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Profiles of Indian Authors Among the Top 100,000 Scientists Worldwide on Standardized Citation Metrics

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ABSTRACT

A publicly available database of 100,000 scientists was compiled by Ioannidis et al. (2019a), which provides standardized author citation metrics based on their SCOPUS records. The scientists were classified into 22 scientific fields and 176 subfields, and career-long data were updated by the end of 2018. Among the top 105,000 authors, 644 Indian authors were identified (0.006%). In this study, the profiles of those 644 Indian authors were explored in citation metrics, functional field and affiliation. The overall quality of Indian authors was lower than the global average based on citation metrics. The majority of the 644 Indian authors were affiliated with Institutions of National Importance or Government research bodies. Also, there was high representation of authors from only three scientific fields; Physics, Chemistry and Clinical Medicine. The paper highlighted few key existent trends in the Indian academic space, and also identified areas of improvement for the future. There remains huge scope for improving the quality of Indian research and publication. Meaningful improvements at all levels of the education sector are essential to achieve quality metrics for the future

Keywords: Bibliometrics, Citation metrics, Top Indian scientists, Publication, Authorship

INTRODUCTION

Bibliometrics is a multidimensional scientific field originally rooted in the disciplines of Library Sciences and Information Studies. While Pritchard (1969) originally defined it as ‘the application of mathematical and statistical methods to books and other media of communication’, the modern conceptualization of it is primarily concerned with the statistical analysis or study of written publications, mainly journal articles and books (Zatorski *et al.,* 2017). As a broad concept, bibliometrics also includes research such as scientometrics, infometrics, webometrics, etc., all of which can be best described as efforts at quantifying different quality parameters of formal publications to assess their growth and distribution (Lievrouw, 1989; Welsh, 2017). The most prevalent methods of bibliometric analyses include citation analysis and impact score formulations, both of which hold prominent weight in modern-day research. The quality of any research publication today is dependent on the range of criteria which include extensive quality peer review and citation impact scores of the journals, as well as the impact profiles of the authors and institutions they represent (Bornmann and Hug, 2018). A great deal of effort has been expended in quantifying and ranking the prominence of articles, journals, authors and institutions, which makes the research sphere more competitive and transparent than it has ever been before.

Used widely in universities and research labs across the globe and especially within the disciplines of science, bibliometric research stands to authenticate and quantify research quality and performance. The most commonly used bibliometric metric is the citation analysis, encompassing indices of the number of articles published by an author, the impact of those articles within a field of study (number of citations) and finally the ranking of the journals in which the articles have been published. The main goal behind citation analysis is to determine the degree of impact made by a particular author or an article by chiefly looking at how influential certain articles have been in stemming further research in that field. Consequently, citations to published scholarly works are habitually used as indicators of a scholar's visibility and the quality or impact of their research (Wortman, 2019). Some of the most popular indexing parameters used in bibliometric studies include impact factor, cite score, Eigen factor, h-index, m-index, g-index, h5 index, etc. which are calculated and disseminated by various indexing agencies and research databases (Hussein, 2016).

A conventionally used citation metric is the Impact Factor (IF) developed by Eugene Garfield, 1972. IF in either 2-year or 5-year form is published by Clarivate Analytics and includes only the journals indexed within the Web of Science (WoS) database. The CiteScore is an alternate measure to the impact factor, and it is tabulated and maintained by Elsevier, the publishers of the Scopus list, which remains the world's largest abstract and citation database (Enago Academy, 2018). The Scopus list by Elsevier and Web of Science (WoS) database are the two most distinct indexing bodies worldwide, and both officiate publication metrics, particularly citation scores calculated using the number of articles published over a time period and the mean number of citations received by those papers in the running year, and updated every year. Another popular alternative to the Impact Factor and Cite score is the *h*-index, given by Jorge E. Hirsch in 2005. It is an author-level metric that is calculated based on the total set of the author's cited papers and the median number of citations received by the author for the various publications (Bornmann and Daniel, 2007; Jones, Huggett and Kamalski, 2011). The *hm*-index is closely related to the *h*-index and was introduced to account and control for multiple authorships. It is calculated as the reduced number of papers author/s have been cited for by other authors *h*m or more times, while the other papers have been cited not more than *h*m times (Schreiber, 2008).

India is one of the premier economic powers in the world today with a rapidly growing research and development infrastructure. Historically, India has a rich heritage in academia and Takshashila, the world's first university, was founded by a group of Indian intellectuals (Gurudev, 2007). In mathematics too, the Indian academician Aryabhatta is credited with coming up with the symbol of number Zero (Revell, 2017). Despite such significant historical, cultural and philosophical underpinnings, the visibility of Indian scholars and their research work at present in the global scholarly sphere is rather dismal (Giri and Das, 2011). Indian universities consistently fare poorly in world university rankings as well with no Indian institution ranking among the top 200 (Sinha, 2019). However, there are few prominent Indian academicians who continue to contribute at the global level, either through ground breaking research or publications, or by heading research efforts at top global universities in the fields of technology, engineering and management sciences (Pulakkat, 2019). Although the volume of research output from India has steadily increased through the decades (Giri and Das, 2011; Gunasekaran and Arunachalam, 2011), the numbers are still diminutive compared to the research powerhouses. It remains an issue of national importance eliciting huge investments and policy formulations in recent times.

There have been numerous bibliometric studies conducted on journal articles by Indian authors as well as the impact of journals and publishing houses operating from India (Thanuskodi, 2012). A considerable amount of studies have also looked at the nature of publication of journals in India. The metrics of Indian journals indexed by WoS or Scopus and the Indian authors publishing in Scopus or WoS indexed journals have been studied many times and highlight the best quality research works emerging from the country (Garg *et al.,* 2006; Barik and Jena, 2014). On the other end, publication practices have also been frequently studied, particularly in recent times, with the unprecedented growth of Open Access (OA) and Author pay models (Gunasekaran and Arunachalam, 2011; Madhan *et al.,* 2017) and highlighting the huge growth of predatory and unfair publication methods in India (Seethapathy *et al.,* 2016; Gupta and Dubey, 2019). The field of Library Sciences and Information studies in India is prominent in the various bibliometric research works and maintaining publication and author statistics for India (Garg and Tripathi, 2017).

The Present Study

In this study, the bibliometric profiles of the top Indian authors appearing in the list of top 100,000 authors worldwide published by Ioannidis *et al.* (2019a; 2019b) was analysed to highlight some key dynamics of the quality of research publications happening in India. The original authors had compiled a public database of 100,000 scientists using SCOPUS publication records, for career-long metrics of authors, most importantly their standardized citation information, including *h/hm* indexes, number of publications and citations, authorship positions, self-citations, etc. A total of 644 Indian authors were identified among the top 105,000 worldwide scientists, and this group can be best described as the epitome of India's research output in the last few decades. It would be interesting to compare the performance indices of Indian authors to the world average to get an idea of India's relative standing among the top quality research output. Few key indicators such as scientific fields, number of publications and citations, *h*- index, institutional affiliation, etc. were tabulated for the Indian authors and compared to worldwide figures. The extent and prevalence of self-citations have been an endearing issue in the research sphere, and the two prominent indexing models SCOPUS and WoS have also been vulnerable in being manipulated to skew impact scores (Jaffe, 2011). In the present study, the extent of self-citations by Indian authors was also tabulated and compared with the global average. Among the 644 Indian scientists, specific descriptive was generated pertaining to nature of institutional affiliation, discipline and field of study, etc.

METHODS

The present study is a quantitative exploratory/ descriptive study of profiles of Indian authors appearing in the standardized database created by Ioannidis et al. (2019a). The data used for the study is completely secondary and is accessible online for free from https://data.mendeley. com/datasets/btchxktzyw/ 1. The authors have compiled multiple datasets with two summative datasets of overall publications and citations until 2017 and 2018 respectively[25,26]. They have also compiled data for publications for a single year for both 2017 and 2018. For this current study, the summative dataset until the year 2018 was used, which was calculated using citation data from Scopus for over 22 years (1 January 1996 to 31 December 2018) (https://data.mendeley.com/datasets/btchxktzyw/ 1#file-bade950e-3343-43e7-896b-fb2069ba3481) and it primarily provides a measure of long-term performance for most living, active and high publishing scientists. A total of 105,000 scientists have been divided into 22 scientific fields and 176 sub-fields, and author information has also been provided for affiliation, number of citations and publications, authorship position and various indexing parameters.

From the initial database of 105,000 scientists, the chunk of 644 Indian authors was transferred to a new database and basic descriptive were compiled using MS- Excel for both the datasheets. The initial database was a huge one with more than 40 performance indices for the 100k scientists, and the data was first explored for various possible perspectives to draw inferences. The most significant findings which elucidated key distributions and trends of the Indian researchers were highlighted in the current study. For category-wise tabulations of scale measures, SPSS v 20 was used.

RESULTS

The standardized citation metrics author database consisted of a total of 105,000 scientists or authors from over 50 countries, and it provided information on citations, *h*-index, co authorship-adjusted *hm*-index, etc. from 1995 to 2018. There were a total of 644 Indian authors in the list from a range of various disciplines including natural sciences, social sciences, commerce, medicine, arts and humanities. A brief summary of the citations information of Indian scientists alongside the Rest of the world (excluding India) is given in Table 1.

From Table 1, it can be inferred that the total citation for Indian authors was well below the global average by about 4,000 citations per author. In terms of the breadth of author performance, the *h* index of Indian authors was lower than the world average whereas the *hm*- index was or par with the rest of the authors. One significant observed was the drastic differences in self-citation proportions. The original dataset had been provided with two sets of measures of total citations; one including self-citations and the second excluding it. The number of self-citations was calculated as the difference between the two variables and its proportion to total citations was calculated in terms of percentages. It was seen that Indian authors had 17.27 percent of self-citations compared to 13.04 percent for the other authors. It indicated that Indian authors had significantly higher number of self-citations.

In the second part of the analysis, the data of 644 Indian authors were distributed into various categories based on affiliation, field of study, citation metrics, etc. First, the 644 authors were distinguished according to the nature of their affiliating bodies. India has a very diverse multi-level educational system comprising primarily of central, state and private universities. At present, there are 409 State Universities, 349 Private Universities, 50 Central Universities and 127 Deemed to be Universities in India alongside 39,050 affiliated colleges and 10,011 stand-alone institutions (All India Survey on Higher Education, 2020; University Grants Commission, 2020a). Among them, there are 95 institutions recognized for National Importance by the Ministry of Human Resource Development by either being created by Act of Parliament for specialized education and research, or through receipt of

Table 1: Comparison of Indian Authors with Rest of the World

Metric	Indian authors	Rest of the world
N	644	104,356
Mean number of total papers per author	258.9	219.22
Mean number of single author papers	16.84	17.22
Total citations	4,732,851	1,091,737,755
Mean number of total citations per author	7,337.75	10,440.03
Mean number of citations per paper	32.4	47.7
Mean of total self-citations	817,173	142,374,531
Self-citations per author (%)	17.27%	13.04%
h-index (2017)	39.79	45.84
hm-index (2017)	21.87	21.67

distinguished status for high-quality output (Department of Higher Education, 2020). There are also numerous Government research bodies, private non-profit research groups and labs, and service organizations which also conduct and publish research works.

Table 2: Distribution of Indian Authors Based on Affiliation

Type of affiliation	No. of authors
Institution of national importance	213
Central university	51
State university	108
Private university	33
Deemed to be university	66
Autonomous government body, lab, project	117
Private research institution, lab, business	28
Health care organization, medical facility	20
Others	8
Total	644

From Table 2, the most significant finding was the high proportion of the top 644 Indian scientists being affiliated with Institutions of National Importance (213) or Government funded autonomous research bodies (117). Institutions in these two categories receive the highest support from the Government and are also known for being institutions of highest quality with specialized education and research works, and only attainable to the brightest students and scholars in India. The third highest number of top authors was from State Universities (108), but given the total of 409 State Universities and the thousands of colleges affiliated with them, the numbers are quite dismal. The number from Central Universities fared slightly better with 51 top authors from 50 total Central Universities. Outside the realm of central and state governance, Private Universities managed the worst, with only 33 top authors from a total of 349 Private Universities in India. Deemed to be Universities had slightly better metrics, with a total of 66 top authors from the 127 Deemed to be Universities. In most instances, Deemed to be Universities are previously Private Universities identified by the central Government as high-performing institutions, and the author distribution demonstrated just that. Next, the author metrics of citations, publications, etc. were tabulated for the different affiliation types as given in Table 3.

In the given matrix of author information in Table 3, several inferences can be made about the overall research performance of the top 644 Indian authors, representing various affiliation groups. Each of the given measures such as number of papers, mean citations per paper, *h*- index, rank in the database, etc. help provide an overall impression of the author categories. Overall, Deemed to be Universities had the most favorable citation indices with highest number of

Table 3: Comparison of Performance (per Author) Based on Affiliation

Type of affiliation	*N*	Mean no. papers	Mean no. citations	Citations per paper	Mean Self-citations	Mean h-index	Median Rank
National imp. ins	213	250.9	6,713.9	30.9	1,028.6	38.2	63,021
Central university	51	202.6	6,011.5	33.6	1,051.9	37.9	67,417
State university	108	277.5	7,269.5	30.8	1,189.6	39.1	60,124
Private university	33	278.6	6,743.27	27.4	1,063.8	36.9	57,478
Deemed to be unis	66	281.1	8,740.8	37.5	2,048.1	44.5	55,565
Gov. bodies	117	266.9	8,222.1	33.7	1,497.8	41.7	70,805
Private institutions	28	213.2	7,035.0	36.0	1,054.1	38.9	61,043
Medical organizations	20	300.8	8,599.1	30.0	1,143.1	42.85	61,701
Others	8	252.3	8,970.6	33.5	2,007.1	43.6	39,411
Total	644	258.9	7,337.8	32.3	1,266.9	39.8	63,737

papers, citations, as well as the *h*-index and rank. This group was surprisingly closely matched by a small group of authors from pure medical facilities/health organizations, who had the highest number of papers per author. It certainly highlighted the global trends in dominance of Clinical Medicine and associated sciences in terms of research output and performance. Among the rest of the groups, Institutions of National Importance, State Universities and Government bodies fared average overall and Central Universities and Private Universities performed worse than the rest of groups. One interesting detail was also the significant disparity in total self-citations between authors from Deemed to be Universities compared with the rest. While the mean total self-citations per author were roughly between 1,000 and 1,400 for most of the eight groups, the same was over 2,000 for authors from Deemed to be Universities alone.

The disciplines or scientific fields of the 644 Indian authors were also tabulated based on the functional areas covered by the journal in which the authors' most significant publications appeared as given in the database by Ioannidis *et al.* (2019a). For this, there were two separate categorizations, one with 22 main categories of scientific fields, and the second one with 176 sub-fields within the 22 main categories. In Table 4, the distribution of the 644 Indian authors in the 22 main scientific fields has been given.

Table 4: Distribution of Indian Authors across 22 Main Categories

Category	No. of authors
Agriculture, Fisheries and Forestry	13
Biology	22
Biomedical Research	48
Built Environment and Design	4
Chemistry	125
Clinical Medicine	107
Earth and Environmental Sciences	23
Economics and Business	4
Enabling and Strategic Technologies	76
Engineering	56
Information & Communication Technologies	30
Mathematics and Statistics	11
Physics and Astronomy	125
Total	644

From Table 4, several significant patterns were observed. It was found that among the top Indian authors, more than half of the authors were from three fields; Chemistry (19%), Physics and Astronomy (19%) and Clinical Medicine (17%). Other significant fields represented were Biomedical research (7%), Engineering (5%) and Enabling and Strategic technologies (12%). One salient aspect of the author distribution was the significantly low representation of scientists from social sciences, commerce, management, arts and humanities, etc. There was clear domination of the natural sciences, and this trend has been pretty evident in the larger dataset as well, with patterns of domination by scientists from natural sciences and medicine being well known in the scholarly community as well (Garg *et al.,* 2006). The distribution of the authors in the 22 categories was further extended in terms of their specific domains of publications and which has been provided in Table 3. The results only further illuminate the same trend observed in Table 2, with clear domination of the natural sciences.

DISCUSSION

In the previous section, a thorough description was provided for the top 644 Indian authors appearing in the list of top 105,000 scientists published by Ioannidis et al. (2019a; 2019b), and key citation indices such as number of papers, citations, citations per paper, *h*-index, rank, etc. were explored. The most salient findings of the exploration detailed in Tables 1–5 can be best detailed in the three points below:

1. When the top 644 Indian scientists were compared with the world's other 104,000 top scientists (Table 1), Indians performed slightly worse than the global

Table 5: Distribution of Indian Authors across Sub-Categories of Disciplines

Category	Nos	Category	Nos
Agronomy and Agriculture	8	Industrial Engineering and Automation	7
Analytical Chemistry	5	Inorganic and Nuclear Chemistry	16
Applied Mathematics	7	Materials	31
Applied Physics	31	Mathematical Physics	14
Artificial Intelligence and Image Processing	11	Mechanical Engineering and Transports	14
Astronomy and Astrophysics	4	Medical Informatics	15
Automobile Design and Engineering	3	Meteorology and Atmospheric Sciences	4
Biochemistry and Molecular Biology	19	Microbiology	18
Bioinformatics	4	Nanoscience and Nanotechnology	12
Biomedical Engineering	6	Networking and Telecommunications	7
Biophysics	4	Neurology and Neurosurgery	8
Biotechnology	13	Nuclear and Particles Physics	9
Cardiovascular System and Hematology	5	Numerical and Computational Maths	3
Chemical Engineering	36	Nutrition and Dietetics	5
Computation Theory and Mathematics	4	Obstetrics and Reproductive Medicine	3
Dairy and Animal Science	4	Oncology and Carcinogenesis	6
Electrical and Electronic Engineering	5	Operations Research	4
Energy	21	Organic Chemistry	31
Environmental Engineering	16	Pharmacology and Pharmacy	8
Epidemiology	3	Physical Chemistry	12
Evolutionary Biology	4	Plant Biology and Botany	21
Fluids and Plasmas	12	Polymers	11
General and Internal Medicine	24	Strategic, Defence& Security Studies	5
General Chemistry	28	Toxicology	9
General Physics	34	Tropical Medicine	4
Immunology	6	Urology and Nephrology	3
Aerospace and Aeronautics | Agricultural Economics and Policy | Arthritis and Rheumatology | Building and Construction | Civil Engineering | Fisheries | Geological and Geomatics Engineering| Gastroenterology and Hepatology| Logistics and Transportation | Marine Biology and Hydrobiology | Mycology and Parasitology | Otorhinolaryngology | Statistics and Probability| Veterinary Sciences| Virology| Physiology	1 each	Business and Management| Complementary and Alternative Medicine| Computer Hardware and Architecture| Computer Hardware and Architecture| Developmental Biology| Economics| General Mathematics| Geology | General Science and Technology| Geochemistry and Geophysics| Information Systems | Mining and Metallurgy| Oceanography| Optics| Orthopedics| Surgery	2 each
		Total	**644**

average with lower total and per citations, despite having more number of papers per author. Indians' citation impact was also lower than the global average; however, proportion of self-citations among total citations was significantly higher for Indian authors than the average of the rest. The high self-citation is just one among the many unfair and unethical practices existing in the Indian scholarly sphere. India remains at the core of the pseudo or predatory publications epidemic with Indian authors having the highest number of articles published in predatory journals as well as highest number of active predatory publishers (Xia *et al.,* 2015; Gopalakrishnan *et al.,* 2016; Demir, 2018). With a ruthless pay or publish model in a complex and very competitive academic field in present-day India, the Government of India, and particularly the University Grants Commission (UGC) has been quite active in developing stringent guidelines for research publications to ensure high quality.

2. Among the top 644 Indian authors (Tables 2 and 3), more than half the authors (330 of 644) were affiliated with Institutions of National Importance or Government Research bodies, indicating the extensive involvement, funding and support of the Government of India, particularly the Ministry of Human Resource Development (MHRD), University Grants Commission (UGC) and other Government departments and processes. Along with State Universities, these three groups make up two-thirds (438 of 644) of total top authors. Deemed to be Universities performed significantly better in the citation metrics despite having a small representation of 66 top authors from the pool of 127 total Deemed to be Universities in the country. Research through private agencies such as health organizations, health service institutions, research labs, etc. was of decent relative quality, but underrepresented at just 50 authors from the six hundred. Private Universities fared the worst in the citation indices and were closely followed by the pocket of 50 authors from the 50 total Central Universities in India.

3. In terms of scientific discipline or field of study of the 644 Indian authors (Tables 4 and 5), more than half of them represented three major fields of Chemistry (19%), Physics and Astronomy (19%) and Clinical Medicine (17%). This clear dominance of scientists from natural sciences is prevalent worldwide and not only in India, and it is no surprise that most of the top articles, journals and authors are from either hard sciences (chemistry, biology, physics) or medicine. It has been argued that existing citation metrics have been tailor-made for natural sciences, with the nature of citations in the social sciences being qualitatively different and limited in impact and reach (Archambault et al., 2006). Scientists from social sciences and arts were severely low in number among the 105,000 top scientists.

The field of Indian academia is at a volatile position at present and riddled with numerous endearing issues related to oversight and planning, funding and support, publication and performance measures, etc. Despite representing only 0.006 percent of the total 105,000 top scientists worldwide, there is a burgeoning unregulated research market plagued by predatory and pay-to-publish models, rendering majority of the research products from India as low quality in the global sphere. In the databases of SCOPUS and WoS, the two world leaders in maintaining quality indices of publications, India is largely under-represented, and majority of publications by Indian authors and journals fall outside the indexing parameters of WoS and SCOPUS.

There have been decisive steps taken by the Governing bodies in recent times, to clean up with publication sphere, and the University Grants Commission (UGC) has begun maintaining and grading lists of journals based on their quality (University Grants Commission, 2019; 2020b). Also, the draft of the new National Education Policy (NEP) was released recently in June 2019 which proposes a major overhaul of the education sector in India with Gross Enrollment Ratio (GER) of 50 percent in higher education by 2035 being the most significant of the goals (Committee for Draft National Education Policy -CDNEP, 2019). The 484 paged document emphasized the need to develop an Indian-centered education system for the creation of an 'equitable and vibrant knowledge society' (p. 153) (CDNEP, 2019). The draft was the first comprehensive education policy for India since 1986 and is based on five pillars of access, equity, quality, accountability and affordability (Khurana, 2019; Roy, 2019). Among the 644 Indiana authors in the list, more than half were from the handful of Institutions of National Importance and Government research bodies. It clearly demonstrates the active hand of Government support in fostering quality research, and a great deal of country-wise restructuring of education has been proposed by the center. One goal of the NEP was the consolidation of the 40,000 plus scattered colleges into 10-15,000 large vibrant multidisciplinary universities. In order to have a shot at the ideal targets of the NEP and also improving worldwide performances of Indian authors, the existing issues and problems in the publication sphere need to be tackled through Government oversight. There is a need for imbibing a new and fair academic culture in India, and a great deal of effort and investment will be required to produce research output that can match the Western powers. The top focus for India for the next few decades should be in improving quality of funding, research, writing, publication, etc.

CONCLUSION

The present study highlighted a few existing trends in Indian academia, in relation to worldwide figures based on standardized information from 105,000 top authors. Not surprisingly, India had a tiny representation among the top authors (0.006%), and their citation metrics were lower than the global average. The study also highlighted the distribution of Indian authors based on affiliation and disciplines revealing obvious patterns. Overall, the insights from the study provide scope for solving critical issues that have hampered India's quest of high-quality research and international recognition.

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