Mapping of breast cancer research in India: a bibliometric analysis

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This study presents a bibliometric analysis of the scholastic output on breast cancer in India. The purpose is to provide an overview of the research activities in the country on the subject during the last ten years, exploring different aspects of scientific literature. Data on 3529 items, including 2945 articles and 584 reviews published during 1 January 2005 to 31 December 2014 were collected using Scopus. An advanced search was conducted in the database. The search results were filtered for English language, journals, India and the period under study. Lotka's law was applied to assess the author productivity and Bradford's law of scattering was used to ascertain the distribution pattern of articles in journals. Most (about 96%) contributions were found to be an outcome of collaborative authorship. Around 19.05% of the papers had collaboration of four authors and 16.53% appeared due to collective efforts of three authors each. Trend of an increasing number of articles published over the period has been observed. Author productivity did not fit the Lotka's law with a value of n = 2. The distribution of articles in journals was found acceptable to the Bradford's law of scattering.

Keywords: Bibliometric analysis, breast cancer, collaborative authorship, research activities.

CANCER is one of the major health concerns worldwide. The year 2012 witnessed 14.1 million new cases of cancer and global mortality of 8.2 million due to the noxious disease[1]. Cancer of the lungs, colorectal and stomach cancer and breast cancer accounted for more than 40% of all cases diagnosed globally. While cancer of the lungs occurred more frequently in men, breast cancer was the most commonly diagnosed cancer in women, constituting 25.2% of all new cases[2].

Cancer is one of the top 10 causes of death in India[3]. Breast cancer accounts for 22.2% of all new cancer diagnoses and 17.2% of all cancer deaths among women in the country[4]. In 2012, 144,937 women were newly detected with breast cancer and 70,218 died due to this fatal disease[5]. The rate of increase in breast cancer in the country 'is so rampant, that if we do not act now, we are in for a major shock in the next twenty years'[6]. More alarming is a considerable shift over the last few decades in the age of young women showing development of breast cancer[7]. While the peak occurrence of breast cancer in the United States and other European countries in women is in their sixties[8], almost 48% of the patients in India are below 50, with an increasing number of patients in the age group between 25 and 40 years[9].

The world age-standardized rate (ASR) of incidences of breast cancer is 43.1 per 100,000 women and the age-standardized breast cancer death rate is 12.9 per 100,000 females. Compared to this, the ASR of incidences of breast cancer in India is 25.76 per 100,000 women. However, in proportion to the incidence rate, the ASR of mortality in the country is much higher than that in the developed countries, taking 12.73 lives per 100,000 women[10]. Hence, in India, on an average, for every two women newly diagnosed with breast cancer, one is dying from this disease. It is estimated that the incidence of new cases of breast cancer in India will rise up to 200,000 per year by 2030 (ref. 11).

Women have a crucial role in the social, economic and cultural development of society. In male-dominated India, the health and care of women is a critical issue. The absence of typical female advantage in life expectancy suggests the systematic problems in the health of women in the nation[12]. Women are mainly exposed to indoor pollutants at home and in the workplace, and there are evidences that they are more vulnerable than men to various chemicals[13]. Improper nutritional intake[14], overweight and obesity in early adulthood[15] also account for this fatal disease. For sustainable well-being of women, it is essential that 'strategic interventions are made at critical stages'[16]. Research, evidence and information are basic to sound health policies[17]. There is significant positive

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correlation between improvement in the survival rate of patients and research output[18]. Therefore, quantitative assessment of the scholarly research output of India on breast cancer is pertinent to map out the growth trends and its future perspectives, as this can have a significant bearing on the future research and policies to tackle the disease in gender-disturbed nation. Bibliometric analysis is a statistical support device to map out and generate different types of information, and knowledge handling and management indicators[19].

Objectives

The present study is aimed at assessing (i) the year-wise distribution of papers, (ii) authorship pattern, (iii) author productivity and productive authors, (iv) institutional contributions, (v) fitness of distribution of papers to Bradford's law of scattering, and (vi) the core journals publishing papers on breast cancer.

Methodology

For bibliometric analysis, data regarding papers on breast cancer were collected using *Scopus* in July 2015, for the period 1 January 2005 to 31 December 2014. *Scopus* is the largest abstract and citation database of peer-reviewed literature, including scientific journals, books and conference proceedings in the disciplines of science, technology, medicine, social sciences, arts and humanities. To access data for the present study, *Scopus* was searched as follows:

- An advanced search was conducted using 'breast cancer' and alternative search terms, i.e. 'breast carcinoma', 'neoplasm of breast', 'tumor of breast', 'tumour of breast', 'mammary cancer', 'ductal carcinoma' and 'invasive carcinoma'.
- The search was restricted to the occurrence of search terms in the title, abstract and keywords of the articles.
- Boolean operator 'OR' was applied to the above search terms to produce an exhaustive number of results.
- The search results were filtered to English language, journals, India and restricted to the period of ten years under study, i.e. 2005–2014.
- The search was further filtered by subject areas to cover articles in medicine, biochemistry, pharmacology, nursing, health science, multidisciplinary and immunology.
- The search results provided 3529 records covering 2945 articles and 584 reviews for the period under study on the given search terms.
- The data were downloaded in Excel format and analysed.
- Data analysis was performed using frequencies and percentages of publications. Besides, Lotka's law was applied to assess the author productivity and Bradford's law of scattering was used to ascertain distribution pattern of articles.

Analysis and discussion

Year-wise distribution of papers

During the period 2005–2014, a total 3529 papers were published on breast cancer by authors with institutional affiliation in India, either individually or in national/international collaboration. The trend of growing number of publications over the period can be observed in Table 1, indicating that with the increasing burden of breast cancer in the country, research on the issue has also increased. This supports the study of Kotepui *et al.*[20] revealing the trend of growing number of publications from Asian countries. It took seven years (2005–2011) to produce 48.54% (1713 papers) of the total contributions during the period under study, while the rest 51.46% was published during the last 3 years (2012–2014) only. The year 2014 produced more publications than the first four years under study, viz. 2005–2008. On an average,

Table 1. Year-wise distribution of papers

Year	No. of papers	Percentage	Cumulative frequency
2005	119	03.38	119
2006	168	04.77	287
2007	176	04.99	463
2008	182	05.16	645
2009	258	07.31	903
2010	365	10.34	1268
2011	445	12.60	1713
2012	534	15.13	2247
2013	608	17.22	2855
2014	674	19.10	3529
Total	3529	100.00	

Table 2. Authorship pattern

No. of authors	No. of papers	Percentage
1	135	03.82
2	449	12.72
3	583	16.53
4	672	19.05
5	524	14.85
6	396	11.22
7	229	06.49
8	159	04.50
9	120	03.40
10	71	02.01
>10	191	05.41
Total	3529	100.00

scientific output on the subject increased by nearly 19% per annum.

Authorship pattern

The number of authors contributing to each publication varied from 1 to 295. A large majority of papers had been written in collaboration, with the exception of only 135 (03.82%) single-authored papers (Table 2), corroborating the findings of Minas *et al.*[21] and Sridevi[22]. Interestingly, 05.41% of the papers resulted from collaboration of more than 10 authors, including 4 articles having more than 100 authors each. Also, 3529 articles and reviews were contributed by 18,544 authors, each publication having around 5 authors, on an average. The degree of collaboration of authorship was calculated using the formula given by Subramanyam[23]

$$C = \frac{Nm}{Nm + Ns} = \frac{3394}{3394 + 135} = 0.9617,$$

where C is the degree of collaboration, Nm the number of multi-authored works, and Ns is the number of single-authored works.

Author productivity

Author productivity was assessed considering the first author of each article (Table 3). A total of 2521 authors had made 3529 contributions. Majority of authors (80.00%) contributed only one paper, followed by 11.79% authors contributing 2 publications each. Lotka's law was applied to calculate the number of expected authors for a given number of publications. Considering the fact that 2017 authors have produced only 1 paper each, the value of n can easily be derived. Putting the value of n as 2, the results shown in Table 3 were obtained.

Table 3 shows that there are only a few productive authors, a large majority contributing to breast cancer occasionally. In contrast to the study of Parta and Bhattacharya[24], the present results suggest that in this case the author distribution does not obey Lotka's law. The difference between the number of observed authors and expected authors was considerably wider.

Prolific authors

The most prolific authors on the subject of breast cancer have been identified and ranked (Table 4). There were 12 authors each publishing more than 20 papers. The author with the highest contribution in terms of the number of papers on breast cancer is Sachdanandam contributing 30 publications, followed by Parshad and Konwar (26 each). Saxena and Sarin contributed 25 and 24 papers respectively. Of the total 18,544 authors, 159 Indian authors made a contribution to 51.40% of the total 3529 publications, whereas the remaining majority to the rest of the 48.60% contributions.

Core journals in the subject

The total 3529 papers analysed in this study appeared in 972 journals from various publishers and geographical locations. Table 5 shows the most productive journals on breast cancer. Around 27.76% (980) of the total publications under the study appeared only in 25 journals, which may be considered as core journals (Table 5).

The impact factor (IF) is a widely accepted quality determinant for journals, reflecting the average number of citations to recent articles published in a journal. Higher the IF, more important the journal is considered to be. However, 10 of the 25 core journals publishing the highest number of articles on breast cancer did not have an IF. Eight of these 10 journals without IF, are being

Table 3. Author productivity

No. of papers	No. of authors observed	No. of authors expected
1	2017 (80.00)	2017 (63.22)
2	297 (11.79)	504 (15.80)
3	105 (04.17)	224 (07.02)
4	45 (01.79)	126 (03.94)
5	21 (00.84)	81 (02.54)
6	11 (00.44)	56 (01.76)
7	8 (00.31)	41 (01.29)
8	3 (00.11)	32 (01.00)
9	3 (00.11)	25 (00.79)
10	1 (00.04)	20 (00.62)
11	4 (00.16)	17 (00.54)
12	2 (00.08)	14 (00.44)
13	1 (00.04)	12 (00.38)
14	1 (00.04)	10 (00.31)
19	1 (00.04)	6 (00.19)
21	1 (00.04)	5 (00.16)
Total	2521 (100.00)	3190 (100.00)

Figures in parenthesis represent percentage.

Table 4. Prolific authors

Author	No. of papers	Percentage
Sachdanandam, P.	30	00.85
Parshad, R.	26	00.73
Konwar, R.	26	00.73
Saxena, S.	25	00.70
Sarin, R.	24	00.68
Ralhan, R.	23	00.65
Kamal, A.	23	00.65
Kumar, R.	22	00.62
Munshi, A.	22	00.62
Gupta, S.	22	00.62
Shanthi, P.	22	00.62
Badwe, R.A.	22	00.62

Table 5. Core journals in the subject

Journal	Rank	No. of papers	Percentage	Country	Impact factor (2014)
Asian Pacific Journal of Cancer Prevention	1	104	02.94	Korea	2.514
Journal of Cancer Research and Therapeutics	2	79	02.23	India	0.791
European Journal of Medicinal Chemistry	3	61	01.72	Italy	3.447
PLoS ONE	4	57	01.61	USA	3.234
Indian Journal of Cancer	5	53	01.50	India	0.802
International Journal of Pharma and Bio Sciences	6	50	01.41	India	Nil
Bioorganic and Medicinal Chemistry Letters	7	49	01.38	UK	Nil
Indian Journal of Surgical Oncology	8	48	01.36	India	Nil
Journal of Clinical and Diagnostic Research	8	48	01.36	India	Nil
Indian Journal of Pathology and Microbiology	9	47	01.33	India	0.466
International Journal of Pharmacy and Pharmaceutical Sciences	10	46	01.30	India	Nil
Medicinal Chemistry Research	11	39	01.10	USA	1.402
Indian Journal of Medical Research	12	29	00.82	India	1.396
International Journal of Pharmaceutical Sciences Review and Research	13	27	00.76	India	Nil
Journal of the Indian Medical Association	13	27	00.76	India	Nil
Research Journal of Pharmaceutical, Biological and Chemical Sciences	14	26	00.73	India	Nil
Diagnostic Cytopathology	15	24	00.68	USA	1.121
Bioorganic and Medicinal Chemistry	16	23	00.65	UK	Nil
Journal of Cytology	16	23	00.65	India	0.374
Breast Cancer Research and Treatment	17	22	00.62	USA	3.940
Molecular and Cellular Biochemistry	18	21	00.59	The Netherlands	2.393
Indian Journal of Surgery	19	20	00.56	India	0.260
Tumor Biology	19	20	00.56	The Netherlands	3.611
Indian Journal of Medical and Paediatric Oncology	20	19	00.53	India	Nil
Cancer Research	21	18	00.51	USA	9.329

Table 6. Zones of journals

Zone	No. of journals	Percentage of journals	No. of papers	k
Core Zone	25	02.58	980	–
Zone 1	141	14.50	1161	5.700
Zone 2	806	82.92	1388	5.699
Total	972	100	3529	

published from India. This corroborates the findings of Patra and Bhattacharya[24], that the Indian cancer research articles are not published in high-impact journals.

Bradford's law of scattering

Bradford's law of scattering is used to describe the distribution of the literature on a particular subject in journals[25]. The law working on mathematical means is based on the principle of centric productivity zones, demonstrating that there are diminishing returns when the literature is published exhaustively. According to the law, journals can be divided into different zones containing the same number of articles. For example, the core zone contains one-third of the total articles; similarly zone 1 contains the same number of articles, but a greater number of journals, and zone 2 contains the same number of articles, but still greater number of journals, and so on. This increase in the number of journals from one zone to the next is according to the expression $1 : n : n^2$. The law helps to distinguish the groups of journals dedicated more specifically to the subject of interest. The number of journals in each zone can be calculated from Bradford's multiplier constant k. In this study, k has been arrived at using the mathematical formulations of Egghe[26], and Egghe and Rousseau[27] as given below

$$k = (\mathrm{e}^{\gamma} \times Ym)^{1/p},$$

where γ is Euler's number having a value 0.57772, Ym is the number of articles published in the top-ranked journals and p is the Bradford group or number of zones, i.e. $p = 3$.

Therefore,

$$k = (1.781 \times 104)^{1/3} = 5.70.$$

The different Bradford groups can be calculated using k. The core zone r_0 can be defined as

$$r_0 = \frac{T(k-1)}{(k^p - 1)},$$

where T represents the total number of journals in the study.

Thus,

$$r_0 = \frac{972(5.70-1)}{(5.70^3 - 1)} = \frac{4568.4}{184.193} = 24.81.$$

Table 7. Institutional contribution

Institution	No. of papers	Percentage
Tata Memorial Hospital	175	04.95
All India Institute of Medical Sciences	169	04.78
University of Madras	90	02.55
Indian Institute of Chemical Technology	81	02.29
Postgraduate Institute of Medical Education and Research	77	02.18
Central Drug Research Institute	63	01.78
National Institute of Pharmaceutical Education and Research	54	01.53
Sanjay Gandhi Postgraduate Institute of Medical Sciences	47	01.33
Chittaranjan National Cancer Institute	46	01.30
National Centre for Cell Science	42	01.19
Indian Institute of Science	41	01.16
Nizam's Institute of Medical Sciences	40	01.13
Banaras Hindu University Institute of Medical Sciences	40	01.13
Osmania University	39	01.10
Institute Rotary Cancer Hospital	38	01.07
Annamalai University	37	01.04
Regional Cancer Centre	36	01.02
Vardhman Mahavir Medical College and Safdarjung Hospital	36	01.02
Manipal University	36	01.02
Jadavpur University	36	01.02

Table 8. Collaboration with other nations

Country	No. of papers	Percentage
India	3529	100.00
United States of America	417	11.81
Germany	57	01.61
United Kingdom	56	01.58
Canada	48	01.36
France	45	01.27
Saudi Arabia	43	01.21
Australia	41	01.16
Singapore	32	00.90
South Korea	30	00.85

Different Bradford zones have been obtained using the values of k and r_0

Core zone $r_0 = r_0 \times 1 = 24.81$,
First zone $r_1 = r_0 \times k = 24.81 \times 5.70 = 141.42$,
Second zone $r_2 = r_0 \times k^2 = 24.81 \times 5.70^2 = 806.08$.

The above theoretical distribution according to Bradford's law enables one to examine the exact fit of the law to the distribution of articles. Using this distribution, the number of journals in each zone has been arrived at Table 6. Using the distribution of journals in Table 6, k is 5.700 and 5.699 for zone 1 and zone 2 respectively. This value of k is similar to that calculated using the formula $k = (e^{\gamma} \times Ym)^{1/p}$. This makes it clear that data collected for the present study fit into the three zones of Bradford's law of scattering, i.e. $1 : k : k^2$ or $1 : n : n^2$.

Institutional contribution

Table 7 gives the top 20 institutions in terms of their contribution to the number of papers on breast cancer. It can be observed that medical institutions and hospitals make a greater contribution to the literature on breast cancer than universities, contrary to the findings of Ortiz *et al.*[28].

Collaboration with other nations

Table 8 lists the major nations along with the number of papers in which Indian authors had collaborated with the authors from other nations. Indian authors contributed 417 publications in collaboration with authors from the United States. India has collaboration in 57 papers with Germany, followed by 56 contributions with the United Kingdom. Canada, France, Saudi Arabia, Australia, Singapore and South Korea are the other nations with which Indian authors have contributed 30 or more papers.

Conclusion

Research and scientific activities on breast cancer involve a high degree of collaboration, not limiting to the geographical boundaries. The present study shows that 11.81% of the papers are contributed by Indian authors in collaboration with authors from the United States. Similarly, countries such as Germany, United Kingdom, Canada, France, etc. collaborate with authors from India. A growing trend of publications in the subject is observed. In comparison to 119 papers published in 2005, the number of contributions has increased by 466% during 2014. Majority of the authors contribute to the subject occasionally. However, author productivity does not fit to Lotka's law, as the observed and expected values vary significantly. The distribution of papers obeys the Bradford's law of scattering identifying 25 core journals. The

inputs to the scientific literature are dominated by a few selected institutions. It is pertinent to mention here that the present study is limited to bibliometric analysis of the scientific literature on breast cancer contributed by India. A comparative study with scientific inputs from other nations on the subject will provide a picture of research trends in the global context.

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