Collaboration pattern in male breast cancer research

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An analysis of 4168 research papers on male breast cancer (MBC) published by different countries and indexed by Science Citation Index Expanded during 2005–2014 indicates that only 15% of the papers were non-collaborative and the rest were published either in domestic or international collaboration. The sub-field of MBC had a high proportion of domestic collaboration. The number of papers written with domestic collaboration was almost three times the number of papers written with international collaboration. The value of co-authorship index (CAI) decreased in single-, two- and multi-authored papers in the second block 2010–2014 as compared to the first block (2005–2009). Higher value of CAI for mega-authored papers reflects higher collaborative coefficient (CC) in 2010–2014. The highest value of CC is for the sub-field S9 (genetics and heredity). This is also indicated by the highest value of CAI for mega-authored papers in this subfield. Among 17 highly productive institutions, CC value is more or equal to the global value of CC for 10 prolific institutions.

Keywords: International collaboration, male breast cancer, research publications.

GROWING complexity and specialization in science has resulted in increasing domestic and international collaborative efforts. Modern research demands an ever-widening range of skills and is no longer an individual pursuit. Today, in most science, technology, engineering and mathematics (STEM) fields more than 90% of research studies and publications are collaborative[1]. Such research more often leads to high impact research and commercial application as reflected in patents[2]. Such efforts can also reduce the time for translating scientific findings into service options within 'real world' communities. Scientific collaboration is more strikingly prevalent today than it was decades ago. In many areas of biomedical science, the trend is towards catalysing collaborative efforts that bring together researchers with diverse scientific backgrounds and perspectives to address perplexing questions and solve complex problems with an interdisciplinary approach[3]. Governments in different countries are taking initiatives to enhance contacts among scientists through collaborative research programmes, both at national and international levels. Such initiatives have resulted in increased collaborations. Adams[4] analysed papers during the past three decades and found that the best science comes from international collaboration. During the 1990s, there was a sharp increase in internationally co-authored papers indicating a rise in collaboration[5]. The increase was dramatic: international collaborations (as measured by internationally co-authored publications) just doubled[6]. The increase was seen across all fields of science at more or less the same rate[7]. Collaborations continued to rise in the early 2000s. The number of internationally co-authored articles grew at a rate faster than traditional 'nationally co-authored' articles. Moreover, internationally coauthored articles were cited more often than nationally co-authored papers[8].

Review of literature

Several studies dealing with collaboration pattern of countries and disciplines have been published earlier. Low[9] highlighted the collaborative research and authorship trend in clinical medicine in Malaysia from 2001 to 2010. Local or domestic collaborations accounted for 60.3% papers and international collaborations 39.7% papers. Articles with international collaboration appeared in higher impact factor journals than those in domestic collaboration, and were also cited more significantly. Prakasan[10] analysed India's strength and weaknesses in collaborative research and observed an increase in the number of international collaborative publications from 4.56% in 1991 to 22.77% in 2010. Basu and Kumar[11] estimated the extent of collaboration in Indian science publications and found an increase in collaborations both in terms of output. Significantly higher impact factor was

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associated with internationally coauthored papers in several disciplines. Garg and Dwivedi[12] analysed collaboration pattern for Japanese Encephalitis (JE) and found JE as a highly collaborative discipline judged by the value of co-authorship index and collaborative coefficient for different countries and different sub-disciplines. Gupta and Karisiddappa[13] studied collaboration patterns in population genetics and found that highly productive authors are also highly collaborative and the focus of collaboration is shifting from local to domestic to international. Garg and Padhi[14] analysed collaboration patterns in laser science and technology and found that most papers had bilateral domestic and international collaboration. China, Israel, the Netherlands and Switzerland had higher share of internationally collaborated papers. Shrivats and Bhattacharya[15] forecast that in 2020 the number of internationally collaborated publication of India would double to 30,213, as compared to the number of collaborative papers in 2012.

Objectives: The specific objectives of this study were: (i) To identify the type of co-authorship pattern and the strength of co-authorship by calculating co-authorship index (CAI) and collaborative coefficient (CC) for prolific countries. (ii) To examine the pattern of collaboration in various sub-disciplines of MBC research and to examine changes if any in two blocks of 2005–2009 and 2010–2014. (iii) To examine the pattern of growth of collaborative research papers during 2005–2014 and in two blocks of five years each using domestic and international collaborative index for the prolific countries. (iv) To examine the pattern of collaboration in prolific institutions using collaborative coefficient.

Methodology

Science citation index expanded (SCI-E) was used for the present collaborative assessment of global MBC research. The data consisted of 4168 papers published on different aspects of male breast cancer (MBC) research during 2005–2014, used by Dwivedi *et al.*[16] in their study on scientometric assessment of the global output in MBC. The downloaded data was enriched with the count of total author and type of collaboration (local, domestic and international). Papers authored by three and four authors were denoted as multiauthored papers and the papers with more than four authors as mega authored papers.

Indicators used for measuring co-authorship and collaboration

Indicators used for measuring co-authorship and collaboration are as follows:

Collaborative coefficient (CC): CC suggested by Ajiferuke[17] is based on fractional productivity defined by Price and Beaver[18]. It is represented by the following formula:

$$\mathrm{CC} = 1 - \frac{\sum_{j=1}^{K} (1/j) F_j}{N},$$

where F_j is the number of j authored research papers; N the total number of research papers published and K is the greatest number of author per paper. CC tends to zero if single-authored papers dominate and to $1 - 1/j$ if j-authored papers dominate. This implies that higher the value of CC, higher the probability of multi or mega-authored papers.

Co-authorship index: This index suggested by Garg and Padhi[14] is obtained by calculating proportional output of single-, two-, multi- and mega-authored papers for different nations and for different sub-specialties of MBC. This is similar to the one suggested earlier[19–21]. $\mathrm{CAI} = \{(N_{i-j}/N_{io})/(N_{oj}/N_{oo})\} \times 100$, where N_{ij} is the number of papers having j-authors from country i; N_{io} the total output of country i; N_{oj} the number of papers having j-authors from all countries; N_{oo} the total output for all countries and $j = 1$, 2, (3, 4) and (>5). Here 'all' implies all the countries included in the study. $\mathrm{CAI} = 100$ implies that a country's co-authorship effort for a particular type of authorship corresponds to the world average. $\mathrm{CAI} > 100$ reflects higher than average co-authorship effort, and $\mathrm{CAI} < 100$ lower than average co-authorship effort by that country for a given type of authorship pattern. The measure is different from what has been suggested by Bordons[22].

Domestic collaborative index (DCI): Domestic collaborative index is measured by calculating proportional output of domestically co-authored papers. For calculating DCI, papers written in local and domestic collaboration have been added together.

$$\mathrm{DCI} = [(D_i/D_{io})/(D_o/D_{oo})] \times 100,$$

Here D_i is the number of domestically co-authored papers for country i; D_{io} the total output for country i; D_0 the number of domestically co-authored papers from all countries and D_{oo} is the total output for all countries. Here 'all' implies all countries included in the study.

International collaborative index (ICI): The value of ICI has been obtained by calculating proportional output of internationally co-authored papers.

$$\mathrm{ICI} = [(I_i/I_{io})/(I_o/I_{oo})] \times 100,$$

I_i is the number of internationally co-authored papers for country i; I_{io} the total output for country i; I_o the number of internationally co-authored papers for all countries and I_{oo} is the Total output for all countries. Here 'all' implies

Table 1. Authorship pattern of MBC research output for prolific countries

Country	Single-authored papers (CAI)	Two-authored papers (CAI)	Multi-authored papers (CAI)	Mega-authored papers (CAI)	Total	Collaborative coefficient (CC)
USA	60 (164)	108 (120)	327 (115)	703 (89)	1198	0.75
PRC	1 (13)	9 (47)	35 (58)	209 (125)	254	0.83
Italy	2 (27)	5 (28)	22 (39)	212 (134)	241	0.84
Germany	3 (42)	19 (108)	57 (103)	155 (101)	234	0.79
Japan	6 (96)	3 (19)	21 (43)	175 (130)	205	0.82
UK	7 (117)	21 (142)	64 (137)	105 (81)	197	0.75
Canada	2(43)	17 (149)	43 (119)	90 (90)	152	0.77
Australia	3 (81)	6 (66)	44 (154)	68 (85)	121	0.77
Turkey	1 (28)	5 (56)	36 (129)	76 (98)	118	0.80
France	4 (114)	15 (174)	16 (59)	80 (106)	115	0.77
India	4 (115)	11 (128)	44 (163)	55 (73)	114	0.74
South Korea	3 (103)	4 (55)	14 (62)	75 (119)	96	0.80
The Netherlands	3 (114)	7 (108)	19 (93)	57 (101)	86	0.77
Taiwan	1 (39)	6 (94)	11 (55)	67 (120)	85	0.81
Spain	1 (41)	1 (17)	16 (84)	62 (118)	80	0.82
Brazil	0	6 (108)	12 (68)	56 (115)	74	0.81
Sweden	0	5 (104)	20 (132)	39 (93)	64	0.79
Denmark	2 (115)	5 (117)	15 (111)	35 (93)	57	0.76
Greece	0	4 (93)	9 (67)	44 (117)	57	0.82
Iran	2 (124)	5 (126)	19 (151)	27 (77)	53	0.74
Other 71 countries	22 (127)	51 (120)	165 (123)	329 (88)	567	0.56
Total	127	313	1009	2719	4168	0.82

Table 2. Pattern of authorship in MBC research during two blocks of 2005–2009 and 2010–2014

Period	Single-authored papers (CAI)	Double-authored papers (CAI)	Multi-authored papers (CAI)	Mega-authored papers (CAI)	Total	Collaborative coefficient (CC)
2005–2009	65 (125)	145 (113)	434 (105)	1068 (96)	1712	0.76
2010–2014	62 (83)	168 (91)	575 (97)	1651 (103)	2456	0.78
Total	127	313	1009	2719	4168	

all countries included in the study. The value of DCI or ICI = 100 indicates that a country's collaborative effort corresponds to world average, DCI or ICI > 100 reflects collaboration higher than world average and DCI or ICI < 100 reflects collaboration less than world average.

Results and analysis

Co-authorship index and collaborative coefficient for prolific countries

Table 1 shows the pattern of authorship of prolific countries in MBC research. The value of CC for the countries listed in Table 1 is 0.82. This implies that the field of MBC research is highly collaborative as the value of CC is close to 1. The value of CC for Peoples Republic of China (PRC), Italy, Japan, Turkey, South Korea, Taiwan, Spain, Brazil and Greece ranged between 0.80 and 0.84 and is almost close to the global value. Data presented in Table 1 also indicates that all these countries except Turkey had higher values of CAI for mega-authored papers, whereas for Turkey the highest value of CAI was for multi-authored papers. The value of CC was less than the global value of CC for the remaining countries. For these countries, the value of CAI was higher either for single- or two- or multi-authored papers. For instance, the maximum value of CAI for USA was for single-authored papers.

We also examined how the pattern of co-authorship has changed during two blocks: 2005–2009 and 2010–2014 (Table 2). Results indicate that in absolute terms the number of two-, multi- and mega-authored papers has increased in the second block of 2010–2014 as compared to the first block of 2005–2009. However, the values of CAI for single-, two- and multi-authored papers have decreased in the second block when compared to the first block. The reverse has happened in the case of mega-authored papers. This also resulted in slight increase of CC in the second block as compared to the first block.

Co-authorship index and collaborative coefficient for various sub disciplines

Data was analysed to examine the pattern of co-authorship in different sub-disciplines of MBC. Results

Table 3. Subject-wise authorship pattern

Sub-discipline	Single-authored papers (CAI)	Two-authored papers (CAI)	Multi-authored papers (CAI)	Mega-authored papers (CAI)	Total	Collaborative coefficient (CC)
S1	37 (76)	100 (81)	354 (88)	1141 (108)	1632	0.79
S2	15 (148)	34 (132)	91 (108)	201 (91)	341	0.75
S3	9 (106)	29 (134)	80 (112)	169 (91)	287	0.76
S4	16 (191)	31 (146)	70 (100)	165 (90)	282	0.74
S5	3 (42)	8 (44)	60 (100)	171 (109)	242	0.81
S6	13 (186)	17 (96)	62 (106)	143 (94)	235	0.75
S7	4 (68)	15 (100)	48 (97)	132 (103)	199	0.78
S8	1 (18)	6 (43)	41 (90)	136 (114)	184	0.82
S9	1 (20)	6 (46)	24 (56)	141 (127)	172	0.83
S10	10 (219)	14 (120)	45 (118)	85 (85)	154	0.73
S11	3 (66)	16 (139)	45 (119)	88 (89)	152	0.77
S12	2 (47)	15 (140)	34 (97)	91 (99)	142	0.78
S13	3 (72)	9 (85)	31 (89)	97 (107)	140	0.79
S14	7 (179)	8 (80)	30 (92)	87 (102)	132	0.76
Other 80 subjects	59 (106)	157 (111)	512 (111)	1139 (94)	1867	0.77
Total	183	465	1527	3986	6161*	

*The total output is more than the actual output as several journals are classified in more than one sub-field. S1, Oncology; S2, General and internal medicine, research and experimental medicine, emergency medicine, legal medicine, tropical medicine, integrative and complementary medicine; S3, Public, environmental and occupational health; S4, Endocrinology and metabolism; S5, Surgery; S6, Pharmacology and pharmacy; S7, Biochemistry and molecular biology; S8, Radiology, nuclear medicine and medical imaging; S9, Genetics and heredity; S10, Obstetrics and gynaecology; S11, Toxicology; S12, Pathology; S13, Neuroscience and neurology and S14, Cell biology.

Table 4. Number of papers published in domestic and international collaboration in two blocks

Blocks	Papers in domestic collaboration (%)*	Papers in international collaboration (%)*	Total** (%)
2005–2009	1660 (33.3)	313 (6.3)	1973 (39.6)
2010–2014	2604 (52.3)	405 (8.1)	3009 (60.4)
Total	4264 (85.6)	718 (13.4)	4982 (100)

*Figures in parentheses indicate percentage of total. **Paper published is more than the actual number because several papers have domestic as well as international collaboration.

indicate that the values of CC for different fields varied between 0.73 and 0.83 (Table 3). It indicates that the discipline of MBC is highly collaborative.

The values of CC for S9 (genetics and heredity), S8 (radiology, nuclear medicine and medical imaging) and S5 (surgery) are almost equal. This is also reflected by higher value of CAI for mega-authored papers in these sub-fields. This is because radiology, nuclear medicine and medical imaging as well as surgery are the backbone for treatment of any type of cancer. Scientists working in medicine are exploring new ways to treat diseases making use of genetics and heredity.

Pattern of growth of domestic and international collaborative papers during 2005–2014

We have also examined the volume of domestically and internationally co-authored papers during 2005–2014. Result shows that of the total papers, 15% were non-collaborative and the rest were written in collaboration. Table 4 presents the distribution of papers published in domestic and international collaboration during two blocks of 2005–2009 and 2010–2014. It indicates that out of total collaborative papers, 40% published in the first block of 2005–2009. Of these, 33% were with domestic collaboration and the remaining 7% with international collaboration. In the second block of 2010–2014, there was a slight increase in the share of domestic and international collaborative research papers and these constitute about 60% of the total collaborative research papers. Of these, the papers published in domestic collaboration were about 52% and the rest (8%) were with international collaboration. It was found that the share of both domestically as well as internationally co-authored papers reached a peak in the last two years, i.e. 2013–2014 (Figure 1). The share of domestically co-authored papers published in these two years is 1169 (27.4%) of the total domestically published papers. Similar trend was observed for internationally co-authored papers. About

Table 5. Local, domestic and international collaboration among different prolific countries

Country	LCP*	DCP*	Total	DCI	ICP*	ICI	Total
USA	629	662	1291	104	156	75	1447
PRC	133	123	256	102	38	90	294
Italy	129	157	286	102	43	91	329
Germany	90	117	207	93	52	139	259
Japan	104	112	216	106	22	64	238
UK	56	116	172	91	50	156	222
Canada	73	84	157	92	43	149	200
Australia	58	81	139	100	23	99	162
Turkey	72	56	128	113	4	21	132
France	43	69	112	98	22	114	134
India	34	37	71	105	8	70	79
South Korea	44	59	103	110	6	38	109
The Netherlands	40	48	88	89	28	167	116
Taiwan	62	72	134	111	7	34	141
Spain	37	42	79	103	11	85	90
Brazil	36	48	84	101	13	93	97
Sweden	28	33	61	83	25	202	86
Denmark	21	31	52	78	26	231	78
Greece	27	29	56	106	6	67	62
Iran	29	34	63	110	4	41	67
Other 71 countries	229	280	509	93	131	142	640
Total	1974	2290	4264		718		4982

*LCP, Local collaborative papers; DCP, Domestic collaborative papers; ICP, International collaborative papers.

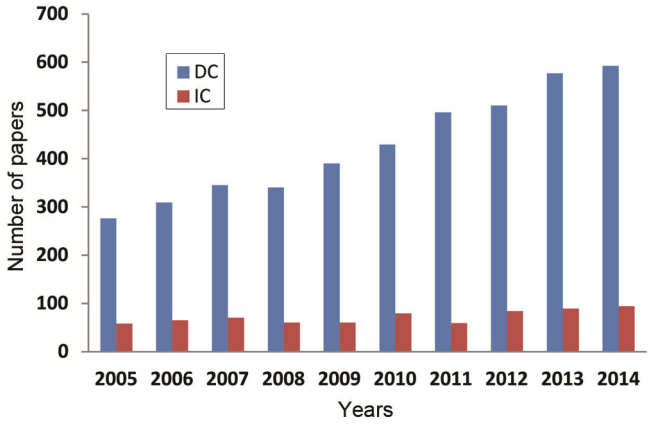

Figure 1. Distribution of domestic and international collaborative output during 2005–2014.

25.9% of the total internationally co-authored papers were published during the last two years.

Domestic and international collaborative profile according to different nations

Table 5 shows the number of papers for each country written in local, domestic and international collaboration besides the values of domestic collaborative index (DCI) and international collaborative index (ICI). It indicates that of the 4982 papers, 1974 are with local collaboration, 2290 papers with domestic collaboration and 718 papers with international collaboration. The papers written in domestic collaboration are almost three times the number of papers written in international collaboration. This pattern of domestic collaboration is similar to that of Japanese Encephalitis[12]. Among the countries listed in Table 5, USA had the highest (30%) share of papers written in domestic collaboration followed by Italy (7%), PRC (6%), Japan (5%) and Germany (5%). Of these countries, Germany had a low value of DCI implying that domestic collaboration in MBC is low. USA also had the highest (22%) share of internationally collaborative papers. The value of ICI for several countries namely Denmark, Sweden, the Netherlands, UK, Canada and Germany is more than 100, implying that these countries have higher international collaboration compared to other countries listed in Table 5.

Collaborative coefficient of prolific institutions

Table 6 lists 17 highly prolific institutions along with the value of collaborative coefficient. Of these, 10 institutions are from USA, two from Canada, one each from Germany, South Korea, PRC, Italy and Sweden. The value of CC for 10 institutions namely University Roma La Sapienza (Italy), Nanjing Medical University (PRC), Seoul National University (South Korea), Massachusetts General Hospital (USA), John Hopkins University (USA), Mayo Clinic (USA), Memorial Sloan Kettering Cancer Centre (USA), University Texas MD Anderson Cancer Centre (USA), National Cancer Institute (USA) and University of Toronto (Canada) was more or close to the global value of CC. This indicates that the prolific institutions had maximum contribution in mega-authored papers resulting in high values of CC.

Table 6. Highly collaborative institutions

Institutions	Collaborative coefficient (CC)
National Cancer Institute (USA)	0.81
University Texas MD Anderson Cancer Centre (USA)	0.82
Harvard University (USA)	0.74
Karolinska Institute (Sweden)	0.77
University of Toronto (Canada)	0.80
Nanjing Medical University (PRC)	0.86
University Roma La Sapienza (Italy)	0.87
Mayo Clinic (USA)	0.81
Memorial Sloan Kettering Cancer Centre (USA)	0.81
Duke University (USA)	0.69
Brigham Women Hospital (USA)	0.77
John Hopkins University (USA)	0.82
McGill University (Canada)	0.78
Seoul National University (S. Korea)	0.86
German Cancer Research Centre (Germany)	0.79
Massachusetts General Hospital (USA)	0.83
University California, San Francisco, (USA)	0.65
Global CC	0.82

Conclusion

The study explored the pattern of co-authorship and collaboration among different countries engaged in MBC research using different co-authorship and collaboration indicators. It is observed that except single-authored papers other types of authorships like two-, multi- and mega-authored papers increased in the second block compared to the first block. The value of CAI decreased in case of single, two and multi-authored papers in second blocks. The global value of CC is 0.82 indicating that MBC research is highly collaborative. Several European countries including Peoples Republic of China has more or equal values of CC as the global value of CC. The study indicates that the value of CC for S9 (genetics and heredity), S8 (radiology, nuclear medicine and medical imaging) and S5 (surgery) are almost equal. This is also indicated by the highest value of co-authorship index for mega-authored papers in these sub-fields. The lowest value of CC is for S10 (obstetrics and gynecology). Most of the prolific countries indicate a low value of domestic collaborative index. However, several countries showed a high value of international collaborative index showing a preference for international collaboration. Of the 17 prolific institutions, 10 institutions had high values of CC indicating a preference for collaboration.

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