

Bradford's Law of Scatter Revisited: Scientometric Analysis Based on Biomedical Literature

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***Abstract** - The article highlights the significance of Bradford's law in today's information age. The classical law is applied to the Biomedical literature retrieved from medIND, online database published by Indian MEDLARS Centre. A total of 7177 original articles were scattered in 49 journals. From these journals the most productive one is Indian Journal of Pediatrics. The Bradford's law was found unfit for the data.*

Keywords: Biomedical literature, Bradford's law, Law of Scatter, MEDLINE , Scientometrics

1. Introduction

Medicine is described as the science and art of preventing illness and disease, treating illness, injury, and disease, and healing. Today, medicine involves health science, biomedical research, and technology to diagnose, treat, and prevent injury, disease, and illness for individuals and society. Biomedicine is a branch of medical science that applies biological and other natural-science principles to clinical practice. Biomedicine involves the study of physiological (patho) processes with methods from biology, chemistry and physics. Approaches range from understanding molecular interactions to the study of the consequences at the in vivo level. These processes are studied with the particular point of view of devising new strategies for diagnosis and therapy.

Biomedical science focuses on understanding the causes, diagnosis and treatment of disease in humans and plays an essential role in healthcare. It requires the integration of a wide range of subjects to understand the biology of disease; mainly anatomy, physiology, biochemistry, genetics, immunology, microbiology, pharmacology and molecular biology. More specific knowledge of disease processes comes from studying specialised biology such as cellular pathology, clinical biochemistry, clinical immunology, haematology, transfusion science and medical microbiology.

Scientometrics is a subfield which applies quantitative methods to study science as an information process¹. Scientometrics helps in measuring the research output and productivity of individual scientists within a group. Scientometric study provides a methodology to rank scientific journals and documents according to their degree of importance, which in turn help

librarians and research administrators to formulate the acquisition policy. Scientometrics is the most significant method to evaluate the number of publications and its change over time. A well known productivity indicator is the number of publications produced by the scientists, institutions, and research groups. Over the years, many methods have been suggested to evaluate the research productivity of countries, universities, research institutions, research teams and research fields. In recent years several formal analytical and predictive methods have developed for describing the phenomena of research productivity. It is frequently measured in terms of published output perhaps because the data on number of publication by the authors can be taken as a measure of research productivity.

2. Relevance of the study

The study helps to give a comprehensive picture of the status of research productivity of biomedicine in India. Research publications are clearly one of the quantitative measures of the basic research activity in a country or an institution. A study relating to the research in biomedicine is very essential to identify the productivity of institutional journals, authors, collaboration trends etc. The results of advanced scientific research create new frontiers to modern world. The study attempts to reveal the Indian output on biomedical literature to the global share using medIND database. Medline is considered as an authentic and comprehensive source of medical literature published all over the world.

3. Objectives of the study

The main objectives of the study are:

1. To identify the most productive journals
2. To examine the validity of Bradford's law in biomedical periodical literature

4. Review of Literature

Gupta,et.al.² analysed the India research output in diabetes during 1999-2008 on several parameters including its growth, rank and global publications share, citation impact, overall share of international collaborative papers, and share of major collaborative partners. It also analyses the characteristics of most productive institutions, authors, and highly-cited papers. The publications output, impact and collaborative publication share of India is also compared with China, South Korea and Brazil.

Zainal & Zainab³ conducted a study on biomedicine, 3697 publications affiliated to Malaysian addresses from the SCI database between 1990 and 2005 were sampled. The study explored publication productivity trends, authorship and collaboration pattern, core journals used, and citations obtained. Main contributions were journal articles (73.3%), most authors (63.7%) contributed only one article and 16.1% produced over 30-68 publications. The productive authors were named either first or second in publications. There were active collaborations with authors from Asia-Pacific countries (35%) and Europe (30%). The majority of publications were contributed by institutions of higher learning (87%). Core journals used follow quite close to Bradford's zonal ratios of 44:152:581. The active research areas were identified. About 71.3% of publications received citations especially those published from 1995 to 1999.

Sooryamoorthy⁴ analysed the medical research in South Africa. Being a scientifically active country in Africa, South Africa has made significant strides in the production of scientific publications. Medicine is one branch of science that has achieved a remarkable position in

this regard. The study also presented the unique patterns of scientific research in medicine, taking into account factors such as the count and fractional count of papers, citations, trends of growth, sectoral participation, partners, and publication outlets, and seeks to provide new insights into the directions medical science is taking in South Africa today.

Tonosaki⁵ prepared a paper which aimed to propose the promotion plan of the scientific journals of Japan. The number of articles whose the author's belonging is a name of a place of Japan was retrieved., and the investigation of the number of journal articles that the Japanese wrote was calculated from 2000 to 2006 in PubMed. The Japanese number of articles published in a foreign journal was calculated by subtracting the number of articles that the Japanese wrote in journals of Japan from the total Japanese articles, and the ratio between the number of articles published by the Japanese researchers in foreign journals and in journals of Japan was examined and the outflow level from which the result of the Japanese research was published in foreign journals was calculated. From this study the total number of articles that the Japanese wrote was 618,643 in PubMed. The total articles that the Japanese wrote at the year from 2000 to 2006 were 38,630 articles. The ratio of the number of articles published in journals of Japan decreases gradually. The ratio of the number of articles published in foreign journals showed the tendency to increase.

Garcia-Garcia, et.al.⁶ analyzed the Spanish scientific work published in the field of obstetrics and gynecology in the most important journals during the period 1986–2002. The material studied (779 original documents) was selected in accordance with the *science citation index* (SCI) of 2001, using the *EMBASE: Obstetrics and Gynecology* database. They applied the customary rules of bibliometrics: Price's Law of increase in scientific literature, Bradford's Law of scattering of scientific literature and Lotka's Law of author productivity. The material studied is closer to an exponential adjustment ($r = 0.958$) than to a linear adjustment ($r = 0.856$). The total number of authors is 1829, who are responsible for 3938 authorships (2.79% of the authors have a productivity index $(PI) \geq 1$ and 70.09% have a $PI = 0$). The majority of the studies were carried out in hospitals (47.62%) and universities (23.36%).

5. Methodology

The publication data during 2002-2011 for the study was taken from medIND, online database published by Indian MEDLARS Centre. Having achieved the target of making bibliographic details from Indian biomedical journals, the Indian MEDLARS Centre took up a challenging project of making available the full-text of select Indian journals. An Online database of full-text of the IndMED journals was designed and successfully launched in August 2003. Hosted from an independent site, medIND⁷ presently has current issues of 63 IndMED journals. Consent of the participating journals' editors has been taken to include the full-text of the contents in the database with the copyright remaining with the editors and ownership of the database with the Centre. The database is accessible free of cost to the medical professionals within and outside India. For the study a total of 7177 original articles were identified. The details with regard to each articles such as title of the article, name of the author, number of authors, year, volume and issue number, name of the institutions and departments were recorded on excel. Scientometric analysis is carried out with the help of statistical techniques.

6. Analysis & Interpretation

6.1 Journal -wise distribution of articles

Table 1: Journal -wise distribution of Original articles

Sl. No:	Name of the Journal	Number of Articles	Rank
1	Indian Journal of Pediatrics	516	1
2	Indian Journal of Medical Research	505	2
3	Medical Journal Armed Forces India	383	3
4	Indian Journal of Clinical Biochemistry	381	4
5	Indian Pediatrics	334	5
6	Journal of Obstetrics and Gynecology of India	325	6
7	Indian Journal Of Community Medicine	263	7
8	Indian Journal of Anaesthesia	255	8
9	Indian Journal Of Medical Microbiology	214	9
10	Journal of Indian Society of Pedodontics and Preventive Dentistry	201	10
11	Journal of Indian Academy of Applied Psychology	183	11
12	Journal of The Anatomical Society of India	182	12
13	Indian Journal of Gastroenterology	181	13
14	Health and Population: Perspectives and Issues	178	14
15	Health Administrator	171	15
16	Trends in Biomaterials and Artificial Organs	170	16
17	Journal of Indian Association of Pediatrics Surgeons	161	17
18	Indian Journal of Tuberculosis	160	18
19	Journal, Indian Academy of Clinical Medicine	159	19
20	Indian Journal of Nephrology	151	20
21	Journal of Indian Academy of Forensic Medicine	148	21
22	J.K. Practitioner	136	22
23	Indian Journal of Chest Diseases and Allied Sciences	131	23
24	Journal of Family Welfare	129	24
25	Endodontology	117	25
26	Nursing and Midwifery Research Journal	112	26
27	Indian Journal of Otolaryngology and Head and Neck Surgery	110	27
28	Indian Journal of Aerospace Medicine	100	28
29	Journal of Exercise Science And Physiotherapy	100	28
30	Indian Journal of Preventive and Social Medicine	94	29
31	Lung India	82	30
32	Indian Journal of Occupational Therapy	78	31
33	Indian Journal of Occupational and Environmental Medicine	76	32
34	Delhi Psychiatry Journal	75	33
35	Indian Journal of Nuclear Medicine	67	34
36	Annals of CARDIAC ANAESTHESIA	62	35
37	Indian Journal of Allergy Asthma and Immunology	62	35
38	Indian Journal of Medical & Paediatric Oncology	59	36
39	Indian Journal of Sexually Transmitted Diseases	58	37
40	Gujarat Medical Journal	57	38
41	NTI Bulletin	39	39
42	Journal of Indian Rheumatology Association	37	40
43	Indian Journal of Pharmacology	35	41
44	Indian Journal of Endocrinology and Metabolism	28	42
45	Journal of Indian Society of Periodontology	28	42
46	Journal of Mahatma Gandhi Institute of Medical Sciences	23	43

47	Asian Journal of Transfusion Science	24	44
48	Indian Medical Gazette	21	45
49	Mens Sana Monographs	16	46
Total		7177	

A total of 7177 original articles are scattered in 49 journals. From these journals the most productive one is *Indian Journal of Pediatrics*. Indian Journal of Pediatrics contains 516 original articles. The second most productive journal is *Indian Journal of Medical Research*, which contains 505 articles. Mens Sana Monographs contain only 16 articles. There are 29 journals which contain more than 100 articles and 20 journals contain less than 100 articles.

6.2 Application of Bradford's law in Original articles

Bradford's law was formulated in 1934 by Samuel C. Bradford with the aim of studying the distribution of scientific literature. Bradford's law states that in a given subject area, a small number of journals account for a sizeable portion of the total publications in that area, whereas increasing numbers of journals publish fewer articles in that area. Journals are ranked and divided into groups or categories, depending on the number of articles they account. These groups are termed Bradford zones⁸. The core journal data was tested by applying Bradford's theory of distribution which states that, 'if scientific journals are arranged in order of decreasing productivity of articles in a subject, they may be divided into a nucleus of periodicals more devoted to the subject and several groups or zones containing the same groups or zones containing the same number of articles as the nuclear when the zones will be 1: n: n² . . . '.

Table 2: To examine the validity of Bradford's law in original articles

Sl. No.	No. of Journals (x)	No. of articles (y)	Cumulative no. of journals (X)	Cumulative no. of articles(Y)	LogX	LogY
1	1	516	1	516	0	2.712
2	1	505	2	1021	0.3010	3.009
3	1	383	3	1404	0.4771	3.147
4	1	381	4	1785	0.6020	3.251
5	1	334	5	2119	0.6989	3.326
6	1	325	6	2444	0.7781	3.388
7	1	263	7	2707	0.8450	3.432
8	1	255	8	2962	0.9030	3.471
9	1	214	9	3176	0.9542	3.501
10	1	201	10	3377	1.0000	3.528
11	1	183	11	3560	1.0413	3.551
12	1	182	12	3742	1.0791	3.573
13	1	181	13	3923	1.1139	3.593
14	1	178	14	4101	1.1461	3.612
15	1	171	15	4272	1.1760	3.630
16	1	170	16	4442	1.2041	3.647
17	1	161	17	4603	1.2304	3.663
18	1	160	18	4763	1.2552	3.677
19	1	159	19	4922	1.2787	3.692
20	1	151	20	5073	1.3010	3.705
21	1	148	21	5221	1.3222	3.717
22	1	136	22	5357	1.3424	3.728
23	1	131	23	5488	1.3617	3.739
24	1	129	24	5617	1.3802	3.749
25	1	117	25	5734	1.3979	3.758
26	1	112	26	5846	1.4149	3.766
27	1	110	27	5956	1.4313	3.774
28	2	100	29	6056	1.4623	3.782
29	1	94	30	6150	1.4771	3.788
30	1	82	31	6232	1.4913	3.794
31	1	78	32	6310	1.5051	3.800

32	1	76	33	6386	1.5185	3.805
33	1	75	34	6461	1.5314	3.810
34	1	67	35	6528	1.5440	3.814
35	2	62	37	6590	1.5682	3.818
36	1	59	38	6649	1.5797	3.822
37	1	58	39	6707	1.5910	3.826
38	1	57	40	6764	1.6020	3.830
39	1	39	41	6803	1.6127	3.832
40	1	37	42	6840	1.6232	3.835
41	1	35	43	6875	1.6334	3.837
42	2	28	45	6903	1.6532	3.839
43	1	24	46	6927	1.6627	3.840
44	1	23	47	6950	1.6720	3.841
45	1	21	48	6971	1.6812	3.843
46	1	16	49	6987	1.6901	3.844

Journals are ranked and the log of cumulative number of journals and articles are calculated.

6.3 Scattering of journals and citations over Bradford zones

Journals are ranked and divided into groups or categories, depending on the number of articles they account. These groups are termed Bradford zones.

Table 3: Scattering of journals and citations over Bradford zones

Zone	No. of citation (each 1/3) (x)	Cumulative no. of citation ($\sum x$)	No. of journals (y)	Cumulative no. of journals ($\sum y$)	Ratio
1	15	15	15	15	1
2	15	30	16	31	1.9
3	16	46	18	49	2.7

From the table it is found that 3 zones are provided and the ratio is calculated as 1:2:3. The ratio between the number of journals in subsequent zones has been observed to be approximately 1: n: n². Therefore here the expected ratio will be 1:2:4. By calculating the Bradford's law here it comes 1:2:3 and therefore the journal productivity do not fit Bradford's law.

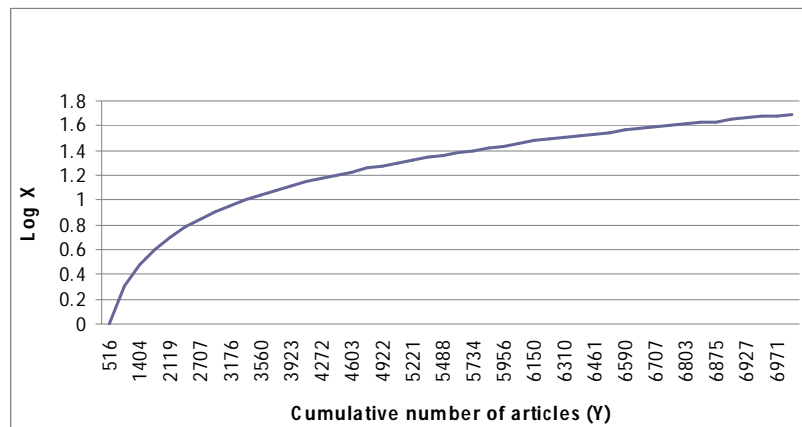


Fig 1. Graphical representation of Bradford's law in original articles

7. Findings

Among 7177 original articles scattered in 49 journals, the most productive journal is *Indian Journal of Pediatrics*. Indian Journal of Pediatrics contains 516 original articles. The second most productive journal is *Indian Journal of Medical Research* with 505 articles. The least productive journal is *Mens Sana Monographs* contains only 16 articles. There are 29 journals

which contain more than 100 articles and 20 journals contain less than 100 articles. From the 49 journals, two journals contain more than 500 articles, four journals contain more than 300 articles, four journals contain more than 200 articles, nineteen journals contain more than 100 articles, twenty journals contain less than 100 articles, From among the 20 journals, nine journals contain less than 50 articles. Bradford's law is not satisfying with biomedical literature.

8. Conclusion

The scientometric analysis of research conducted in Biomedicine in various Indian institutions from 2002-2011 indicates that the trend in the number of articles produced showed an increase in 2005 but showed a substantial decrease in 2006. The study reveals the need for improving biomedical research facilities in India. The policy-makers and planners should concentrate in providing ample fund and infrastructural facilities to improve the scene of medical research in India. The study provides an understanding of core journals, major institutions research trends, age of journals and rate of citation per article in Biomedicine in India.

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