication output of the BRICS countries during the period of 2001 to 2016 was 1,38,411. A total of 17,62,590 citations were received for 1,38,411 publications during the period with 12.73 average citations per paper. The citation window varied from 1 to 16 years, as the papers published in the year 2001 will have 16 year citation window, and the paper published in the year 2016 will have only one year citation window. Among the BRICS countries, for the overall period of study, China is in leading position by constituting 53.62 percent of the BRICS publication output and received 51.45 percent of citations of the overall citations received by all

the BRICS countries during the same period. Next to china, India had the second highest share of 25.14 percent with 27.87 percent of the total citations. Despite the fact that the South Africa's publication share lesser than that of the Russia, the South Africa received more citations (3.47 percent) with higher citations per paper (15.02) as compared to that of its counterpart Russia (2.92 percent, with 8.34 average citations per paper).

Among the BRICS countries, China's percentage of Publications Not Cited (PNC) is lesser, indicating more global visibility of the Chinese publications. On the other hand, Russia's percentage of PNC is higher indicating lesser global visibility and recognition of the Russian publications. The Publication Efficiency Index (PEI) is based on an index developed by Frame (1977) and later used in their studies by Garg (2002) and Guan and Ma (2004, 2007). The PEI value for Brazil, India and South Africa is more than 1, which indicates that the impact of the publications from these countries is more than the research efforts made by them. Whereas, the PEI value for Russia and China is lesser than 1, which indicates that despite the research efforts made by these countries, the impact of the publications from these countries was lesser.

Table 5. Shift in the Transformative Activity Index

Country	2001-2008	TAI	2009-2016	TAI	2001-2016	Change in TAI
Brazil	6182	125	12979	91	19161	-34
Russia	2187	137	3984	87	6171	-50
India	9927	110	24875	96	34802	-14
China	16253	85	57957	105	74210	20
South Africa	1315	125	2752	91	4067	-34
	35864		102548		138411	

The publication output is divided into two blocks based on the year of publication as the criteria. The Transformative Activity Index (TAI) was calculated using the formula as suggested by Guan and Ma (2004). It is evident from the data in the table 5 that among the BRICS countries, except China, the publication activity in all the other countries is decreasing from the first block period to second block period. Whereas, China's publication activity is increasing in a very faster pace. Brazil, Russia, India and South Africa have shown a negative shift in their publication activity.

The Relative Growth Rate (RGR) and Doubling time (DT) of pharmacy and pharmacology publications of the BRICS countries and the world for a period of 15 years is given the Table 6. The RGR is measured by employing the formula which was applied first in the field of Botany (Hunter, 1978, 1982; Poorter & Garnier, 1996; Hoffman & Poorter, 2002) to study the growth analysis of plants. The relative growth rate of world's pharmacy and pharmacology publications output declines gradually from 0.77 to 0.88. Whereas, the Doubling time for the world goes on increasing from 0.9 to 8.66. The mean Relative Growth Rate and Doubling time for the world is

0.22 and 4.75 respectively. The RGR for the pharmacy and pharmacology publications of the BRICS countries goes on decreasing over the period of 20 years. On the other hand, the Dt for the publications of the BRICS nations goes on increasing. Thus, the RGR and DT of the BRICS nations and the world are inversely proportional to one another.

Table 6. Comparison of RGR and Dt of publications of the BRICS countries and the World

Year	Brazil		Russia		India		China		South Africa		World	
	RGR	DT	RGR	DT	RGR	DT	RGR	DT	RGR	DT	RGR	DT
2001												
2002	0.85	0.82	0.81	0.86	0.78	0.89	0.77	0.9	0.57	0.22	0.77	0.9
2003	0.47	1.47	0.45	1.54	0.49	1.41	0.54	1.28	0.4	1.73	0.45	1.54
2004	0.42	1.65	0.39	1.78	0.39	1.78	0.41	1.69	0.37	1.87	0.35	1.98
2005	0.31	2.24	0.53	1.31	0.3	2.31	0.36	1.93	0.28	2.48	0.25	2.77
2006	0.3	2.31	0.19	3.65	0.28	2.48	0.46	1.51	0.23	3.01	0.23	3.01
2007	0.24	2.89	0.17	4.08	0.25	2.77	0.25	2.77	0.19	3.65	0.19	3.65
2008	0.25	2.77	0.17	4.08	1.04	0.67	0.26	2.67	0.23	3.01	0.17	4.08
2009	0.21	3.3	0.17	4.08	0.24	2.89	0.23	3.01	0.16	4.33	0.15	4.62
2010	0.17	4.08	0.14	4.95	0.2	3.47	0.21	3.3	0.17	4.08	0.13	5.33
2011	0.15	4.62	0.16	4.33	0.18	3.85	0.21	3.3	0.17	4.08	0.12	5.78
2012	0.16	4.33	0.13	5.33	0.15	4.62	0.19	3.65	0.14	4.95	0.11	6.3
2013	0.12	5.78	0.11	6.3	0.17	4.08	0.19	3.65	0.12	5.78	0.11	6.3
2014	0.12	5.78	0.11	6.3	0.13	5.33	0.17	4.08	0.13	5.33	0.09	7.7
2015	0.1	6.93	0.11	6.3	0.09	7.7	0.16	4.33	0.13	5.33	0.08	8.66
2016	0.1	6.93	0.11	6.3	0.1	6.93	0.15	4.62	0.11	6.3	0.08	8.66

Table 7. Authorship Pattern of the BRICS Countries' publications

Country	Single authored publications	CAI	Two authored publications	CAI	Multi authored publications	CAI	Mega authored publications	CAI	Total
Brazil	259	67	1074	67	4052	80	13776	114	19161
Russia	311	247	583	113	1829	111	3448	87	6171
India	935	132	5790	200	13968	152	14109	64	34802
China	1057	70	3574	58	15492	79	54087	115	74210
South Africa	251	307	480	145	1352	128	1984	79	4067
Total	2813		11501		36693		87404		138411

CAI - Co-authorship index

The articles were categorized into four groups i.e., Single, Two, Multi (three and four authors) and Mega authors (five and above). To calculate Co-authorship Index (CAI), the formula suggested by Schubert and Braun (1986) has been employed. The collaboration research activity among the BRICS countries was calculated using the Co-authorship Index and presented in Table 7. The CAI of mega authors for Brazil and China is higher than the average. It indicates that the major papers published by these two countries were produced as the result of a group effort, and the authors preferred to work in large teams. The CAI value for two authors and multi authors is

higher than the average for Russia, India and South Africa which indicate that the major portion of the publication output by these nations during the period were as the result of collaborated research effort of two to four authors as a team. The CAI value of single authorship for Russia, India and South Africa is higher than the average indicating that still the single or solo authorship publications or individual research works prevail in these three nations.

Table 8. Share of Collaborative papers in the national output of the BRICS countries

Country	Total Papers			Total Collaborative Papers			Shift 01-03 to 14-16
	2001-16	2001-03	2014-16	2001-16	2001-03	2014-16	
Brazil	19161	1405	5227	18902 (98.6%)	1378 (98.07%)	5178 (99.0%)	0.9
Russia	6171	513	1731	5860 (94.9%)	482 (93.9%)	1676 (96.8%)	2.9
India	34802	2070	9467	33867 (97.3%)	2007 (96.9%)	9200 (97.2%)	0.3
China	74210	2857	28569	73153 (98.6%)	2789 (97.6%)	28106 (98.4%)	0.8
South Africa	4067	358	1252	3816 (93.8%)	319 (89.1%)	1203 (96.1%)	7

It is clear from the table 8 that Brazil and China had the highest proportion of collaborative papers within their national output (98.6 percent) during the period 2001 to 2016, followed by India (97.3 percent), Russia (94.9 percent) and South Africa (93.8 percent). The collaborative research activity in the BRICS has shown a positive shift during the period 2001 to 2016. Within the BRICS, South Africa and Russia have shown a significant shift. South Africa registered the largest shift with 7 percent, followed by Russia with a shift of 2.9 percent. On the other hand, Brazil, China and India showed very marginal shift of 0.9, 0.8 and 0.3 percent respectively.

Dissection and Conclusion

It is interesting to note that, although China is in lead in terms of pharmacy and pharmacology publications output among the BRICS countries, the impact of the publications by China was lesser than the research efforts devoted by it. It is found that the citation growth rate is not in the same pace as the publication growth rate. The cause may be the publication inflation (Fu et al. 2013). It is evident from the study that the publication output of China is growing at a very faster pace. The reason may be that China's rise in its R&D expenditure and the utilitarian governance is at institutional as well as at national level (Fu et al. 2013). The utilitarian practice will give rise to compulsion on an individual author to publish more number of publications in order to get bonus, research funding, recognition among scientific community etc., further leading to publication inflation. If this trend continues, China may become a tough competitor to the USA in terms of pharmacy and pharmacology publications output.

According to the NSTMIS report on R&D statistics, for the year 2014-15, China, Brazil and Russian Federation have expended 2.0%, 1.24% and 1.19% of their GDP for R&D respectively. Whereas, India and South Africa have invested 0.69% and 0.73% of their GDP for R&D

respectively. Majority of the developed countries allocate more than 2% of their GDP for R&D (NSTMIS, 2017-18). Except China, all the other developing countries among the BRICS nations spend lesser than 2% of their GDP for R&D. Thus, other than China, all the other BRICS countries should increase their research expenditure as well as efforts in the pharmacy and pharmacology research in order to keep pace and to bridge the qualitative and quantitative research gap between the BRICS and the leading developed countries. The intra-collaborative efforts among the BRICS nations and the inter-collaborative works in between the BRICS and the other developed countries should be increased. This will further strengthen the alliance within the BRICS countries and in between the BRICS and the other developed countries.

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