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INDIAN RESEARCH OUTPUT IN IMMUNOLOGY AND MICROBIOLOGY 2012-2016: A SCIENTOMETRIC STUDY

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INDIAN RESEARCH OUTPUT IN IMMUNOLOGY AND MICROBIOLOGY 2012-2016: A SCIENTOMETRIC STUDY

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Abstract:

Background: The study examines India's research productivity in immunology and microbiology during 2012-2016, depending on various parameters, including India's annual average research growth rate, institutional output profile of institutions and profiles of some of the most productive authors.

Aim: The focus of this study is to analyze performance of India's research output in immunology and microbiology, the quality and productivity of major institutions participating in research in microbiology and immunology and the productivity and quality of leading authors in research in immunology and microbiology.

Methods: The study in the area of immunology and microbiology using 5 years publications data from 2012-2016 in Scopus database.

Result: India has published 8181 papers in Immunology and Microbiology during 2012-2016. The highest productive author of India is A. Chowdhary, with 39 contributions. The highly productive Institutes are Postgraduate Institute of Medical Education and Research, AIMS, Banaras Hindu University, Indian Veterinary Research Institute, etc.

Conclusion: The findings of studies like this help in assessing the characteristics of scientific outputs that should be a major issue not only for scientists or researchers themselves but also for higher level of administration, for heads of university or research institutes, and moreover for research funding agencies.

Keywords: Research output, Bibliometrics, Scientometrics, Author productivity, Scopus Microbiology, Immunology

1. Introduction:

The primary objective of any library and documentation centre is to satisfy the information needs of users within their limited resources. Librarians usually adopt various acceptable techniques or tools for judicious selection of resources. Twentieth century can be described as the era of the development and growth of metric sciences. Bibliometrics, scientometrics, technometrics, librametrics, sociometrics, econometrics, cybermetrics or webometrics or informatics, all are used synonymously (Sen 2004; Ming, 2000). "Statistical Bibliography" was the name previously given to the emerging field of quantitative analysis of bibliographies, which was later, replaced in 1969 by the term "bibliometrics" coined by Pritchard. For some years both "bibliometry" and "bibliometrics" were in fashion throughout the academia. Scientometrics focuses on research in the sciences, social sciences, and the humanities among several other academic fields (Mingersa and Leydesdorff, 2015). It is considered as the study of the quantitative aspects of science and technology. Measurement of research quality and its impact, comprehension of the processes of citations, mapping scientific fields and the usage of indicators in research policy and management all come under the umbrella of scientometrics.

2. Review of Literature

Many remarkable attempts have been made to quantifying scientific output. The main purpose of quantitatively evaluation of scientific output is to complement thorough reviews by experts. Scientific Output quantification has the potential to influence the efficiency of scientific research. Traditionally scientific output was assessed using peer review in the form of assessment from a handful of experts. But the main limitation of this process is the subjective nature of peer. With the advancement in current technologies, information sciences and the wide wealth of data on authors, publications and citations, scientific output quantification of individuals, Institutions and Countries is attainable.

Alejo-Machado et al. "presented a bibliometric study of scientific output on

learning to rank (L2R) between 2000 and 2013. This is relatively new area of research, which has emerged during the last 10 years within the field of artificial intelligence and information retrieval. For this study to be successful, every relevant bibliographic L2R record retrieved from the Scopus database was considered" (Alejo-Machado, Fernández-Luna & Huete, 2014).

Cavacini, Antonio "for the period 1996–2014 compared the scientific output of 16 Middle Eastern countries to 27 West European countries and to the average world production. Israel was the leading nation during1996–2014 in terms of the total number of citations and of total citations per document. In terms of scientific documents produced Turkey and Iran were in the lead. The findings showed no common trend could be found among Middle Eastern counties in the assessment of their scientific production" (Cavacini, 2016).

Dragos, Cristian Mihai et al. highlight "financing of education and research, population size, the number of scholarly journals and English as the official language as the main driving forces of scientific output in economics and business. Multiple OLS regressions and data provided by Web of Knowledge and the World Bank were used in this study. The study covering 56 nations also explored the relationship between scientific output and the efficient use of research funding" (Dragos, Dinu, Pop & Dabija, 2014).

Ebadi, Ashkan and Andrea Schiffauerova analyzed "researchers' scientific production and several influencing and boosting factors on it. Time related statistical models for the period of 1996 to 2010 confirmed a positive impact of funding on the quantity and quality of the publications. A positive relation between the career age and the rate of publications is also observed but on the contrary a negative relation between the career age and the quality of works is observed" (Ebadi & Schiffauerova, 2016).

Girap, Priya et al. analyzed "the publications of Technical Physics and Prototype Engineering Division at Bhabha Atomic Research Centre. A total of 704 research papers were published during the period 1986-2006 in various domains. The

highest number of publications (80) was in the year 2006 with an average number of 33.52 publications per year. S.K. Gupta with 215 publications, G.P. Kothiyal with 171 publications and S.C. Sabharwal with 151 publications were among most prolific authors. *Physica C* (37), *Journal of Crystal Growth* (30), *Physical Review B* (28), *Pramana* (16), and *Bulletin of Indian Vacuum Society* (12) are few of the preferred journals for publishing. Collaboration trend was multi-authored publications with more than 94 per cent multi-authored publications" (Girap, Surwase, Sagar & Kademani, 2009).

Gupta, B.M. and Adarsh Bala "analyzed the research output of India during 2002–11 in the field of schizophrenia research with variety of parameters including the growth, citation impact, rank and global publications share, percentage of international collaborative papers, contribution by collaborative partner countries, contribution to various subject-fields, characteristics of most productive institutions and authors, and of high cited papers. Scopus had been used to gather the data for 10 years by searching the keywords schizophrenia research in the combined Title, Abstract and Keywords fields. India ranked at 15th position (with 882 papers) in schizophrenia research during 2002–11 with 1.58% global publication share and an annual average publication growth rate of 21.80%. Citation impact per paper of India was 3.60 and during 2002–11 international collaborative publications share was 26.98%" (Gupta & Bala, 2013).

Gök, Abdullah, John Rigby, and Philip Shapira investigated the relationships between the citation impacts of scientific papers and the sources of funding acknowledged as having supported those publications in the paper by studing six Smaller European Countries for the Impact Of Research Funding On Scientific Outputs. "The study examined several relationships associated with impact of funding and first citation, total citations, and the chances of becoming highly cited. The links between citations and types of funding by organization and also with combined measures of funding were explored. The relationship between funding intensity and funding variety and citation were examined particularly. Authors found that funding is not related to the first citation in the study but is

significantly related to the number of citations and top percentile citation impact" (Gök, Rigby & Shapira, 2015).

Igoumenou, Artemis et al were determined that research should be evaluated by measuring of research productivity and then funding decisions must be made while understanding the geographic Trends Of Scientific Output And Citation Practices. "They examined characteristics of citation practices in articles published in 50 Web of Science indexed in the field of Psychiatry and relevant clinical neurosciences journals. The study between January 2004 and December 2009 comprised 51,072 records that produced 375,962 citations. Relation between citation patterns including self-citations and countries was examined. Most publications came from the USA, with Germany being in second position and UK third in productivity. Harvard University within USA published most articles" (Igoumenou, Ebmeier, Roberts & Fazel, 2014).

Lewison, Grant et al examined the scientific outputs of Malaysia and its ethnic group from 1982 to 2014 and the effects Of The New Economic Policy. Malaysia ethnic communities were divided into three groups Chinese, Indians and Malays. "There was a major increase in Malay participation in research, which had risen from 20 % of researchers in 1982–1984 to 65 % in 2012–2014, corresponding with declines in the percentages of Chinese and Indian authors, although their absolute numbers increased because Malaysian scientific output has increased so rapidly in the last 10 years" (Lewison, Kumar, Wong, Roe & Webber, 2016).

Salimi, Negin assessed "the quality of scientific outputs using the BWM through an extensive literature review aimed to identify first different quality metrics. A multi- criteria methodology (best worst method) was developed and used to find the importance of each quality metric. Based on each quality metric and the data, which are collected from Scopus, the quality of research papers published by the members of a university faculty was measured. The proposed model in this paper provides the opportunity to measure quality of research papers also by considering the importance of each quality metric"(Salimi, 2017).

Yi, Fengyun, Pin Yang, and Huifeng Sheng aimed to "analyze the current state of research and trends in studies in Ebola research using Web of Science database to search for data, which encompassed original articles published. The keyword "Ebola" was used to identify articles for the purposes of this study. A total of 2477 publications on Ebola were published between 1977 and 2014 were retrieved from the database. Among countries USA has highest scientific output with huge number of funding agencies. *Journal of Virology* published 239 papers, followed by *Journal of Infectious Diseases* and *Virology*, which published 113 and 99 papers, respectively. A total of 1911 papers on Ebola were cited 61,477 times." (Yi, Yang & Sheng, 2016).

3. Objective

The main objective of the study is to examine, using scientometric tools, the total contribution in the field of Immunology and Microbiology during the five years period of the study. The specific objectives of the study are: -

i. To estimate the share of Indian research output globally in terms of quality and quantity;
ii. To study the growth of Indian output in terms of quality and quantity;
iii. To study the contribution of leading Indian academic Institutes in the subject area under study;
iv. To identify and analyze the contribution of most efficient Indian Researchers through their output.

4. Scope

Microbiology has many areas of specialization. It is a science based on the study and effects of microorganisms. Many techniques that were developed by microbiologists are used in molecular and cell biology to provide the foundation for studying higher organisms. Immunology is study of immune system including its structure and functional disorders of the immune system, blood, immunization, and transplantation. A number of universities and colleges are

offering courses at graduation and masters' level in microbiology as well as facilities for doctoral research. Besides universities and colleges, a number of research institutes are engaged in R&D work in this field. Few medical colleges and universities also teach Immunology as a subject as part of their medical degree courses. A number of research institutes, which are part of CSIR, ICMR, DBT, and DST also focus their R&D work in this area (Kaur and Gupta 2009).

5. Methodology

The study uses Scopus database to extract all the relevant data on Immunology and Microbiology research in India for the five years period (2012-16). Scopus reflects the largest abstract and citation database of peer-reviewed literature, scientific journals, conference proceedings and books. Scopus has a comprehensive overview of the world's research in the various fields of science, technology, medicine, social sciences, and arts and humanities. It contains more than 22,600 titles from more than 5,000 international publishers with smart tools to track, analyze and visualize research

6. Data Analysis and Interpretation

India published 8181 research papers during the period 2012-2016 in Immunology & Microbiology, with the maximum output in the year 2014 with 2336 papers. The year 2015 with 2291 papers was close second. There is an increase in the contribution from 2012 to 2014, after that there is decline in the contribution by a very small percentage of 0.55%. There is a drastic decline observed in the contribution when we compare year 2015 to year 2016; the contribution is decreased by more than 50 percent.

Year	No of papers	%
2016	1140	13.93
2015	2291	28.00
2014	2336	28.55
2013	1215	14.85

2012	1199	14.66
Total	**8181**	**100**

Table 1: Indian contribution in Immunology & Microbiology (2012-2016).

6.1. Document Profile

The Table 2 shows the types of documents contributed by the authors. It is clearly visible that authors have touched all the horizons of research such as Article, Review, Letter, Note, Conference paper, Editorial, Book chapter, Short Survey, Book, Erratum, Article in press with the frequency of 6995, 577, 271, 121, 55, 41, 29, 19, 17 and 5 respectively.

Document Type	**Frequency**	**Percentage**
Article	6995	85.50
Review	577	7.05
Letter	271	3.31
Note	121	1.48
Conference Paper	55	0.67
Editorial	51	0.62
Book Chapter	41	0.50
Short Survey	29	0.35
Book	19	0.23
Erratum	17	0.21
Article in Press	5	0.06
Total	**8181**	**100%**

Table 2: Types of Documents Contributed in Immunology & Microbiology (2012-2016).

6.2. Authors Profile

Based on the publication output data by Indians in Immunology & Microbiology, authors having 15 or more than 15 contributions were selected. The author A. Chowdhary with 39 contributions was identified as highest productive author of the study. The second position is shared by A, Chakrabarti and J.F. Meis, with 37 contributions each. R. Lal is at third position with 33 contributions. The two authors C.V. Ramana and C. Sasikala, with 31 contributions each, again share the fourth position. T. Ramamurthy and Y.S. Shouche are at fifth position with 29 contributions each.

Author Name	**Contribution**
Chowdhary, A.	39
Chakrabarti, A.	37
Lal, R.	33
Ramana, C.V.	31
Sasikala, C.	31
Ramamurthy, T.	29
Shouche, Y.S.	29
Arockiaraj, J.	28
Sharma, S.	27
Sundar, S.	27
Babu, S.	26
Joshi, C.G.	21
Singh, S.	21
Batra, H.V.	20
Dhama, K.	19
Rodrigues, C.	19
Rudramurthy, S.M.	19
Das, P.	18

Kang, G.	18

Table 3: Productive authors of India in Immunology & Microbiology (2012-2016)

Further deep analysis of top 15 high productive authors with 20 and more than 20 papers is also done. The year wise contribution along with their affiliation is presented in Table 4. There is a continuous increase in research papers from Chowdhary A from Vallabhbhai Patel Chest Institute, University of Delhi, Delhi and Chakrabarti, A. from Postgraduate Institute of Medical Education and Research, Chandigarh till 2015. The overall trend is that till year 2014 and 2015 there is an increase in articles and in year 2016 there is a rapid decrement. The trends for few authors are shown from Figure 1 to Figure 14.

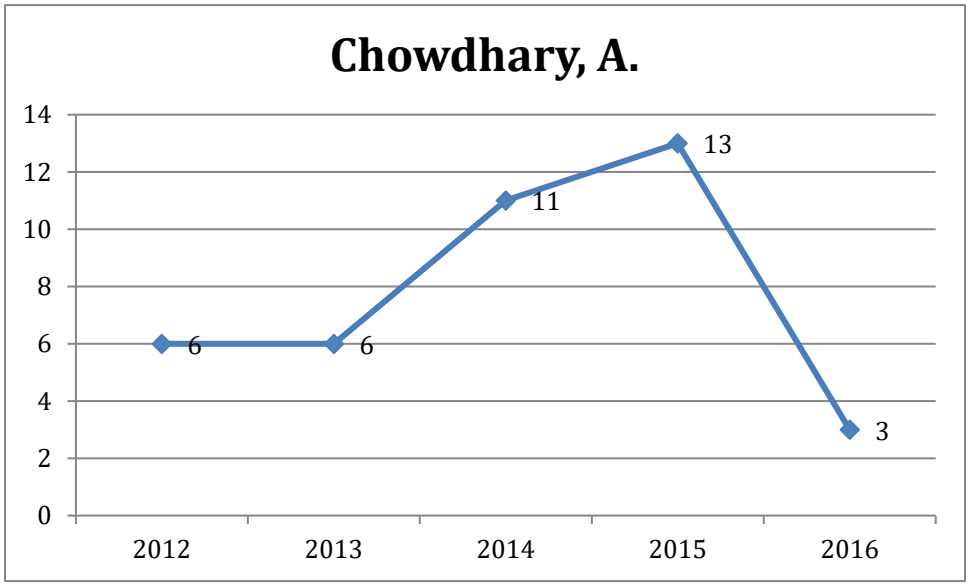

Figure 1. Contribution & its Trend (A.Chowdhary).

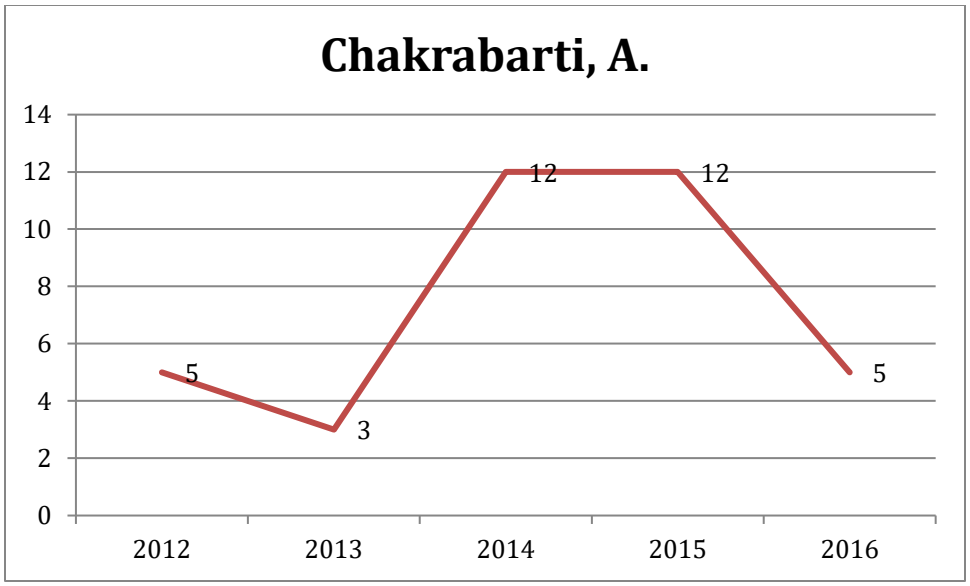

Figure 2. Contribution & its Trend (A.Chakrabarti)

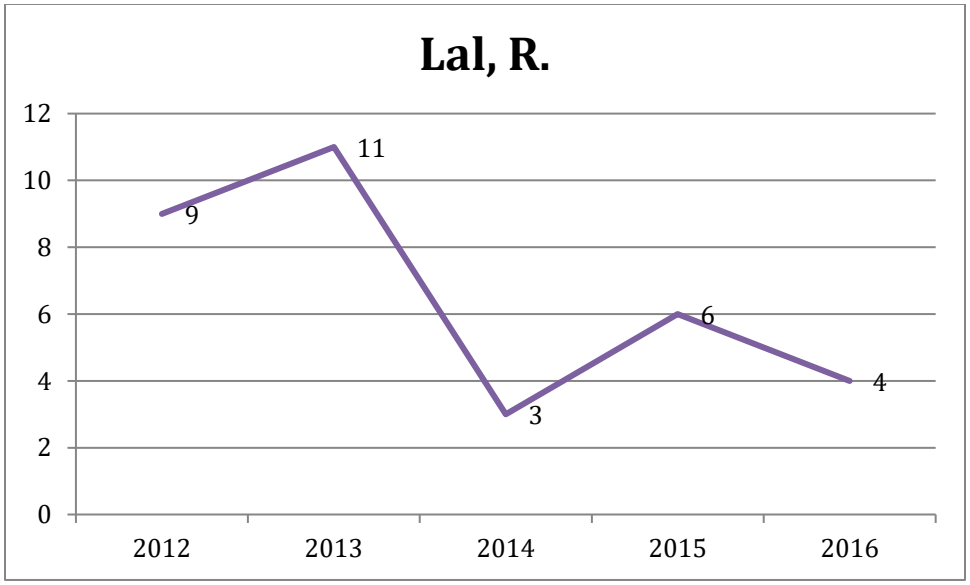

Figure 3. Contribution & its Trend (R,Lal).

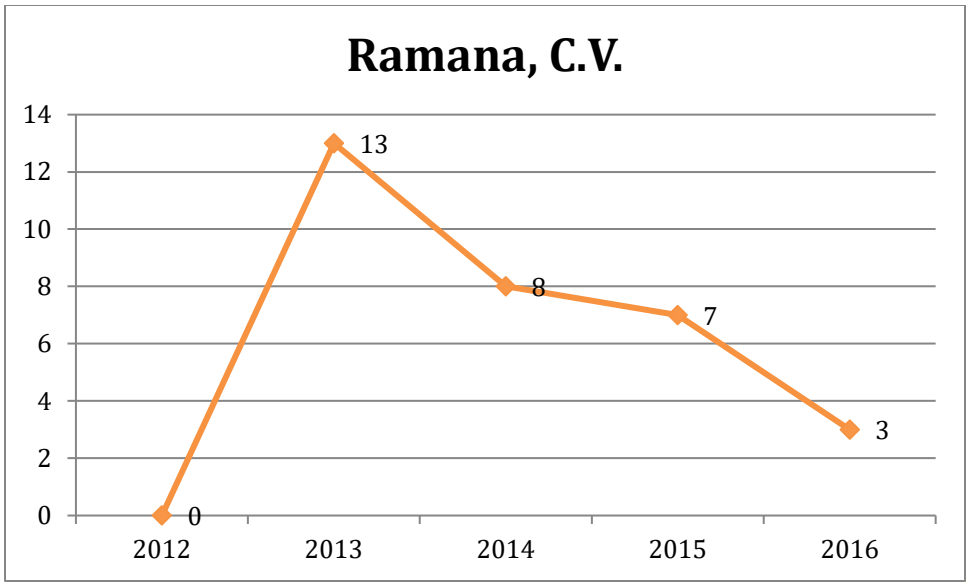

Figure 4. Contribution & its Trend (C.V. Ramana)

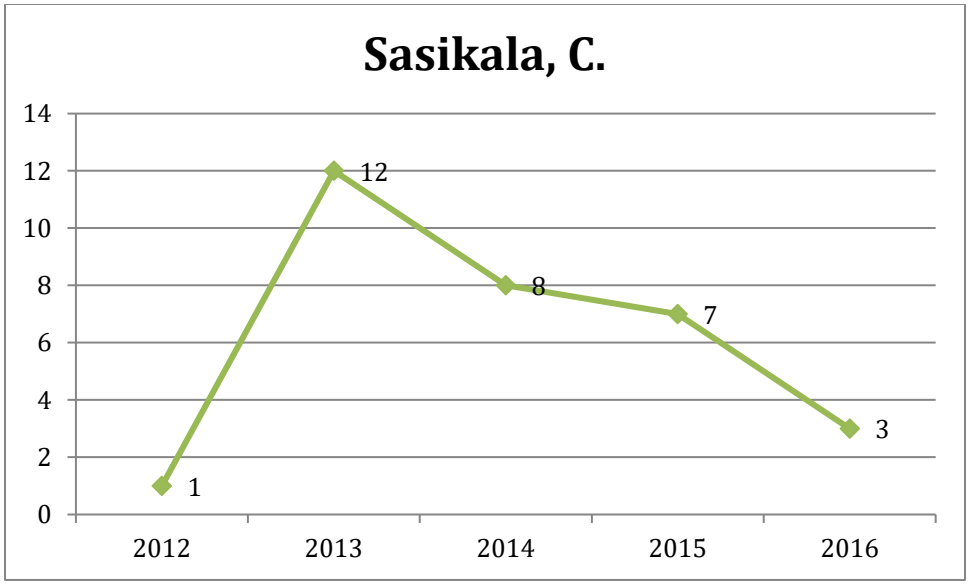

Figure 5. Contribution & its Trend (C, Sasikala)

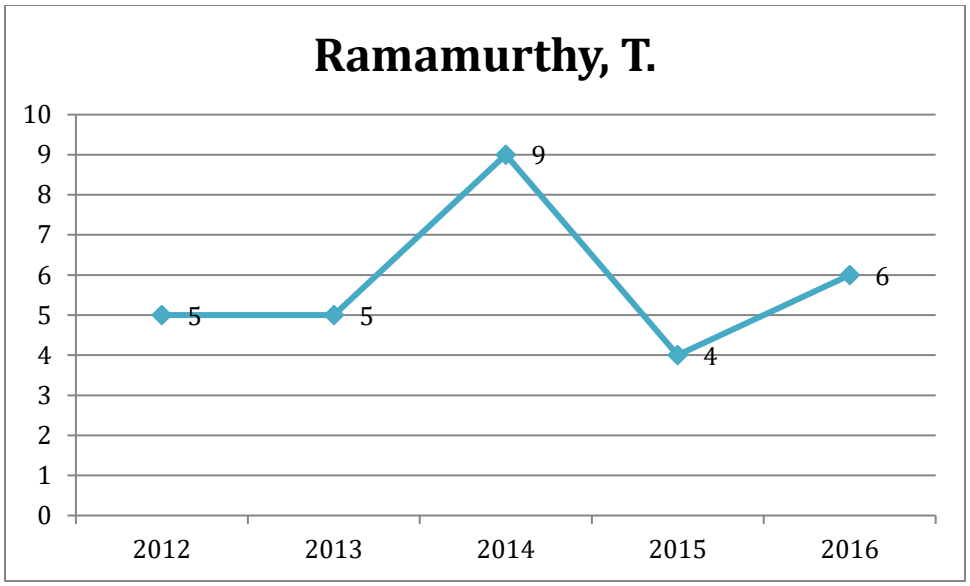

Figure 6. Contribution & its Trend (T. Ramamurthy)

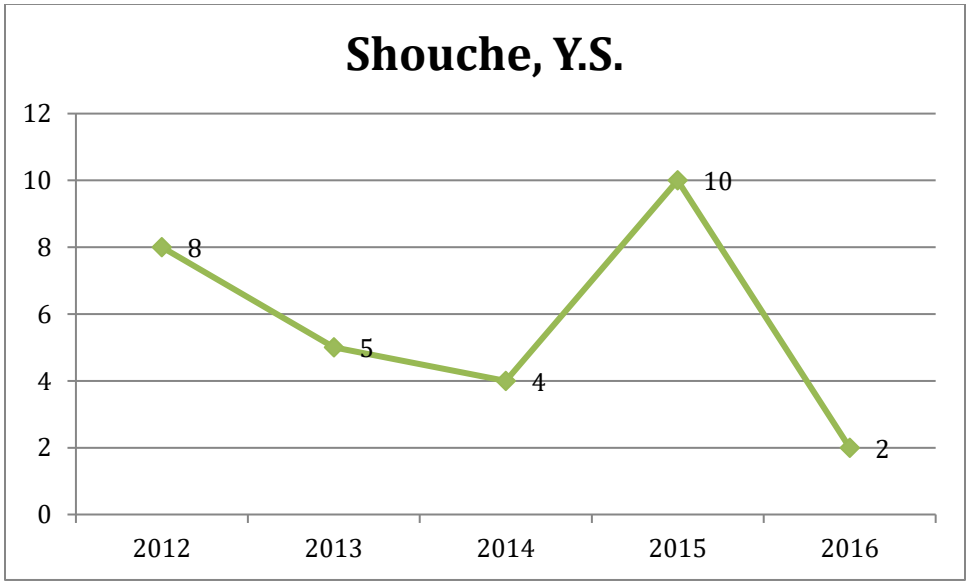

Figure 7. Contribution & its Trend (T.S. Shouche)

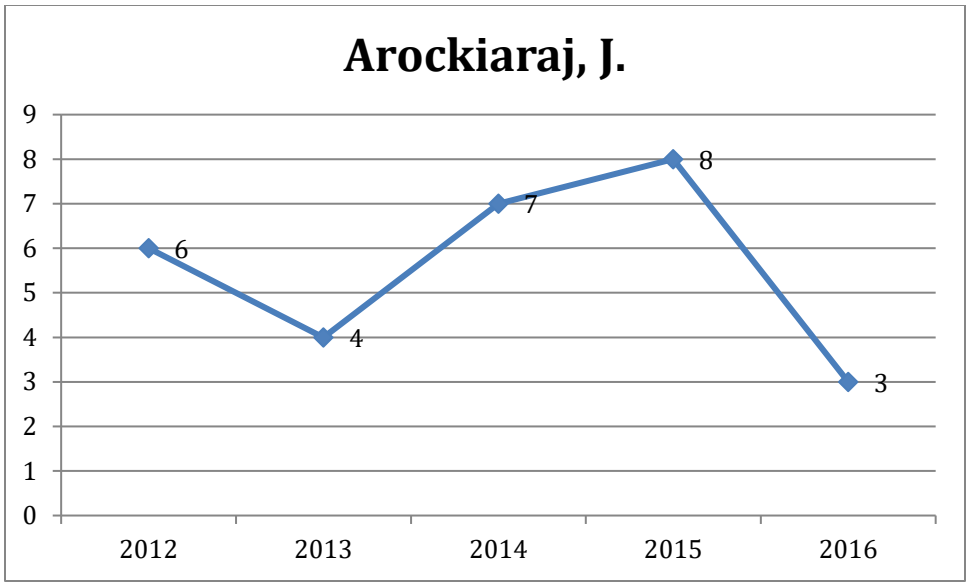

Figure 8. Contribution & its Trend (J. Arockraraj)

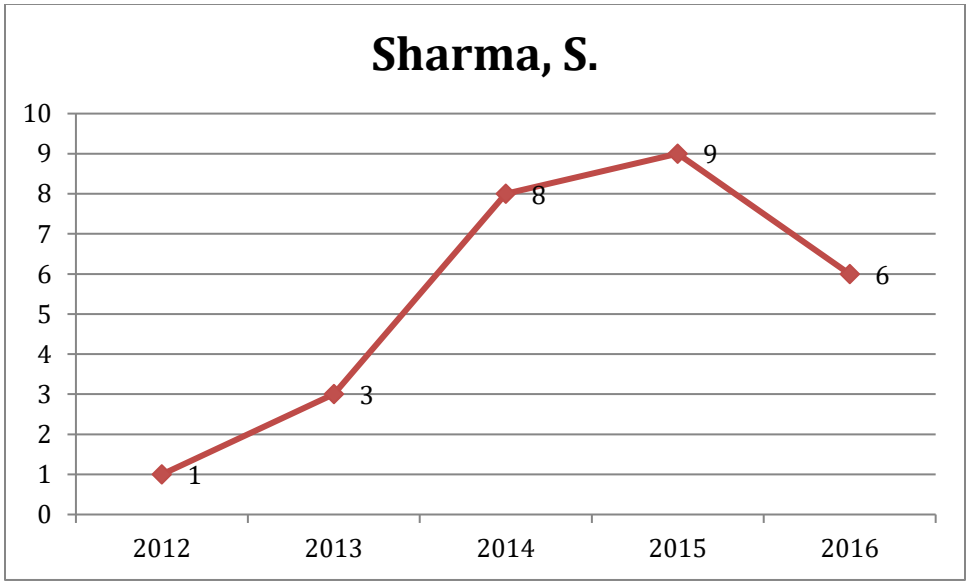

Figure 9. Contribution & its Trend (S. Sharma)

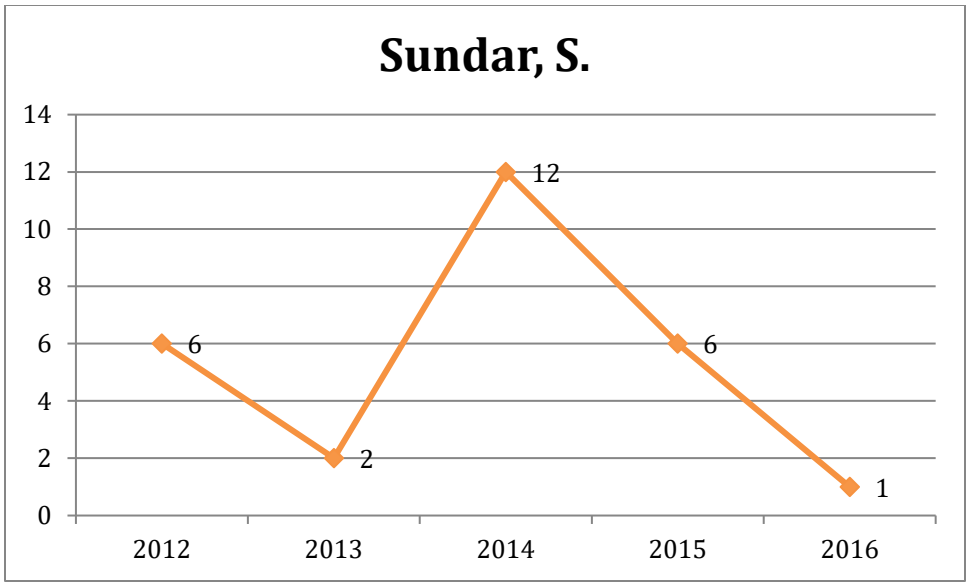

Figure 10. Contribution & its Trend (S. Sundar)

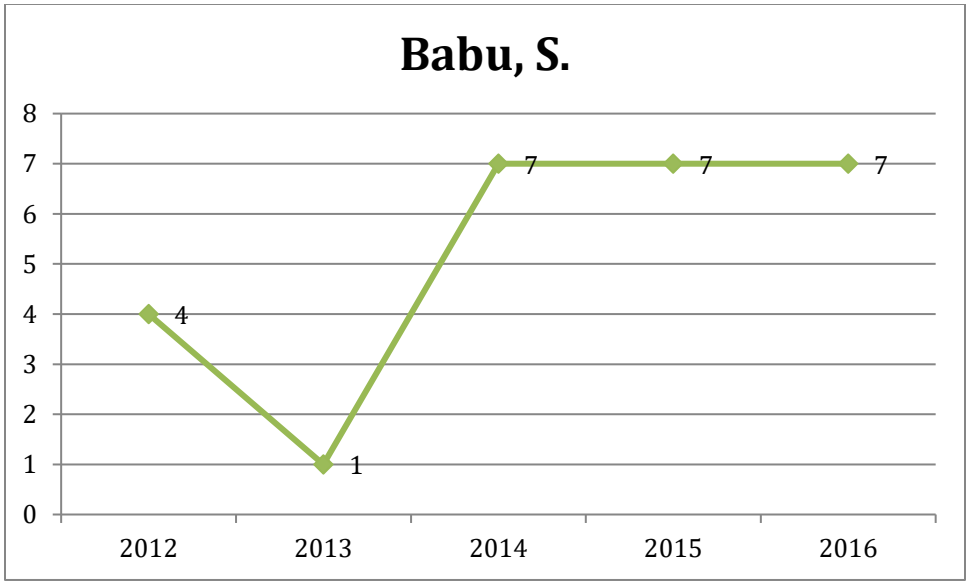

Figure 11. Contribution & its Trend (S. Babu)

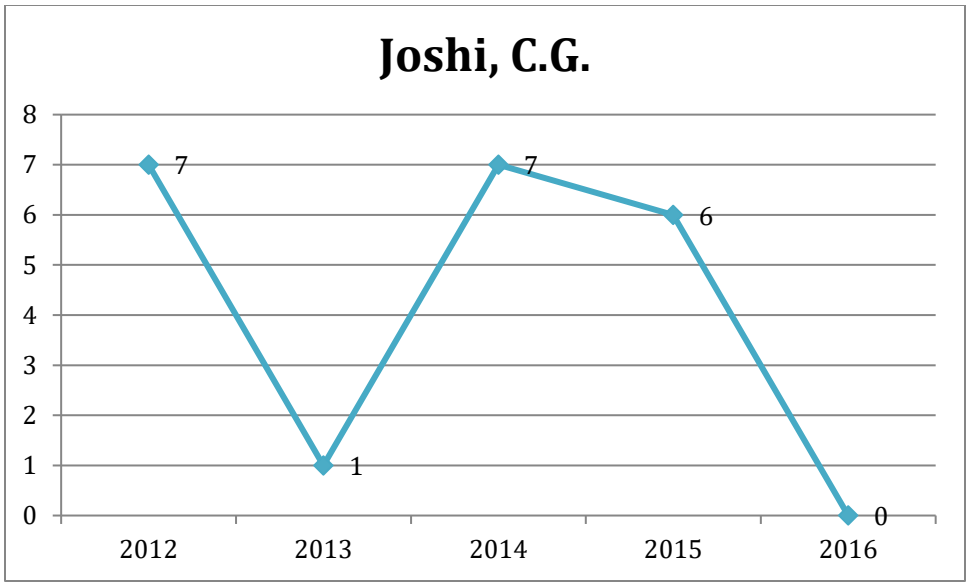

Figure 12. Contribution & its Trend (C.G. Joshi)

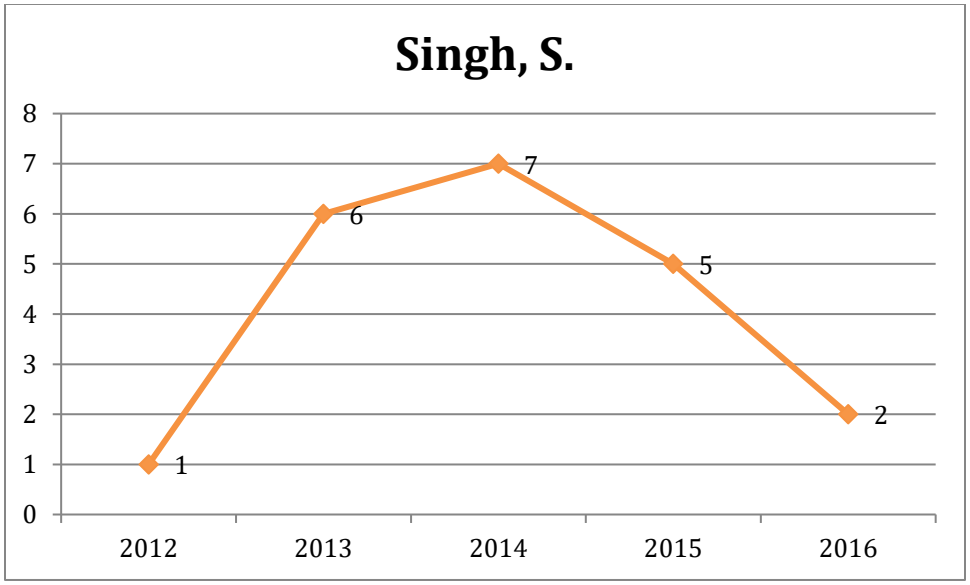

Figure 13. Contribution & its Trend (S. Singh)

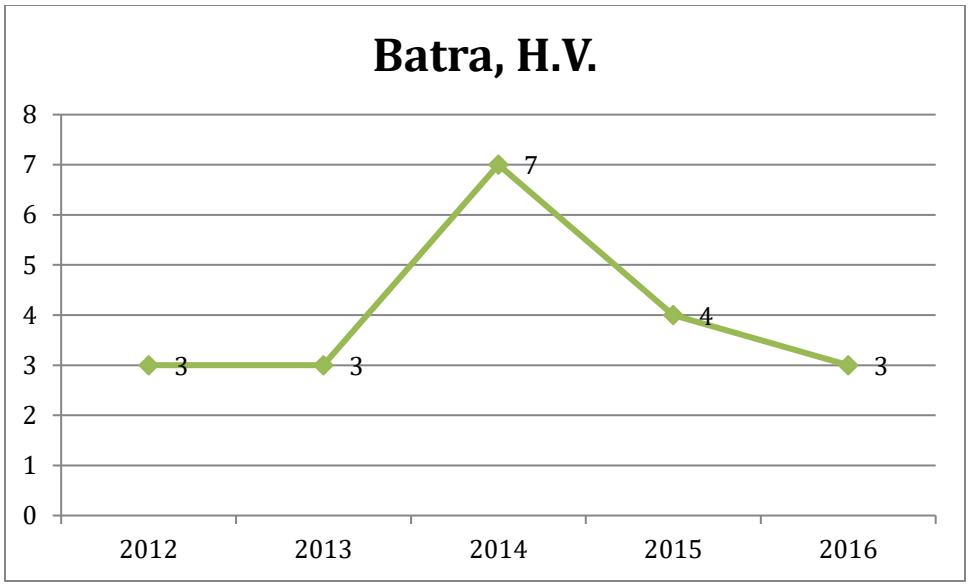

Figure 14. Contribution & its Trend (H.V. Batra)

Authors	**TC**	**Affiliation**	**2012**	**2013**	**2014**	**2015**	**2016**
Chowdhary, A.	39	Vallabhbhai Patel Chest Institute, University of Delhi, Delhi	6	6	11	13	3
Chakrabarti, A.	37	Postgraduate Institute of Medical Education and Research, Chandigarh	5	3	12	12	5
Meis, J.F.	37	Radboud University Nijmegen, Netherlands	6	6	11	10	4
Lal, R.	33	University of Delhi, Delhi	9	11	3	6	4
Ramana, C.V.	31	University of Hyderabad, Hyderabad	0	13	8	7	3
Sasikala, C.	31	JNT University Hyderabad, Hyderbad	1	12	8	7	3
Ramamurthy, T.	29	National Institute of Cholera and Enteric Diseases, Kolkata,	5	5	9	4	6
Shouche, Y.S.	29	National Centre for Cell Science, Maharashtra,	8	5	4	10	2
Arockiaraj, J.	28	SRM University, Chennai,	6	4	7	8	3
Sharma, S.	27	L.V. Prasad Eye Institute, Patia, Bhubaneswar, Odisha	1	3	8	9	6

Sundar, S.	27	Banaras Hindu University, Varanasi	6	2	12	6	1
Babu, S.	26	National Institutes of Health, Chennai	4	1	7	7	7
Joshi, C.G.	21	Anand Agricultural University	7	1	7	6	0
Singh, S.	21	All India Institute of Medical Sciences, New Delhi	1	6	7	5	2
Batra, H.V.	20	Defence Food Research Laboratory, Karnataka	3	3	7	4	3
	436		**68**	**81**	**121**	**114**	**52**

TC: Total Contribution

Table 4: Distribution of Contributions by top 15 authors and their affiliation.

6.3. Institutional Profile

Table 5 below covers highly productive Indian institutes and affiliations of authors with contributions more than 17 papers that contribute in the field of Immunology & Microbiology. The top 5 institutes are Postgraduate Institute of Medical Education and Research, All India Institute of Medical Sciences, Banaras Hindu University, Indian Veterinary Research Institute, Institute of Microbial Technology India, Indian Institute of Science with 257, 253, 138, 136 and 121 contributions respectively. It is clearly visible that Immunology & Microbiology are among the hot topics presently and it reflects from the list of institutes, universities mentioned below.

Name of the Institute	**Papers**
Postgraduate Institute of Medical Education and Research	257
All India Institute of Medical Sciences	253
Banaras Hindu University	138
Indian Veterinary Research Institute	136
Institute of Microbial Technology India	121
Indian Institute of Science	121

University of Delhi	113
University of Hyderabad	110
University of Calcutta	108
Central Drug Research Institute India	97
Vellore Institute of Technology	94
Christian Medical College, Vellore	92
National Institute of Cholera and Enteric Diseases India	89
Indian Agricultural Research Institute	85
Jawaharlal Nehru University	79
Indian Council of Agricultural Research	78
Panjab University	75
Sanjay Gandhi Postgraduate Institute of Medical Sciences Lucknow	74
Indian Institute of Technology, Kharagpur	73
National Centre for Cell Science India	71
L.V. Prasad Eye Institute India	71
Banaras Hindu University Institute of Medical Sciences	70
Anna University	68
Indian Council of Medical Research	67
Bharathidasan University	67
Indian Institute of Technology Delhi	66
Institute of Genomics and Integrative Biology India	65
Indian Institute of Chemical Biology	65
National Dairy Research Institute India	61
Central Food Technological Research Institute India	59
Bose Institute	59
SRM University	59
National Institute of Immunology India	57
Bhabha Atomic Research Centre	57
Chhatrapati Shahuji Maharaj Medical University	55
Aligarh Muslim University	55

Table 5: Productive Institutes of India in Microbiology & Immunology (2012-2016).

6.4. Findings

On deep analysis of the interpreted data the following important conclusions were drawn:

1. India has published 8181 papers in Immunology and Microbiology during 2012-2016. Thus, it can be concluded that research on immunology and microbiology is quite popular in India.
2. The maximum publications were in 2014 i.e. 2336 papers and the minimum in 2016 i.e. 1140 papers.
3. The highest productive author of India in Immunology and Microbiology (2012-2016) is A. Chowdhary, with 39 contributions.
4. There is a steady increase in the annual research output from 2012 to 2014 in the field understudy.
5. A drastic decline is observed in the Indian contribution when we compare the year 2015 numbers with the year 2016's; the contribution is decreased by more than 50 percent.
6. The majority of the contributions is in the form of Article (6995 papers) and followed by Review (577 papers).
7. The top five highly productive Institutes are Postgraduate Institute of Medical Education and Research, All India Institute of Medical Sciences, Banaras Hindu University, Indian Veterinary Research Institute, Institute of Microbial Technology India and Indian Institute of Science.

7. Conclusion

The findings of studies like this help in assessing the characteristics of scientific outputs that should be a major issue not only for scientists or researchers themselves but also for higher level of administration, for heads of university or research institutes, and moreover for research funding agencies.

With the increase in research and number of papers published, assessing quality of scientific outputs has become difficult. Even excellent quality proposals cannot always guarantee funding or tenure which creates a competitive situation. Several vital decisions such as decisions on employments, promotions or granting of scientific awards in universities and research centers depend on the assessment of quality of scientific outputs of researchers. India has great potential in giving and sustaining the quality publications in Immunology and Microbiology. The country needs to upgrade its research capacity, competence and knowledge base to help in bridging the downfall in publications.

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