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Review Article

Highly Cited Publications Output by India in Clinical Pharmacology during 2000-14: A Scientometric Assessment

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ABSTRACT

Objectives: The main objective of this research is to identify highly cited papers in clinical pharmacology and to analyze their publication and citation data to study their citation characteristics, and understand what role contributing authors, participating research organizations as well as international collaborative countries play in Indian clinical pharmacology research. **Design:** The publications output of Indian clinical pharmacology papers published during 2000-14 were screened in Scopus database and highly cited papers, with at least 100 citations since publication, were identified and shortlisted for their bibliometric analysis. The statistics cover collaboration across authors, institutions, foreign participating countries in the publication of highly cited papers. To assess comparative contributions of authors/ organizations, a new indicator, the Major Contributor Index (*MCI*), was used. Citation trends for all papers, as well as for top papers, are presented. **Results:** A total of 76 highly cited articles, constituting 1.45% share of world highly cited papers output and 0.75% share of India's publications output, were published by India in clinical pharmacology output during 2000-14. This study covered only those papers that received at least 100 citations since publication. In recent years, top-cited articles have reached their citation peak in the early years of their citation life cycle, but have shown a more-rapid decreasing trend compared to top-cited articles from past decades. These 76 highly articles have received 14059 citations, with an average citation per paper of 184.99. The leading Indian organizations participating in highly cited research papers were All India Institute of Medical Sciences, New Delhi (7 papers), Panjab University, Chandigarh (6 papers), Jadavpur University, Kolkata (5 papers), National Institute of Mental Health & Allied Sciences, Bangalore, Aligarh Muslim University, Annamalai University, Banaras Hindu University, Varanasi, Sathyabama University, Guru Jambeshwar University, Hisar, Post Graduate Institute of Medical Education & Research, Chandigarh, Institute of Life Sciences, Bhubaneswar and Drug Research & Development Center, Kolkata (2 papers each).The leading authors were S.K. Bhattacharya (3 papers), J.K. Grover, S.P.Yadav, S. Garg, A.K. Singla, A.Garg, S. Ghosal, A. Bhattacharya, S. Khanna, A. Bhattacharya, S. Praveen and S.K.Sahoo (2 papers each). The leading international collaborative countries were USA (10 papers), Germany and U.K. (3 papers each), Japan, Russia Federation, Belgium and Canada (2 papers each). The *MCI* varied among leading organizations, as well as among individual authors. **Conclusions:** The output of highly cited papers by Indian authors in clinical pharmacology is still not significant given the fact that 208 authors contributed only one paper each once in 15 years, 11 contributed two papers each once in 15 years, and 1 contributed three papers once in 15 years. India still ranks 10th highest country with 1.45% share to the world output of highly cited papers compared to 61.41% share by USA. The quality of research in clinical pharmacology in India is though growing significantly over time, but there is very little evidence of corresponding growth in publication rate of highly cited papers in India.

Key words: Clinical pharmacology, India, Highly Cited Papers, Major Contributed Organizations, Authors, International Collaboration, Bibliometrics, Scientometrics.

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INTRODUCTION

Clinical pharmacology is a relatively young discipline and involves scientific study of drugs in man, their rational use which includes personalized medicine, safety and efficacy of medicines, consideration to cost, availability, etc. In recent years, the scope of clinical pharmacology has expanded to contribute more proactively to public health, to development of drugs from bench to bedside to marketing and life thereafter. The discipline was started in India in 1960s. Since then, it has been contributing to development of new drugs, clinical research, clinical trials for new drug, new drug regimens, rational use of drugs, pharmacogenetics, etc. Contributions in these areas have come from various organizations like Council for Scientific and Industrial Research (CSIR), Indian Council of Medical Research (ICMR), the centers of excellence developed by ICMR, World Health Organization (WHO), departments in academic organizations, pharmaceutical industry, etc. However, these developments have been rather slow and inadequate to meet the future challenges.[1,2]

Literature Review

There is no study in the literature on pharmacology and clinical pharmacology pertaining to analysis of high cited papers. However, few studies were carried out on quantitative analysis of pharmacological research output of India. Among such studies, Nayak, Mor and Unnikrishan[3] analyzed the publications of pharmacy schools in India from 1947 to 2009. It was found that the annual rate of increase in publications peaked at 30 to 40% between 2005 and 2007. Karnataka came first with more than 16% of the country's publications output with over 13% of citations. The top ten schools bagged about 52% publications and 70% citations. The break-up data placed Dr Harisingh Gour University, Sagar on top for the maximum number of publications and Panjab University for the highest citations as well as citations per paper Only 21 papers from Indian pharmacy schools have a total citation count of more than 100.

The current trend holds promise for rapid growth, although quality of publications has not yet become the priority of most researchers. The next study by Mueen Ahmad, Gupta and Gupta[4] analyzed performance of Indian pharmacological research during the last ten years (2003-12) using publications data covered in Scopus database, based on several parameters including global publication share and rank of 15 most productive countries, India's publication growth rate and citations impact, its pattern of citations output, international collaboration profile, institutional profile, geographical distribution of output, contribution and impact of top organizations and authors, pattern of communications and characteristics of high cited papers. In another study Gupta, Mueen Ahmad and Gupta[5] analyzed high productivity organizations in pharmaceutical science in India, using the publications data indexed and covered in Scopus database from 2008 to 2012. It identified their overall strength of these pharmaceutical organizations, measured in terms of select quantitative and qualitative indicators. It also provides a comparative evaluation and performance of different types of Indian pharmaceutical organizations. The study concludes that model of research funding of research institutes, institutes of national importance and universities is comparatively more effective in terms of quantity and quality of research performance. The paper also lists suggestions for national policy formulation for growth and development of pharmaceutical research in the country

METHODOLOGY

The study derived data on highly-cited papers from the Scopus, an international multidisciplinary bibliographical and citation database, in August 2015 and covered the period from 2005 to 2014. A highly-cited article (TC2014 ≥ 100) was defined as an article registering at least 100 citations since its publication up to August 2015. In total, there were 76 India's highly cited articles in clinical pharmacology that received at least 100 citations since publication. The impact factor (IF) of a journal was based on the Journal Citation Report (JCR) 2013.

The study organized publication and citation data into groups such as: (i) first author publications (FP), (ii) corresponding author publications (RP), (iii) FP-RP. Both first and corresponding author publications, (iv) the number of citations since publication to 2014 is referred as TC2014, (v) citations received in the year of publications (C0), (vi) citations in the first year after publication (C1), (vii) the number of citations received in year 2014 is referred as C2014, (vi) national and international collaborative publications, and (vii) most productive journals, etc.

The data was analyzed to assess the quantum of research under various groups, its global share, research quality, life cycle of research publications, contribution of different types of Indian authors and organizations in clinical pharmacology. Indian organizations have been classified into groups such as: (i) institutes of national importance, (ii) research institutes, (iii) universities, (iv) colleges, (v) engineering colleges, (vi) medical and allied sciences colleges, (vii) industrial enterprises and (viii) non-profitable institutions.

The collaboration type was determined from addresses data of the authors. An article could be either a single-country article, in which all authors' addresses (one or more) were from the same country, or bilateral or multilateral international collaborative article, co-authored by researchers from 2 or more countries (India and other country).

In a single author article where authorship is unspecified, the single author is presumed both as first author and corresponding author. Similarly, in a single institutional article, the institution is classified both as the first author institution and the corresponding author institution. In addition, only the first affiliation of corresponding author was considered when the author had multiple affiliations

At the individual level, a non-alphabetical name order sends a clear signal to the market that the author who is listed first actually contributed more. The first author is the person who contributed most to the work and writing of the article.[6] The corresponding author is perceived as the author contributing significantly to the article independent of the author position.[7] The corresponding author supervised the planning and execution of the study and the writing of the paper.[8] It is generally assumed that the first author and the corresponding author played significant roles, and they are the major contributors in producing a research paper. Thus, in this research, a newly developed indicator as suggested by Chuang and Ho,[9] the *MCI*, was used to assess the extent to which a researcher or an institution contributed to publishing an article. The *MCI* is calculated as the sum of first-author articles and corresponding articles divided by 2-times the total number of articles. It implies the percentage of instances one takes on the leadership role (first author or corresponding author) out of the total possible available opportunities. The equation is:

$$MCI=(FP-RP)/2TP,$$

Where *FP* is the number of first-author articles, *RP* is the number of corresponding-author articles, and *TP* is the number of total articles. When the *MCI* = 0, there is no first- or corresponding-author article. When the *MCI* = 1, all articles are either first- or corresponding author articles. *MCI* has two implications. First, it probably indicates a higher capability or productivity in conducting independent research. Second, it could, as well, indicate a more prominent role in collaborations. On the contrary, a low *MCI* is probably a sign of heavy reliance on collaboration, as well as relying on others to provide a leadership role in conducting research.[9]

OBJECTIVES

The main objective of this study is to examine the characteristics of highly cited Indian publications in clinical pharmacology published during 15 years between 2000 and 2014. The study in particular will assess: (i) the annual distribution of Indian contributions, its research quality and its global share, (ii) the contribution made by authors and organizations from different types of Indian organizations, (iii) institutional participation measured in terms of single institution publications and collaborating institution publications; (iv) nature of international collaboration (bilateral or multilateral), and (v) media for communication of publications and (vi) characteristics of top 10 publications.

ANALYSIS, RESULTS AND DISCUSSION

Publications Analysis

As per data sourced from SCOPUS database covering the period 2000-14, the world output of highly cited papers (HCPs) in clinical pharmacology, cited at least 100 times since their publication, stood at 5242 papers. The annual world output of highly cited papers in clinical pharmacology dropped from 2200 in 2000, the first year of this study period to 292 papers in 2014, the last year of this study period. Highly cited papers constituted 1.97% share of the world output covering all of publications in clinical pharmacology (265489 papers) during 2000-14.

India ranked 10th highest country with 1.45% share to the world output of highly cited papers in clinical pharmacology (76 HCPs). In the ranking of top 10 leading countries by their world output of highly cited papers in clinical pharmacology, the USA topped with highest world share (61.41%, 3219). The top five nations USA, U K, Germany, Italy, and Canada constituted 6.41% - 61.41% share of the world output of the highly cited papers (5242 HCPs) in clinical pharmacology during 2000-14 (Table 1, Figure 1).

Table 1: Distribution of Publications Output of Top 10 Most Productive Countries in Clinical Pharmacology: 2005-14

	Publications Count	World Publications Share %	Rank	HCPs (highly Cited Papers) Count	World Share of HCPs %	Rank	National Share of HCPs %	Rank
USA	83629	31.50	1	3219	61.41	1	3.85	1
U K	23816	8.97	2	898	17.13	2	3.77	2
Germany	17396	6.55	3	611	11.66	3	3.51	3
China	17295	6.51	4	103	1.96	9	0.60	10
Italy	15171	5.71	5	371	7.08	4	2.45	6
Japan	14993	5.65	6	240	4.58	7	1.60	8
India	10108	3.81	7	76	1.45	10	0.75	9
Spain	9663	3.64	8	175	3.34	8	1.81	7
Canada	9576	3.61	9	336	6.41	5	3.51	4
France	9274	3.49	10	320	6.10	6	3.45	5
World	265489	100.00		5242	100.00			

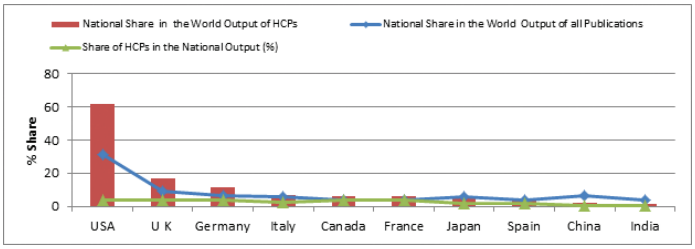

Figure 1: Comparative World Share of Highly Cited Papers of Top 10 Most Productive Countries in Clinical Pharmacology: 2000-14

Table 2: Distribution of Highly Cited Papers by India across Publication Types: 2000-14

Type of Publication	TP	TC	CPP
Articles	30	6115	203.83
Reviews	43	7106	165.26
Conference Paper	1	593	593.00
Letter	1	121	121.00
Short Survey	1	124	124.00
Total	76	14059	184.99

TP=Total papers; TC=Total citations; CPP = Average citation per paper

India ranked 9th highest with its highly cited papers constituting 0.75% share of the national output during 2000-14. In the national ranking of countries by their share of highly cited papers, United States topped the list with 3.85% highest national share. The top five countries -- USA, U.K., Germany, Canada, and France -- relatively produced 3.45% - 3.85% share of their national output as highly cited papers during 2000-14. It is evident that national output of highly cited papers in India is relatively too low compared to top ranking countries. (Table 1, Figure 1).

India ranked 7th highest with its national output constituting 3.81% share (10108 papers) in the world output in clinical pharmacology covering all of research publications including even highly cited papers. United States topped with 31.50% global share (83629 papers) relative to 3.81% by India during 2000-2014. Annual output of highly cited papers in clinical pharmacology during 2000-14 remained range bound between 2 and 11 paper per year.

Of all the 76 highly cited papers produced by India, 30 (39.47%) appeared as articles, 43 (56.58%) as reviews and 1 (1.32%) paper each as conference papers, short surveys, letters. Unexpectedly, conference paper registered the highest citation impact per paper (593), followed by articles (200.83), reviews (165.26), Short survey (124) and Letter (121.0) during 2000-2014 (Table 2).

Citations Analysis

The 76 highly cited papers under this study cumulated 14059 citations in 15 years during 2000-Aug 2015. Citation to papers has been used as a proxy for describing the quality of research, to judge how 76 highly cited papers in clinical pharmacology inter-compare in their performance on quality and impact. The citation impact of 76 highly cited papers averaged to 184.99 citations per paper in 15 years period, and citation impact of their annual output distributed across 15 publication years ranged between 129.5 and 346 citations per paper (CPP). Citation window is this study is variable since citations to papers have been counted from their publication year till August 2015. CPP as such is not a valid indicator for inter-comparing impact of 76 highly cited papers across 15 differential citation window periods. This study, therefore, used 'citation density' - another citation impact indicator - which normalizes citation window period, and measures citation impact in terms of both; (i) citations

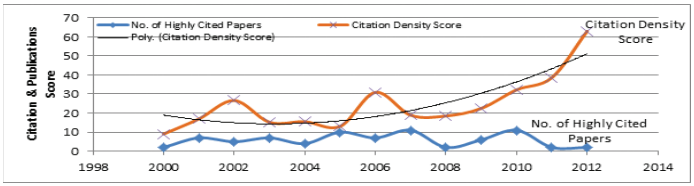

Figure 2: Citation Density of Highly Cited Papers I Clinical Pharmacology, 2000-2014

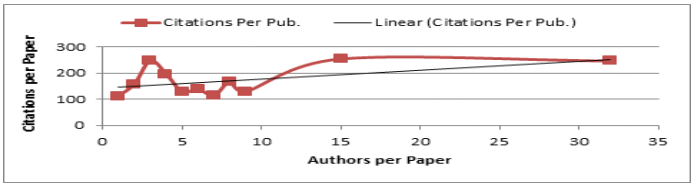

Figure 3: Citation Distribution by Authorship per Paper in Clinical Pharmacology: 2000-15

Table 3: Citation Density of India's Highly Cited Papers in Clinical Pharmacology: 2000-14

Year	India				
	No. of Highly Cited Papers	Citations Count	CPP	Citation Density	Citation Window Period in Years
2000	2	271	135.5	9.03	15
2001	7	1662	237.43	16.96	14
2002	5	1730	346.00	26.62	13
2003	7	1276	182.29	15.19	12
2004	4	683	170.75	15.52	11
2005	10	1302	130.2	13.02	10
2006	7	1946	278.00	30.89	9
2007	11	1662	151.09	18.89	8
2008	2	259	129.50	18.50	7
2009	6	809	134.83	22.47	6
2010	11	1772	161.09	32.22	5
2011	2	309	154.50	38.63	4
2012	2	378	189.00	63.00	3
2013	0	0	0.00	0	2
2014	0	0	0.00	0	1
Total	76	14059	184.99	24.69	15

CPP=Average citations per paper

Table 4: India's Highly Cited Papers in Clinical Pharmacology Distributed by Citation Frequency Range: 2000-14

Citation Range	No of Highly Cited Papers	Total Citations	Publications Share	Citations Share
100-199	57	7664	75.00	54.51
200-299	13	3239	17.11	23.04
300-399	1	310	1.32	2.20
400-499	2	920	2.63	6.54
500-599	2	1115	2.63	7.93
800-899	1	811	1.32	5.77
Total	76	14059	100.00	100.00

per paper and (ii) citations per citation year. Citation density is calculated by 'number of citations per paper' divided by 'number of citation years'. For example, 'citation density' of 5 highly cited papers published in the year 2002 was found to be 26.62 citations per paper per citation year (1730/5/13) = 26.62 (Table 3). The citation density of 76 highly cited papers averaged to 21.4 citations per paper per citation year. Citation density was highest with 63 CPP/PCY for a set of 2 papers published in the year 2012 and the smallest with 9.03 CPP/PCY for another set of 2 papers published in the year 2000. The study witnessed gradual rise in citation density score of highly cited papers published since 2007 onward from 18.89 in 2007 to 63 CPP/PCY in 2012. The citation density of papers published during the initial years of this study (2000 – 06) was relatively lower and fluctuating across different publications years (Table 3, Figure 3).[26]

The citations to highly cited papers cover a wide citation spectrum spreading across from 100 to 899 citations per paper. The distribution of highly cited papers across differential-citation frequency ranges is skewed. Bulk of highly cited papers (75%), accounting for the largest citation share (54.51%), define low-end citation frequency range (100-199 times). Nearly 17% papers, accounting for the second largest citations share (23.04%), are covered in the citation range (200-399 times). Only 3.95% papers, accounting for 13.70% share of total 14059 citations during 2000-14, relate to top-end citation range (500-899 times). Nearly 2.63% papers, accounting for the smallest citations share (6.54%), cover mid-section (400-999 times) of the citation range (Table 4, Figure 2).

Contribution of Top Cited Authors in Research

In all, 303 Indian and foreign authors contributed to 76 highly cited papers in clinical pharmacology. Of these, 222 were Indian and 81 foreign authors. The study revealed that most of highly cited papers were contributed by Indians in their role as first author. Amongst 303 authors, thirty three (10.89%) made contributions as first author, another set of thirty three (10.89%) made contributions as corresponding author, and sixty three (20.79%) contributed both as first author and corresponding author. Amongst 222 Indian authors, twenty nine (13.06%) made contributions as first author along with corresponding author, thirty one (13.96%) as sole author, and fifty three (23.87%) both as first author and corresponding author. Among 81 foreign authors, four (4.94%) contributed as corresponding author, two (2.47%) as first author and ten (12.35%) both as first author and corresponding author. Of the 222 Indian authors to highly cited papers, 73 were affiliated to universities, 54 authors to research institutions, 28 to institutes of national importance, 20 to pharmaceutical colleges, 8 to industrial enterprises, and 1 each to college, hospital and state government department.

Authorship to 76 highly cited papers varied widely from 1 to 32 authors per paper with an average of 3.95 authors per paper; and the largest authorship to highly cited papers was 32 authors per paper. Most of highly cited papers were either joint author or multi author papers in clinical pharmacology. Sole authorship highly cited papers are relatively fewer. The rising trend to highly cited papers with multiple-authorship indicates that quality research in clinical pharmacology is becoming more and more of a team based activity/ multi-institutional activity. Secondly, multiple-authorship seems to hold potential to influence relatively high to very high citations (Table 5, Figure 3). Of the 222 Indian authors, 208 contributed one paper each once in 15 years, 11 contributed two publications each once in 15 years; 1 contributed three papers in all 15 years. It shows that frequency of contribution to highly cited papers by Indian authors in clinical pharmacology is not significant.

Top 12 authors, each contributing at least 2 highly cited papers, were ranked on volume of their output in clinical pharmacology (Table 6).

Their MCI index varies from 0.0 to 1.0. No correlation was found between their rank order and MCI index.

Contribution of Top Organizations in Research

In all 135 organizations (74 Indian and 61 foreign) had participated in contributing 76 highly cited papers in clinical pharmacology research in India during 2000-14. Of the 74 Indian research organizations, only 13 were comparatively more productive, with each contributing 2 to 7 highly cited papers in clinical pharmacology in 15 years during 2000-14. The other 61 were low productivity organizations, with each contributing only one publication each during the same period. Research institutions dominated the publications output of highly cited papers in clinical pharmacology with largest share (36.84%, 28 papers), followed by universities (30.26% share, 23 papers), institutes of national importance and medical colleges (15.79% share, 12 papers each), pharmaceutical colleges and industrial enterprises (7.89% share, 6 papers each), engineering colleges (2.63% share, 2 papers), college, hospital and state government department (1.32% share, 1 paper each) during 2000-14 (Table 7).

MCI greater than 0.500 indicates that the institution has high potential to conduct research independently, contribute to research productivity significantly, or play more prominent role in research collaboration. On the contrary low MCI is a sign of heavy reliance on others to play leadership role in conducting research or in research collaboration. Engineering colleges and state government departments (with MCI of value 1) have indeed contributed significantly to research reported in highly cited papers, followed by pharmaceutical colleges (MCI=0.83), universities (MCI=80), research institutes (MCI=0.67), institutes of national importance and medical colleges (MCI=0.58 each), and industrial enterprises (MCI=0.33), engineering colleges (MCI=0.35), and industrial enterprises (MCI=0.18) (Table 7). Top 13 research organizations, each with a minimum of 2 contributions, are ranked in Table 8. Their MCI varies between 0.4 and 1.0.

Of the 74 Indian participating organizations in clinical pharmacology, 21 were universities, 15 research institutes, 13 medical colleges, 9 pharmaceutical colleges, 6 industrial enterprises, 4 institutes of national importance, 2 each as engineering colleges and colleges and 1 each as hospital and government departments 2000-14. Among the 76 highly cited papers, 37 papers had the participation of 1 organization each, 23 papers with 2 organizations each, 7 papers with 3 organizations each, 6 papers with 4 organizations each, 1 paper each with 5, 7 and 28 organizations (Table 9).

Table 5: Citation Productivity in Clinical Pharmacology by Authors per Paper: 2000-14

Authors per publication	No. of Publication	No. of Citations	Av. Citation Per Pub.
1	2	225	112.5
2	19	3017	158.8
3	21	5215	248.3
4	14	2765	197.5
5	6	775	129.2
6	8	1113	139.1
7	2	228	114.0
8	1	167	167.0
9	1	130	130.0
15	1	255	255.0
32	1	247	247.0
	76		

Collaboration in Highly Cited Papers

Of all the 76 highly cited publications in clinical pharmacology, 38 resulted with authorship to each of these papers belonging to co-authors from the same single parent organization only (labeled as publications with authorship by single Indian organization), 20 resulted from national collaboration with authorship to each of these papers belonging to 2 or more Indian organizations (labeled as national collaborative publications), and 18 resulted from international collaboration with authorship to each of these papers belonging to 2 or more Indian and foreign organizations (labeled as international collaborative publications) (Table 10). Internationally collaborative publications scored higher citation impact with 204.1 citations per publication compared to single institution publications with 199.6 citations per publication and national collaborative publications with 140.1 citations per publication (Table 10).

Contribution of Organizations: Single Institution Participation

In all, 38 highly cited papers resulted from participation of 24 Indian organizations and 113 authors; authorship to each of these 38 papers

Table 6: Top 12 Highly Cited Authors from India in Clinical Pharmacology during 2000-14

S.No	Name of the Author	Affiliation	TP	FP-RP	FP	RP	MCI
1	S.K. Bhattacharya	Institute of Medical Sciences, BHU, Varanasi	3	2	0	1	0.83
2	J.K. Grover	All India Institute of Medical Sciences, New Delhi	2	2	0	0	1.00
3	S.P. Yadav	All India Institute of Medical Sciences, New Delhi	2	0	0	0	0.00
4	S. Garg	National Institute of Pharmaceutical Education & Research, Mohali	2	0	0	1	0.20
5	A.K. Singla	Punjab University, Chandigarh	2	1	0	1	0.75
6	A.Garg	Punjab University, Chandigarh	2	0	1	0	0.25
7	S.Ghosal	Institute of Medical Sciences, BHU, Varanasi	2	0	0	0	0.00
8	A.Bhattacharya	Institute of Medical Sciences, BHU, Varanasi	2	0	0	0	0.00
9	S.Khanna	National Institute of Mental Health & Allied Sciences, Bangalore	2	0	0	0	0.00
10	A.Bhattacharya	Drug R & D Center, Kolkata	2	0	1	0	0.25
11	S.Praveen	Institute of Life Sciences, Bhubaneswar	2	0	2	0	0.50
12	S.K.Sahoo	Institute of Life Sciences, Bhubaneswar	2	0	0	2	0.50

TP=Total Papers; FP=Number of first-author top cited articles; RP=Number of corresponding top-cited articles

Table 7: Distribution of Highly Cited Papers across Indian Organizations: 2000-15

Type of Organization	TP	%TP	FP-RP	FP	RP	MCI
Universities	28	36.84	9	14	13	0.80
Research Institutes	23	30.26	4	11	12	0.67
Institutes of National Importance	12	15.79	4	3	3	0.58
Medical Colleges	12	15.79	5	4	0	0.58
Pharmaceutical Colleges	6	7.89	4	1	1	0.83
Industrial Enterprises	6	7.89	2	0	0	0.33
Engineering Colleges	2	2.63	2	0	0	1
Colleges	1	1.32	0	0	0	0
Hospital	1	1.32	0	0	0	0
State Government Department	1	1.32	1	0	0	1
Total	76	36.84				

FP=Number of papers with first authors; RP=Number of papers with corresponding authors; TP=Total Papers; MCI=Major Contribution Index

Table 8: Thirteen Leading Indian Organizations in Clinical Pharmacology, 2000-14

S.No	Name of the Organization	TP	(FP, RP)	FP	RP	MCI
1	All India Institute of Medical Sciences, New Delhi	7	5	0	0	0.59
2	National Institute of Pharmaceutical Education &Research, Mohali	6	6	0	0	1.0
3	Panjab University, Chandigarh	5	2	0	0	0.4
4	Jadavpur University, Kolkata	3	2	0	0	0.67
5	National Institute of Mental Health & Allied Sciences, Bangalore	2	0	0	0	0.0
6	Aligarh Muslim University	2	2	0	0	1.0
7	Annamalai University	2	2	0	0	1.0
8	Banaras Hindu University, Varanasi	2	1	0	1	0.75
9	Sathyabama University	2	1	0	0	0.5
10	Guru Jambeshwar University, Hisar	2	1	0	0	0.5
11	Post Graduate Institute of Medical Education & Research, Chandigarh	2	1	0	0	0.5
12	Institute of Life Sciences, Bhubaneswar	2	2	0	0	1.0
13	Drug Research & Development Center, Kolkata	2	1	0	1	0.75

TP=Total Papers; FP=Number of first-author top cited articles; RP=Number of corresponding top-cited articles

Table 9: Distribution of Citations to Highly Cited Papers by Affiliating Organizations, 2000-14

Affiliating Organizations per Publication	Number of Papers	Total Citations	Average Citations per Publication
1	37	7461	201.6
2	23	3210	139.6
3	7	1977	282.4
4	6	871	145.2
5	1	167	167.0
7	1	114	114.0
28	1	247	247.0
	76	14052	184.9

Table 10: Citation Performance of Highly Cited Publications by Collaboration Type: 2003-12

Type of Collaboration	Total Publications	Total Citations	Average Citations per Publication
Co-authors with affiliation to same single Institution	38	7583	199.6
National collaborative Institutions	20	2802	140.1
International collaborative Institutions	18	3674	204.1
	76	14059	185.0

comprised co-authors coming from the same single organization only. Their share in the output of highly cited publications by India in clinical pharmacology during 2000-14 was 50%. Of the 38 highly cited papers, 13 were contributed by research institutes, 12 by universities, 7 by institutes of national importance, 3 by medical colleges, 2 by industrial enterprises and 1 by engineering college.

Of the 24 Indian organizations, 9 were universities (with 12 publications), 6 research institutes (with 13 publications), 3 each institutes of national importance and medical colleges (with 7 and 3 publications), and 1 each engineering college and industrial enterprise (with 1 publication each). The detail of these organizations are as follows: (i) Universities – Jamia Hamdard, Annamalai, Punjab, Aligarh, Jadavpur, H.S.Gour, BHU, Amravati and Himachal (ii) Research Institutes – NIPER-Mohali, ILS-Bhub, NCCS-Pune, CIMAP-Lucknw, NIO-Goa and CHemjobiotech Research Institute; (iii) Institutes of National Importance – AIIMS-Delhi, PGIMER-Chandigarh and IIT-Guwahati; (iv) Medical Colleges – CMC-Vellore, IMS-BHU and Seth GS Med Coll & Hosp; (iv)Engineering College – IT-BHU, and (v) Industry – Nektar Therapeutics Ltd and Matrix Lab Ltd. Amongst the above stated organizations, National Institute of Pharmaceutical Education & Research (NIPER), Mohali contributed the largest number of publications (6), followed by AIIMS-Delhi (5 publications), Jamia Hamdard University , Annamalai University and ILS-Bhubaneswar (2 publications each), and the remaining 19 organizations contributed 1 publications each. The distribution of 38 papers by authorship per publications was as follows: 2 papers were contributed by 1 author each, 15 by 2 authors each, 13 by 3 authors each, 4 by 4 authors each, 3 by 5 authors each, and 1 by 6 authors in all. The authorship to 38 papers averaged to 3 authors per publication.

Contribution of Organizations: National Collaborative institutions

In all, 20 publications resulted from participation of 36 Indian organizations and 82 authors; authorship to each of the 20 papers comprised two or more Indian organizations (labeled as national collaborative publications). The share of such papers in the output of highly cited publications in clinical pharmacology was 26.32%. In the output of these 20 publications, 14 publications resulted from collaboration across 15 universities, 6 resulted from collaboration across 5 research institutes, 4 resulted from collaboration across 5 pharmaceutical colleges, 4 publications each resulted from collaboration across 4 medical colleges and 4 industrial enterprise, 1 publication each resulted from collaboration across institute of national importance, hospital and state government department.

The organizations which collaborated in these 20 highly cited papers include: (i) Universities – Panjab, Aligarh, Jadavpur, BHU, Baroda, Madras, Calcutta, Pune, JNU, Sardar Patel, Punjabi, Sathybama, Guru Jambeshwar, SRM and UICT-Mumbai, (ii) Research Institutes – Drug Research & Development Center, Kolkata, NIOT-Chennai, IGIB-Delhi, NCL-Pune, DRDO-Gwalior; (iii) Institutes of National Importance – AIIMS-Delhii; (iv) Medical Colleges – IMS-BHU, IG Med Coll, IPGMER-Kolkata and Dr ALMPGIBMS, Univ Madras., (iv) Pharmaceutical Colleges – Bharati Vidyapeeth; SF Institute of Pharmaceutical Science, Dr BC Roy Coll Pharmacy, Lone Shiva Coll Phar, Singhged Coll Phar; (v) Industry–Sun Pharma, Orchid Healthcare, Pharmanza Ind and Nicholas Piramal.

Punjab University, Chandigarh had collaborated in the largest number of publications (3), Sathyabama University and Guru Jambeshwar University in 2 publications, and 33 other organizations collaborated in 1 publication. In terms of distributional of 20 papers by institutional participation, 16 papers had participation of 2 organizations in each, 2 papers each had participation of 3 and 4 organizations. The institutional authorship to 20 national collaborative papers averaged to 2.3 organizations per paper. Of the 82 authors in 20 papers, 35 were affiliated to universities, 18 to pharmaceutical colleges, 11 to medical colleges, 9 to research institutes, 5 to industrial enterprises, 2 to institutes of national importance, and 1 each to hospital and state government department. In terms of distribution of authorship to 20 papers, 3 were contributed by 2 authors each, 5 publications each by 3 and 4 authors each, 2 contributed by 5 authors each, 3 contributed by 6 authors each and 1 publication each contributed by 7 and 9 authors. The authorship to 20 papers averaged to 4.25 authors per publication. Of the 20 national collaborative publications, in 8 papers authors contributed both as first author and corresponding author, in 6 other authors contributed only as first author, and in another 6 authors contributed only as corresponding author.

Contribution of Organization: International Collaborative Institutions

In all, 18 highly cited papers resulted from international collaboration across 61 Indian and 22 foreign institutions, with participation of 81 Indian and 26 foreign authors representing 22 countries. Each paper resulted from participation of two or more Indian and foreign organizations. These 18 papers accounted for 23.68% share of total output of highly cited papers in clinical pharmacology. Of the 18 papers, 3 resulted from collaboration across 4 institutes of national importance, 4 from collaboration across 4 research institutes, 2 from collaboration across 3 universities, 2 from collaboration across 2 colleges, 3 from collaboration across engineering colleges, and 2 each resulted from collaboration across 3 pharmaceutical colleges.

National Institute of Mental Health & Neurological Sciences, Bangalore participated in 2 publications each and the rest 18 organizations in 1 publication each. The list of 19 participating organizations distributed by institutions type are : (i) Medical Colleges (5) – SGPGIMS-Lucknow, Sri Ramchandra Med College, PGIMS-Kolkata, Medical College, Jammu and Kempegowda Institute of Medical Sciences, Bangalore; (ii) Institutes of National Importance (3) – AIIMS-Delhi, NIMANS, Bangalore and PGIMER-Chandigarh; (iii) Universities (2) – Panjab University and University of Delhi; (iv) Pharmaceutical Colleges (2) – LM College of Pharmacy, Ahmedabad and CU Shaw College of Pharmacy, Ahmedabad; Engineering College (1) – Mepco Schenk Engineering College, Sivaski; Colleges(2) – Dr Ambedkar College, Nagpur and NMSS Vellicharry College, Nagpur.

In terms of distribution of participation of organizations in 18 highly cited papers, it was found that 6 publications resulted from participation of 2 organizations in each, another 6 from participation of 3 organizations in each, 2 from participation of 4 organizations in each, another 2 from participation of 5 organizations in each, 1 from participation of 7 organizations, and another 1 from participation of 28 organizations. The institutional authorship to 19 publications averaged to 4.61 organizations per publication. In terms of distribution of authors per publication, it was found that 3 publications resulted from participation of 2 authors in each, another 3 from participation of 3 authors in each, 5 from 4 authors in each, 3 from 6 authors in each, 2 from 7 authors in each, 1 from 8 authors, and another 1 resulted from 32 authors. The personal authorship to 18 highly cited papers averaged to 5.94 authors per paper. In terms of distribution of countries per publication, 13 publications resulted from participation of 2 countries in each, 2 from participation of 2 countries in each, another 2 from participation of 3 countries in each, and 1 paper each resulted from participation of 4, 6 and 18 countries in each. The average number of countries per publication was 3.33.

Of the 22 collaborating countries in 18 highly cited clinical pharmacology, United States participated in the largest number of publications (10), followed by Germany and U.K. (3 publications each), Japan, Russia Federation, Belgium and Canada (2 publications each), Italy, Saudi Arabia,

Table 11: Foreign Collaborating Countries in Highly Cited Papers in Clinical Pharmacology, 2000-14

Country	Number of publications with			
	Total	Both FP and RP	FP	RP
USA	10	4	1	2
Germany	3	1	1	1
U.K.	3	0	0	1
Japan	2	1	0	0
Russia Federation	2	1	0	0
Belgium	2	0	0	0
Canada	2	0	0	0
Italy	1	1	0	0
Saudi Arabia	1	1	0	0
Denmark	1	1	0	0
Australia	1			
Taiwan	1			
China	1			
Argentina	1			
New Zealand	1			
Croatia	1			
Brlarus	1			
Bulgaria	1			
Slovakia	1			
South Korea	1			
Sri Lanka	1			
Trinidad & Tobago	1			
Total	22	42	30	38

TP=Total Papers; FP=Number of first-author top cited articles; RP=Number of corresponding top-cited articles

Table 12: Distribution of 76 Highly Cited Papers in Clinical Pharmacology by Citation and Impact Factor

IF Range	Range of Citations					
	100-199	200-299	300-399	400-499	500 & More	Total
12.01 – 13.0	1	1				2
8.01 - 9.00	3					3
7.01 - 8.00	1	1				2
5.01 – 6.00	12	4				16
4.01 – 5.00	3		1	1		5
3.01 – 4.00	12	2			1	15
2.01 – 3.00	20	3		1	2	26
1.01 – 2.00	4	1				5
0.01 – 1.00	2					2
	58	12	1	2	3	76

Australia, Taiwan, China, Argentina, New Zealand, Croatia, Belarus, Bulgaria, Slovakia, South Korea, Denmark, Sri Lanka and Trinidad &Tobago (1 publication each). In these 18 international collaborative publications, 11 authors participated both as first author and corresponding authors, 7 as first author only, and 7 other as corresponding authors. Besides, 9 foreign authors participated both as first author and corresponding author, 3 as first author only and 5 as corresponding authors only. From India, 2 authors participated both as first author and corresponding author, 4 as first author and 2 as corresponding author only. The relative contribution of various foreign countries as first author and corresponding author publications is shown in Table 11.

Medium of Communication

Journals play an important role in the communication structure of science. All of the 76 highly cited publications in Indian clinical pharmacology were published in 45 peer reviewed journals. No significant correlation was found between citation numbers of highly cited papers and the impact factor of their reporting journals (Table 12)

Of 45 journals, 32 (71.11%) reported one highly cited publication each, 6 (13.33%) reported two publications each, 5 (11.11%) reported three publications each, 1 (2.22%) journal each reported eight and nine publications respectively. Table 13 (given at the end) lists the top 45 journals which published highly cited publications. *Nanomedicine* published largest number of the highly cited publications (9 papers, 11.84% share), followed by *Journal of Ethnopharmacology* (8 publications, 10.53% share), *International Journal of Pharmaceutics, Biorganic & Medicinal Chemistry, Pharmcological Research, Medicinal Research Review and Drug Discovery Today* (3 publications. 3.95% share each), *Journal of Antimicrobial & Chemotherapy, Phytotherapy Research, Phyomedicine, Life Sciences, Toxicology and Advanced Drug Delivery Reviews* (2 publications, 2.63% share each), etc.

Top 10 Highly Cited Articles

Of the top 10 highly cited papers, 6 were published from 2001-04, 3 in 2006 and 1 in 2010. Three papers were published in *Journal of Ethnopharmacology* [IF=2.939], and 1 each in *Life Sciences* [IF=2.702], *International Journal of Pharmaceutics* [IF=3.785 }, *Biochemical Pharmacology* [IF=4.650], *Neuro-Psychopharmacology & Biological Psychiatry* [IF=7.048], *Phytotherapy Research* [IF=2.397], *Journal of Control Release* [IF=7.261], and *Nanomedicine* [IF =5.824]. Table 15 lists these 10 leading papers in clinical pharmacology with a TC2014 > 275. Both citation numbers and ranking for the TC2014 are displayed. The top most article - "Medicinal plants of India with anti-diabetic potential was published by Grover, J.K., Yadav, S., Vats, V in *Journal of Ethnopharmacology* in 2002 and had TC2014 of 811. The study organized publication and citation data into seven groups such as (i) first author publications (FP), (ii) corresponding author publications (RP), (iii) the number of citations since publication to 2014 is referred as TC2014, (iv) citations received in the year of publications (C0), (v) citations in the first year after publication (C1), (viii) the number of citations received in year 2014 is referred as C2014, (vi) national and international collaborative publications, and (vii) most productive journals etc (Table 14).

Effect of Time Period on Citations Output

Citation life cycle of highly cited papers published in the time period 2000-10 exhibit two trends i) papers that exhibit typical early peak, reaching their citation peak in 5 years since publication (Thakkar, K.N. *et al*. Nanomedicine 2010, 276 citations) (Rahman. I *et al*. Biochemical Pharmacology 2006, 488 citations), ii) papers that exhibit delayed recognition, delayed citation peak, reaching their citation peak in 8 -10 years since publication. In overall, life cycle of highly cited papers (TC2014 > 100) lasted from 6 to 14 years and that they all enter decline in citation after reaching their peak. As can be seen, highly cited papers in clinical pharmacology effectively have dated life cycle but they differ significantly in their cumulative citations output (TC2014) ranging from 276 to 811 (Table 15, Figure 4). It is significant to note that papers that

Table 13: List of journals publishing 1 or more high cited papers

S.No	Name of the Journal	Total Papers	IF 2013	
1	Nanomedicine	9	5.824	10(276), 12 (270), 16 (216), 21 (188), 22 (180), 30 (161), 35 (151), 38 (149) and 44 (130).
2	Journal of Ethnopharmacology	8	2.939	1(811), 5 (432), 8 (282), 25 (175), 26 (173), 43 (142), 74 (102); 76 (100)
3	International Journal of Pharmaceutics	3	3.785	3(522), 28 (165) and 72 (106);
4	Biorganic & Medicinal Chemistry	3	2.951	23 (179), 67 (108), 73 (102);
5	Pharmcological Research	3	3.976	19 (201), 34 (152), 50 (123
6	Medicinal Research Review	3	8.131	29 (165), 52 (122); 58 (116)
7	Drug Discovery Today	3	5.964	18 (201), 33 (152) and 75 (100);
8	Journal of Antimicrobial & Chemotherapy	2	5.439	53 (121) and 64 (112);
9	Phytotherapy Research	2	2.397	7(293) and 31 (161)
10	Phyomedicine	2	2.877	41 (145) and 66 (110);
11	Life Sciences	2	2.702	3(593) and 49 (124)
12	Toxicology	2	3.621	62 (114), 71 (107)
13	Advanced Drug Delivery Reviews	2	12.707	17(212) , 55 (119)
14	Acta Pharmaceutica	1	1.025	61 (114)
15	Alimentary Pharmacology and Therapeutics	1	5.478	57(119)
16	Basic and Clinical Pharmacology & Toxicology	1	2.294	32(159);
17	Biochemical Pharmacology	1	4.650	4 (488)
18	ChemBioChem	1	3.060	46(128)
19	Chinese Medicine	1	1.490	47(124)
20	Chirality	1	1.724	48(124)
21	Current Drug Metabolism	1	3.487	56(119)
22	Current Medicinal Chemistry	1	3.715	36(151)
23	Current Medicinal Chemistry - Anti-Cancer Agents	1	2.939	37(150)
24	Current Opinion in Pharmacology	1	4.227	27(167)
25	Drug Safety	1	2.620	69(108)
26	Environmental and Molecular Mutagenesis	1	2.553	14(247)
27	European Journal of Medicinal Chemistry	1	3.432	40(148)
28	European Neuropsychopharmacology	1	5.395	59(116)
29	Indian Journal of Pharmacology	1	0.679	39(149)
30	International Journal of Pharmcology	1	0.981	(148)
31	Journal of Control Release	1	7.261	9(280)
32	Journal of Drug Targeting	1	2.723	70(107)
33	Journal of Occupational Health	1	1.096	65(111)
34	Journal of Pharmacy & Pharmaceutical Science	1	1.681	15(234)
35	Journal of Pharmacology and Experimental Therapeutics	1	3.855	20(189)
36	Journal of Toxicology - Clinical Toxicology	1	3.122	13(255)
37	Marine Drugs	1	3.512	63(113)
38	Neuropsychopharmacology	1	7.048	42(142)
39	Pharmacology, Biotechnology & Behavior	1	2.820	(123)
40	Pharmacological Reports	1	2.165	60(114)
41	Pharmacology Biochemistry and Behavior	1	2.820	51(123)
42	Planta Medica	1	2.339	54(120)
43	Progress in Neuro-Psypgarmacology & BiologicaL Psychiatry	1	4.025	6(310)
44	Toxicological Sciences	1	4.478	45(130)
45	Vascular Pharmacology	1	4.620	24(177)
		76		

Table 14: List of Top 10 Most Highly Cited Papers in Clinical Pharmacology

1. Grover, J.K., Yadav, S., Vats, V.
Medicinal plants of India with anti-diabetic potential
(2002) *Journal of Ethnopharmacology*, 81 (1), pp. 81-100. Cited 811 times.

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Document Type: Article
Source: Scopus

2. Maheshwari, R.K., Singh, A.K., Gaddipati, J., Srimal, R.C.
Multiple biological activities of curcumin: A short review
(2006) *Life Sciences*, 78 (18), pp. 2081-2087. Cited 593 times.

[a] Department of Pathology, Uniformed Services University of the Life Sciences, Center for Combat Casualty and Life Sustainment Research, 4301 Jones Bridge Road, Bethesda, MD 20814, United States
[b] Industrial Toxicological Research Center, Lucknow, India

Correspondence Address
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Document Type: Conference Paper
Source: Scopus

3. Singla, A.K., Garg, A., Aggarwal, D.
Paclitaxel and its formulations
(2002) *International Journal of Pharmaceutics*, 235 (1-2), pp. 179-192. Cited 522 times.

University Institute of Pharmaceutical Sciences, Panjab University, Chandigarh 160 014, India

Correspondence Address
Singla A.K.; Univ. Inst. of Pharmaceutical Sci., Panjab University, Chandigarh 160 014, India; email: aksingla@mailmetoday.com

Document Type: Article
Source: Scopus

4. Rahman, I., Biswas, S.K., Kirkham, P.A.
Regulation of inflammation and redox signaling by dietary polyphenols
(2006) *Biochemical Pharmacology*, 72 (11), pp. 1439-1452. Cited 488 times.

[a] Department of Environmental Medicine, Division of Lung Biology and Disease, University of Rochester Medical Center, MRBX 3.11106, 601 Elmwood Avenue, Rochester, NY 14642, United States
[b] Department of Biochemistry, Dr. Ambedkar College, Nagpur, MS, India
[c] Novartis Institute for Biomedical Research (Horsham), United Kingdom

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Rahman I.; Department of Environmental Medicine, Division of Lung Biology and Disease, University of Rochester Medical Center, MRBX 3.11106, 601 Elmwood Avenue, Rochester, NY 14642, United States; email: irfan_rahman@urmc.rochester.edu

Document Type: Article
Source: Scopus

5. Ahmad, I., Beg, A.Z.
Antimicrobial and phytochemical studies on 45 Indian medicinal plants against multi-drug resistant human pathogens
(2001) *Journal of Ethnopharmacology*, 74 (2), pp. 113-123. Cited 432 times.

Department of Agricultural Microbiology, RAK Institute of Agricultural Sciences, Aligarh Muslim University, Aligarh 202002, India

Correspondence Address
Ahmad I.; Department Agricultural Microbiology, RAK Institute Agricultural Sciences, Aligarh Muslim University, Aligarh 202002, India

Document Type: Article
Source: Scopus

6. Vaswani, M., Linda, F.K., Ramesh, S.
Role of selective serotonin reuptake inhibitors in psychiatric disorders: A comprehensive review
(2003) *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 27 (1), pp. 85-102. Cited 310 times.

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Vaswani M.; Department of Psychiatry, All India Inst. of Medical Sciences, New Delhi 110029, India; email:meeravaswani@hotmail.com

Document Type: Review
Source: Scopus

....Continued

Table 14: Cont'd

7. Garg, A., Garg, S., Zaneveld, L.J.D., Singla, A.K.
Chemistry and pharmacology of the Citrus bioflavonoid hesperidin
(2001) *Phytotherapy Research*, 15 (8), pp. 655-669. Cited 293 times.

[a] University Institute of Pharmaceutical Sciences, Panjab University, Chandigarh 160014, India
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[c] Rush Presbyterian St. Luke's Medical Centre, 1653, West Congress Parkway, Chicago, IL 60612, United States

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Singla A.K.; Univ. Inst. of Pharmaceutical Sci., Panjab University, Chandigarh 160014, India; email: anilksingla@rediffmail.com

Document Type: Review
Source: Scopus

8. Grover, J.K., Yadav, S.P.
Pharmacological actions and potential uses of Momordica charantia: A review
(2004) *Journal of Ethnopharmacology*, 93 (1), pp. 123-132. Cited 282 times.

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Correspondence Address
Grover J.K.; Department of Pharmacology, All India Inst. of Medical Sciences, Ansari Nagar, New Delhi 110049, India; email:jkgrover@hotmail.com

Document Type: Review
Source: Scopus

9. Sudhakar, Y., Kuotsu, K., Bandyopadhyay, A.K.
Buccal bioadhesive drug delivery - A promising option for orally less efficient drugs
(2006) *Journal of Controlled Release*, 114 (1), pp. 15-40. Cited 280 times.

Buccal Adhesive Research Laboratory, Division of Pharmaceutics, Department of Pharmaceutical Technology, Kolkata, 700032, India

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Bandyopadhyay A.K.; Buccal Adhesive Research Laboratory, Division of Pharmaceutics, Department of Pharmaceutical Technology, Kolkata, 700032, India; email: akbju@yahoo.com

Document Type: Review
Source: Scopus

10. Thakkar, K.N., Mhatre, S.S., Parikh, R.Y.
Biological synthesis of metallic nanoparticles
(2010) *Nanomedicine: Nanotechnology, Biology, and Medicine*, 6 (2), pp. 257-262. Cited 276 times.

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Document Type: Review
Source: Scopus

were published in 2007-2010 had a more-rapid rise in citation numbers, and needed relatively fewer years to reach their citation peak. If such a trend continues, high percentile articles will certainly reach their citation peaks even faster and need relatively fewer years since their publication (Table 15, Figure 5).

DISCUSSION

This study analyses 76 highly cited papers in clinical pharmacology that India published during the period 2000-14. The study covered only such papers that received at least 100 citations since their publication till August 2015. The publications and citations data for the study was sourced from Scopus database. Citation in research evaluation is viewed as an acknowledgement of intellectual debt and scientific progress. Highly cited papers illustrate high quality science and a useful tool for quality assessment of key (most influential) contributors to science and technology.

USA dominates global leadership in clinical pharmacology with highest 61.41% share, followed by U K, Germany, Italy, and Canada with 6.41% - 17.12% share to the world output of highly cited papers in clinical pharmacology during 2000-14. India ranked 10th highest country with 1.45% share to the world output of highly cited papers, 9th highest with 0.75% share of highly cited papers in the national output, and 7th highest with 3.81% share to the world output of all of publications in clinical pharmacology including highly cited papers.

76 highly cited papers were published across 45 Indian and foreign journals. *Nanomedicine* published the largest number of the highly cited publications (9 papers, 11.84% share), followed by *Journal of Ethnopharmacology* (8 publications, 10.53% share), *International Journal of Pharmaceutics, Biorganic & Medicinal Chemistry, Pharmcological Research, Medicinal Research Review and Drug Discovery Today* (3 publications. 3.95% share each), *Journal of Antimicrobial & Chemotherapy, Phytotherapy Research , Phyomedicine, Life Sciences, Toxicology and Advanced Drug Delivery Reviews* (2 publications, 2.63% share each), etc.

Citation impact of 76 highly cited papers averaged to 184.99 citations per paper. But citation impact of annual output of highly cited papers spreads across a wide spectrum ranging between 130.5 in 2000 and 189 citations per paper in 2012, with a high of 346 in 2002 and low of 129.5 citations per paper in 2008.

Surge in the citation density score over time up from 9.03 CPP/PCY in the year 2000 to 63.0 CPP/PCY in 2012 illustrates how fast the research in clinical pharmacology in India has been growing in quality and impact. However corresponding growth in India's output of highly cited

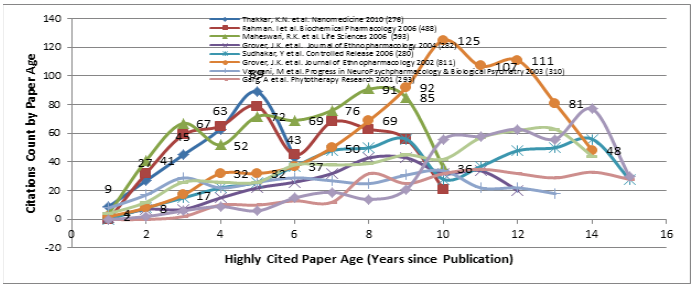

Figure 4: Citation Life Cycle of Top 10 Highly Cited Papers in Clinical Pharmacology by Paper Age, 2000-14

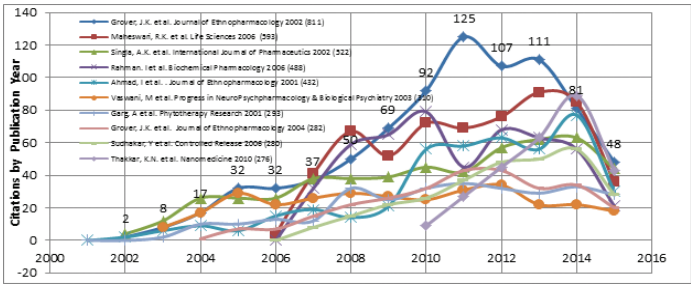

Figure 5: Citation Life Cycle of Top 10 Highly Cited Papers in Clinical Pharmacology by Publication Year: 2000-14

Table 15: Distribution of Citations to Top 10 Most Highly Cited Papers in Clinical Pharmacology, 2000-14

		TC	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
1	Grover, J.K. *et al.* Journal of Ethnopharmacology 2002	811		2	8	17	32	32	37	50	69	92	125	107	111	81	48
2	Maheswari, R.K. *et al.* Life Sciences 2006	593						4	41	67	52	72	69	76	91	85	36
3	Singla, A.K. *et al.* International Journal of Pharmaceutics 2002	522		4	12	26	26	26	38	38	39	45	42	57	62	63	44
4	Rahman. I *et al.* Biochemical Pharmacology 2006	488						0	32	59	65	79	45	68	63	56	21
5	Ahmad, I *et al.* Journal of Ethnopharmacology 2001	432	0	2	6	9	6	15	19	14	21	56	58	63	56	77	30
6	Vaswani, M *et al.* Progress in NeuroPsychpharmacology & Biological Psychiatry 2003	310			8	17	29	22	26	29	27	25	31	34	22	22	18
7	Garg, A *et al.* Phytotherapy Research 2001	293	0	0	2	10	10	13	12	32	25	32	35	32	29	33	28
8	Grover, J.K. *et al.* Journal of Ethnopharmacology 2004	282				1	7	7	15	22	26	32	43	43	32	34	20
9	Sudhakar, Y *et al.* Controlled Release 2006	280						0	8	15	22	26	37	48	50	56	28
10	Thakkar, K.N. *et al.* Nanomedicine 2010	276										9	27	45	63	89	43

papers in clinical pharmacology is still missing. It remained range bound between 2 to 11 papers per year.

Citation life cycle of highly cited papers exhibit two trends: i) papers that reach their citation peak early within 5 years of their publication. For example, papers published during 2007-2010 saw a more-rapid rise in citation numbers, and needed relatively fewer years to reach their citation peak, ii) papers that exhibit delayed recognition, delayed citation peak, reaching their citation peak in 8 -10 years since their publication. Thereafter they decline in citation numbers and follow a descending path. If such a trend continues, high percentile papers will certainly reach their citation peaks even faster than expected and would relatively need fewer years to their citation peak.

Authorship to 76 highly cited papers varied widely from 1 to 32 authors per paper with an average of 3.95 authors per paper. Most of highly cited papers were either joint author or multi author papers in clinical pharmacology. Sole authorship highly cited papers were fewer. The multiple-authorship in highly cited papers signals a trend towards team based/ multi-institutional collaborative research and an effective approach to produce high quality research in clinical pharmacology.

Amongst 303 authors to 76 highly cited papers, thirty three (10.89%) made contributions as first authors, thirty three (10.89%) made contributions as corresponding authors, and sixty three (20.79%) contributed both as first author and corresponding author. Of the 222 Indian authors to highly cited papers, 73 were affiliated to universities, 54 authors to research institutions, 28 to institutes of national importance, 20 to pharmaceutical colleges, 8 to industrial enterprises, and one each to college, hospital and state government department respectively. The leading authors of highly cited papers in clinical pharmacology include J.K. Grover of AIIMS-New Delhi, S.P. Yadav of AIIMS-New Delhi, S.Ghosal of IMS-BHU-Varanasi, A.Bhattacharya of IMS-BHU-Varanasi and S.Khanna of NIMANS-Bangalore, S.K. Bhattacharya of IMS-BHU-Varanasi, A.K. Singla of Panjab University, Chandigarh, S.Praveen of ILS-Bhubaneswar, S.K.Sahoo of ILS-Bhubaneswar), A.Garg of Panjab University, Chandigarh, A.Bhattacharya of Drug R & D Center, Kolkata and S. Garg of NIPER-Mohali.

Research institutions dominated the publications output of highly cited papers in clinical pharmacology with largest share (36.84%, 28 papers), followed by universities (30.26% share, 23 papers), institutes of national importance and medical colleges (15.79% share, 12 papers each), pharmaceutical colleges and industrial enterprises (7.89% share, 6 papers each), engineering colleges (2.63% share, 2 papers), college, hospital and state government department (1.32% share, 1 paper each) during 2000-14. The leading organizations from India in clinical pharmacology research include National Institute of Pharmaceutical Education &Research,

Mohali, Aligarh Muslim University, Annamalai University and Institute of Life Sciences, Bhubaneswa (MCI = 1 each), followed by Banaras Hindu University, Varanasi and Drug Research & Development Center, Kolkata (MCI=0.75 each), Jadavpur University, Kolkata (MCI=0.67), Sathyabama University , Guru Jambeshwar University, Hisar and Post Graduate Institute of Medical Education & Research, Chandigarh (MCI=0.50 each) and Panjab University, Chandigarh (MCI=0.40).

International collaboration is an indispensable requirement to produce highly cited papers. This study observes that internationally collaborated papers averaged higher citation rate per paper (204.1) relative to nationally collaborated papers (140.1). Among 76 highly cited papers, 18 resulted from international collaboration across 22 countries. United States participated in the largest number of publications (10), followed by Germany and U.K. (3 publications each), Japan, Russia Federation, Belgium and Canada (2 publications each), Italy, Saudi Arabia, Australia, Taiwan, China, Argentina, New Zealand, Croatia, Belarus, Bulgaria, Slovakia, South Korea, Denmark, Sri Lanka and Trinidad &Tobago (1 publication each).

CONCLUSION

The output of highly cited papers by Indian authors in clinical pharmacology is still not significant quantitatively given the fact that as many as 208 authors contributed only one paper each once in 15 years, 11 contributed two papers each once in 15 years, and 1 contributed three papers once in 15 years. There is very little evidence of growth in the output of highly cited papers in India over time. It remained range bound between 2 to 11 papers per year. India ranked 10th highest country with 1.45% share to the world output of highly cited papers compared to USA with 61.41% share. The qualitative performance of India in clinical pharmacology has been significant. Surge in citation density score over time up from 9.03 CPP/PCY in the year 2000 to 63.0 CPP/PCY in 2012 illustrates how fast the research in clinical pharmacology in India has been growing in quality and impact. Much of this is to be attributed to team based/ multi-institutional collaborative research and an effective approach to produce high quality research in clinical pharmacology. High quality research in clinical pharmacology in India is still confined to select few top-end organizations/institutions belonging to research sector and higher education sector in the country. The slow growth in high quality papers in clinical pharmacology is indicative of dearth of high profile, productive scientists or of productive scientific institutions in the country. The challenge before the top science leadership in country is how to bridge capacity and high capability gap in clinical pharmacology research.

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CONFLICT OF INTEREST

None

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