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Pattern of Collaboration in the Discipline of Japanese Encephalitis

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ABSTRACT

An analysis of 2074 papers indexed by Science Citation Index-Expanded and published by different countries on various aspects of Japanese Encephalitis (JE) during 1991 to 2010 indicates that JE is a highly collaborative discipline as judged by the values of co-authorship index and the collaborative coefficient for different countries and different sub-fields. Of the total published papers, about two-third were written in collaboration. Of these, 214 (10 %) were written with local collaboration, 700 (34 %) with domestic collaboration and 478 (23 %) with international collaboration. Among all the countries, USA is the most important partner country for all the collaborating countries. The study indicates that the share of collaborative papers increased almost four times in 2001-2010 as compared to 1991-2000. USA, Japan, Taiwan and India produced about 70 % of domestically co-authored papers. USA also had the largest number (21 %) of the internationally co-authored articles. Among 17 highly collaborative institutions, the highest (six) are from India, and Liverpool University (UK) had the highest number of internationally collaborative papers, followed by Centre of Disease Control and Prevention (USA).

Keywords: Japanese encephalitis, collaboration, domestic collaborative index (DCI), international collaborative index (ICI), co-authorship index (CAI)

1. INTRODUCTION

Modern research demands an ever widening range of skills and is no longer a pursuit of an individual. Keeping this in view, Governments in different countries are taking initiatives to enhance contacts among scientists through collaborative research programs, both at the national and international levels. Such initiatives have resulted in increased collaborations at national and international levels. For instance, the share of papers written by authors located in two or more different institutions rose from about 33 % in 1981 to 50 % in 1995, while the total papers rose by about 20 %. During the same period, the share of co-authored papers rose from about 6 % to 15 %[1].

According to Beaver & Rosen[2] collaboration came forward in response to professionalisation and increased knowledge. Because of this, there has been an increasing trend towards collaboration in almost all fields of science and technology. However, the extent of collaboration and their rate of growth vary from one subject to another, one branch to another branch of the same subject and from one country to another country.

Collaboration in research can take a variety of paths. Based upon the type of participants, their status, and location, etc., collaboration can broadly be classified into three categories. These are local, domestic and international collaboration. A local collaboration occurs when two or more scientists of the same institute working in different divisions work together while a domestic collaboration occurs when two or more scientists from the same country engaged in different institutions come together and international collaborations takes place when two or more researchers from different countries join hands to solve a problem. Among these, the international collaboration has received the maximum attention. International scientific collaboration is particularly advantageous for less advanced countries but also beneficial for highly industrialised countries[3].

2. REVIEW OF LITERATURE

In the past several studies dealing with collaboration at national and international level have been published in literature. For instance, Basu & Kumar[4] estimated the extent of international scientific collaboration of India for the period 1990-1994, using Science Citation Index (SCI) and found an increase in collaboration both in terms of output and the extent of network and impact. Prakasan[5], *et al*. have also observed that India's share in international collaborative publications

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have grown from 4.6 % in 1991 to 22.8 % in 2010. Gupta[6], *et al*. studied India's scientific collaboration with South Asian countries and found that India had strong collaborative links with Bangladesh as compared to Pakistan, Nepal and Sri Lanka. Gupta & Karisiddappa[7] studied collaboration patterns in the specialty of population genetics and found that highly productive authors are also highly collaborative and the focus of collaboration is shifting from local to domestic and international collaboration. Garg & Padhi[8] analysed collaboration in laser science and technology and found that most of the papers had bilateral domestic and international collaboration. China, Israel, the Netherlands and Switzerland had higher share of internationally collaborated papers. He[9] examined international collaboration of G7 countries with China and found that US was the major collaborator of China among all the G7 countries.

3. OBJECTIVES OF THE STUDY

The present paper investigates the trends of collaboration in Japanese Encephalitis (JE). The JE is a zoonotic disease caused by an arbovirus and is transmitted by Culex mosquitoes, which particularly breed in flooded rice fields. The disease is transmitted to man by the bite of infected mosquitoes. The clinical manifestations of the disease are rapid onset of high-grade fever, headache, neck stiffness, disorientation, coma, seizures, spastic paralysis, and death. The fatality rate varies between 10-40 % and those who survive do so with several neurological complications. In areas where the JE virus is common, encephalitis occurs mainly in young children, but can also affect adults. The JE is a leading cause of viral encephalitis and a significant cause of disability in Asia with 30,000-50,000 clinical cases reported annually. The distribution of JE is linked to irrigated rice production combined with pig rearing. Vaccine for JE is available since 1940 but, has not reached in many poor countries of Asia, because of the lack of awareness of the disease and its cost. An inexpensive live-attenuated vaccine is used in China, but is not available elsewhere.

In an earlier study[10], the authors analysed 2074 papers published on different aspects of Japanese Encephalitis (JE) during 1991 to 2010 and found that the output came from 62 countries of which 14 countries contributed about 90 % of the total output. The highest number of publications came from USA, followed by India. The output increased manyfolds since 1991 except a significant dip in 2005. These papers appeared in 501 journal titles, which originated from 29 different countries. 87 % of the total output was concentrated among 15 sub-disciplines and the remaining in other 53 sub-disciplines. Highest output (18 %) was in the sub-discipline of virology. Among the prolific institutions, the publication output of institutions from the USA and Taiwan had higher impact as compared to other countries. All the prolific Indian institutes had a low impact. The present paper investigates the trends of collaboration in JE.

Scientific collaboration has been measured using different parameters. The specific objectives of the study are to:

- Identify the type of co-authorship pattern to calculate co-authorship index and to measure the strength of co-authorship among different nations using collaborative coefficient (CC) suggested by Ajiferuke[11];
- Identify the pattern and magnitude of collaboration in different sub-specialties of JE and to study if it has changed in two blocks of 1991-2000 and 2001-2010;
- Study the pattern of growth of collaborative research papers during 1991-2010 and how it has changed in two blocks of 1991-2000 and 2001-2010;
- Identify the magnitude and pattern of local (within the same institute), domestic (within the same country) and international collaboration and to measure the domestic and international collaborative index for the identified nations;
- Identify the most prolific institutions having collaboration and the type of their collaborations.

4. DATA AND METHODOLOGY

The Science Citation Index Expanded (SCIE), a product of Thomson Reuters (formerly Institute of scientific Information, USA), was used as the source of data for the present study. The keyword used for downloading the data was 'Japanese Encephalitis' in the topic field for the period 1991-2010. The search strategy yielded 2402 records that dealt with different aspects of JE research. From these downloaded records, 162 records were removed that were published as biography, meeting abstracts, corrections, editorial, news items, proceedings, reprints and book reviews. Of the remaining 2240 records, 166 records did not contain sufficient information like name of the institution and country and hence were not included in the analysis. Thus, the total number of papers included in the analysis was 2074 published by different countries. Bibliographic details for each record included author(s) and their affiliation. Data was later enriched with the count of total authors, type of collaboration (local, domestic and international). Papers contributed by 3 or 4 authors were clubbed together as multi-authored and the rest with more than 4 contributors as mega authored papers. Indicators used for measuring co-authorship and collaboration have been described as:

4.1 Collaborative Coefficient (CC)

The measure has been suggested by Ajiferuke[11] and is based on fractional productivity defined

by Price and Beaver[12]. It is given by following formula:

$$CC = 1 - \frac{\sum_{j=1}^{k} \left(\frac{1}{j}\right) F_j}{N}$$

Here, *Fj* denotes the number of *j* authored research papers*; N* denotes total number of research papers published; and *k* is the greatest number of authors per paper.

According to Ajiferuke[11], CC tends to zero as single authored papers dominate and to 1-1/*j* as *j*-authored papers dominate. This implies that higher the value of CC, higher the probability of multi or mega authored papers.

4.2 Co-authorship Index (CAI)

This has been suggested by Garg & Padhi[8] and is obtained by calculating proportional output of single, two, multi and mega-authored papers for different nations and for different sub-specialties of JE. The methodology is similar to one suggested by Price[13] and used to calculate Activity Index (AI) suggested by Frame[14] and elaborated by Schubert and Braun[15].

$CAI = \{(N_{ij}/N_{io})/(N_{oj}/N_{oo})\}x100$

where,

N_{ij} = Number of papers having *j*-authors from country *i*,

N_{io} = Total output of country *i*,

N_{oj} = Number of papers having *j*-authors from all countries,

N_{oo} = Total output for all countries and

j = 1, 2, (3, 4), and (>5)

Here, 'all' implies all the countries included in the study.

CAI = 100 implies that a country's co-authorship effort for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort, and CAI < 100 lower than average co-authorship effort by that country for a given type of authorship pattern. The measure is different than what has been suggested by Bordons[16].

4.3 Domestic Collaborative Index (DCI)

This measure is obtained by calculating proportional output of domestically co-authored papers. For calculating DCI, papers written in local and domestic collaboration have been added together.

$DCI = \{(D_i/D_{io})/(D_o/D_{oo})\}x\ 100$

where,

D_i = Number of domestically co-authored papers for country *i*,

D_{io} = Total output for country *i*,

D_o = Number of domestically co-authored papers from all countries,

D_{oo} = Total output for all countries.

Here, 'all' implies all countries included in the study.

4.4 International Collaborative Index (ICI)

The value of ICI has been obtained by calculating proportional output of internationally co-authored papers.

$ICI = \{(I_i/I_{io}) / (I_o /I_{oo})\}\ x100$

where,

I_i = Number of internationally co-authored papers for country *i*,

I_{io}= Total output for country *i*,

I_o = Number of internationally co-authored papers for all countries,

I_{oo}= Total output for all countries.

Here, 'all' implies all countries included in the study.

The value of DCI or ICI = 100 indicate 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.

5. RESULTS AND DISCUSSIONS

5.1 Co-authorship Index and Collaborative Coefficient for Different Nations

Table 1 presents the distribution of output by single, two, multi, and mega-authored papers besides the values of the CAI and CC for each country. The average value of CC for JE is 0.68. This implies that the collaborative pattern in the field of JE is characterised by co-authored papers and not by single authored papers. Table 1 indicates that Japan, Taiwan, China, Thailand, South Korea and Brazil had more than average value of CC (0.68). It implies that these countries must have higher values of CAI either for multi or mega-authored papers. Table 1 indicates that of the above listed six countries, Japan, China, Thailand and South Korea had the highest values of CAI for mega-authored papers while Taiwan and Brazil had the highest value for multi-authored papers. Among all the countries listed in Table 1, Singapore and Germany had the lowest value of CC. This is also reflected by the high values of CAI for single authored papers.

Authors also calculated how the pattern of co-authorship has changed during two blocks i.e. 1991-2001 and 2001-2010. The results of the analysis are given in Table 2. It indicates that in absolute terms the number of multi and mega authored papers have increased significantly in the second block of 2001-2010 as compared to the first block of 1991-2000. However, as reflected by the values of CAI for different type of authorship pattern for two blocks, there appears to be no significant change in the pattern of co-authorship during the two blocks of study. This is also reflected by the values of CC which are same for both the blocks.

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

results of the analysis are presented in Table 3. It indicates that the highest value of CC is for S12 (public, environmental and occupational health). This is also indicated by the highest value of co-authorship index for mega authored papers within this sub-field. The lowest value of CC is for S13 (neurosciences and neurology) and this is confirmed by the highest values of co-authorship index for

Table 1. Authorship pattern of research output in JE 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	47 (168)	78 (118)	108 (84)	251 (96)	**484**	0.64
India	10 (47)	67 (135)	142 (146)	146 (74)	**365**	0.67
Japan	7 (44)	32 (87)	60 (83)	173 (117)	**272**	0.71
Taiwan	1 (10)	13 (59)	53 (123)	95 (108)	**162**	0.73
Australia	4 (46)	26 (130)	45 (114)	73 (91)	**148**	0.69
China	1 (23)	2 (19)	12 (59)	61 (148)	**76**	0.76
England	8 (182)	18 (175)	16 (79)	34 (83)	**76**	0.62
Thailand		9 (101)	14(80)	43 (120)	**66**	0.73
S. Korea	3 (89)	2 (25)	8 (52)	45 (143)	**58**	0.73
France	5 (154)	8 (105)	19 (127)	24 (79)	**56**	0.64
Austria	4 (198)	2 (42)	11 (118)	18 (95)	**35**	0.65
Singapore	10 (540)	3 (69)	7 (82)	13 (75)	**32**	0.49
Brazil	2 (144)	1 (31)	7 (110)	14 (108)	**24**	0.72
Germany	3 (246)	3 (105)	9 (161)	6 (53)	**21**	0.59
Other	15 (130)	17 (62)	40 (76)	127 (118)	**199**	0.69
Total	**120**	**281**	**551**	**1123**	**2074**	**0.68**

Multi-authored (papers with 3 & 4 authors), mega-authored (papers with >4 authors) CAI- co-authorship index

Table 2. Pattern of authorship in JE during two blocks of 1991-2000 and 2001-2010

Period	Single-authored papers (CAI)	Two-authored papers (CAI)	Multi-authored papers (CAI)	Mega-authored papers (CAI)	Total	Collaborative coefficient (CC)
1991-2000	27 (97)	71 (98)	146 (105)	278 (98)	**522**	0.73
2001-2010	84 (101)	216 (101)	407 (97)	845 (101)	**1552**	0.73
Total	**111**	**287**	**553**	**1123**	**2074**	

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	23 (74)	73 (94)	156 (101)	341 (104)	**593**	0.70
S2-S6	21 (71)	68 (91)	151 (104)	320 (104)	**560**	0.70
S7-S9	28 (111)	65 (104)	108 (88)	276 (104)	**477**	0.68
S10	28 (135)	55 (104)	94 (91)	221 (101)	**398**	0.67
S11	15 (118)	29 (91)	59 (91)	141 (104)	**244**	0.68
S12	4 (37)	15 (57)	39 (74)	146 (128)	**204**	0.74
S13	18 (195)	30 (131)	57 (125)	70 (71)	**175**	0.62
S14	5 (67)	22 (118)	38 (101)	77 (98)	**142**	0.69
S15	5 (67)	23 (124)	46 (124)	68 (88)	**141**	0.68
Other 53 subjects	29 (128)	64 (111)	134 (118)	209 (88)	**436**	0.66
Total	**176**	**444**	**882**	**1868**	**3370**	**0.68**

*The total output is more than the actual output as several journals are classified in more than one sub-discipline; S1 Virology, S2-S6 Microbiology; biotechnology and applied microbiology; biochemistry and molecular biology; cell biology; genetics and hereditary, S7-S9 Tropical medicine; research & experimental medicine; general & internal medicine, S10 Immunology, S11 Infectious diseases, S12 Public, environmental & occupational health, S13 Neurosciences and neurology, S14 Veterinary sciences, S15 Entomology.

single and two authored papers. For the remaining sub-disciplines the value of CC is almost equal to the average, which again indicates that the field is characterised by co-authored papers.

5.2 Pattern of Growth of Domestic and International Collaborative Papers

Authors also analysed how the volume of domestically and internationally co-authored papers changed during the period of study. Table 4 presents the distribution of papers published in domestic and international collaboration during 1991-2000 and 2001-2010. It indicates that during the first decade (1991-2000) only about 14 % papers appeared as a result of collaborative research. Of these 10 % were in domestic collaboration and the remaining 4 % in international collaboration. In the later decade there was a steep rise in the share of domestic and international collaborative research papers and these constitute about 53 % of the total research output. Of these, the share of domestic papers was about 34 % and the rest were in international collaboration. Data indicates that the share of both domestically as well as internationally co-authored papers reached a peak during 2008-2010. The share of domestically co-authored papers published in these three years is about 30 % of the total domestically published papers. Similar trend is observed for internationally co-authored papers and the share of internationally co-authored papers during last three years is about 40 % of the total internationally co-authored papers. Fig. 1 presents the graphical distribution of the domestically and internationally co-authored papers during 1991-2010 which also indicates a steep rise in domestic and international collaborative papers in the later block.

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

Blocks	Papers in collaboration		Total
	Domestic	International	
1991-2000	207	87	522
2001-2010	707	391	1552
Total	**914**	**478**	**2074**

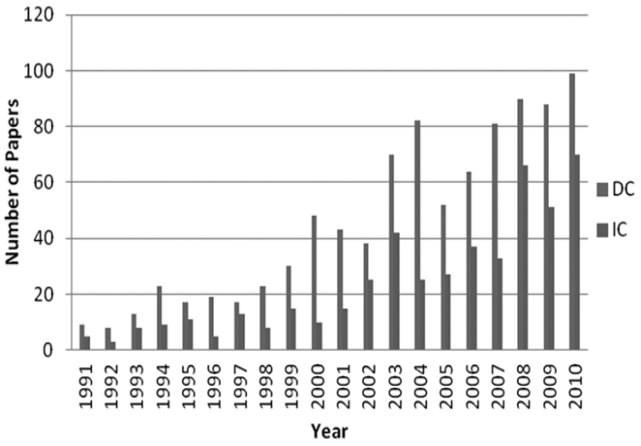

Figure 1. Year-wise distribution of domestic and international collaborative output.

5.3 Domestic and International Collaborative Profile according to Different Nations

The results of Domestic Collaborative Index (DCI) and International Collaborative Index (ICI), besides, the absolute number of papers for each country written in local, domestic and international collaboration are given in Table 5. It indicates that out of 2074 papers published by different nations, about two-third were written with local, domestic and international collaboration. Of these, 214 (10 %) were written with local collaboration, 700 (34 %) with domestic collaboration and 478 (23 %) with international collaboration. The number of papers written in domestic collaboration is almost twice the number of papers written in international collaboration. Similar results have been obtained by Bordons[16] in their study on local, domestic and international collaboration for biomedical research. Among all the countries listed in Table 5, USA had the highest number (25 %) share of domestically co-authored papers followed by Japan (16 %), Taiwan (15 %) and India (14 %). These four countries produced about 70 % of domestically co-authored papers. Among these four countries Taiwan had the highest value of DCI. Austria, Germany and England had the lowest value of DCI, because the share of domestically co-authored papers for these countries is very small.

Further analysis of the raw data indicates that like domestically co-authored papers, USA also had the largest number (21 %) of the internationally co-authored articles. Four European countries namely England, France, Austria and Germany together constituted about 19 % of the internationally co-authored articles. Among these countries England had the highest (12.5 %) share of internationally collaborative papers. Seven Asian countries (India, Japan, Taiwan, China, Thailand, South Korea, and Singapore) together constituted about one-third of the internationally co-authored articles. Among these, Thailand and China had 8 % and 6 % share of internationally co-authored papers. Further analysis of data indicate that England had the highest value of ICI among European countries, while among Asian countries Thailand had the highest value of ICI. Raw analysis of data indicates that among all the countries USA is the most important partner country for all the countries listed in Table 5.

Papers published in local, domestic and international collaboration originated from 679 institutions spread all over the world. Of these 574 (84.5 %) belonged to prolific countries listed in Table 1 and the rest 105 were scattered in other countries. Among the

prolific countries USA had the highest (159) number of institutions followed by India (74), Japan (68), and Australia (51). Table 6 lists 17 highly collaborative institutions. Of these six are from India, three each from USA and Japan, two from Taiwan and one each from England, Thailand, and Australia. Out of 17, 8 are academic institutions and the rest 10 are research institutions. These institutions contributed 366 papers in local, domestic and international collaboration, which constituted about one-fourth of the papers written in collaboration and the rest three-fourth of the papers were produced by remaining

Table 5. Local, domestic, and international collaboration among different nations

Country	Local collaborative papers	Domestic collaborative papers	Total	Domestic collaborative index (DCI)	International collaborative papers	International collaborative index (ICI)	Total papers
USA	64	166	230	108	99	89	**484**
India	38	91	129	81	11	12	**365**
Japan	20	128	148	124	52	83	**272**
Taiwan	26	90	136	191	16	44	**162**
Australia	05	75	80	122	33	97	**148**
China	07	28	35	104	22	126	**76**
England	02	8	10	29	44	251	**76**
Thailand	09	15	24	83	30	197	**66**
S. Korea	07	24	31	120	18	71	**58**
France	05	7	12	48	20	156	**56**
Austria	00	5	5	33	19	236	**35**
Singapore	02	10	12	85	8	108	**32**
Brazil	07	12	19	180	5	91	**24**
Germany	04	3	7	75	7	145	**21**
Other	18	38	56	64	93	203	**199**
Total	**214**	**700**	**914**		**478**		**2074**

Table 6. Highly collaborative institutions

Name of institute	No. of collaborative papers			
	Local	Domestic	International	Total
University of Texas (USA)	25	9	13	**47**
University Queensland (Australia)	2	24	8	**34**
Centre of Disease Control and Prevention (USA)	1	13	16	**30**
Academia Sinica (Taiwan)	5	19	4	**28**
SGPIMS (India)	8	14	2	**24**
Kobe University (Japan)	5	8	11	**24**
National Institute of Infection Disease (Japan)	3	17	3	**23**
Washington University (USA)	13	7	3	**23**
Nagasaki University (Japan)	4	5	13	**22**
Liverpool University (England)	2	1	19	**22**
Mahidol University (Thailand)	3	6	10	**19**
NIMHANS (India)	10	6	1	**17**
National Medical Defence Centre (Taiwan)	6	7	1	**14**
Indian Institute of Science (India)	0	10	2	**12**
Indian Council of Medical Research (India)	1	7	2	**10**
King George Medical College (India)	5	3	1	**9**
National Institute of Virology (India)	1	7	0	**8**
Total	**94**	**163**	**109**	**366**

institutions. Among the institutes listed in Table 6 Liverpool University (UK) had the highest number of internationally collaborative papers followed by Centre of Disease Control and Prevention (USA).

6. CONCLUSIONS

Using different co-authorship and collaboration indicators, the study identified the pattern of co-authorship and collaboration among different countries engaged in Japanese Encephalitis (JE) research. The study indicates that the collaborative pattern in the field of JE is characterised by multi and mega authored papers and not by single authored papers. Only Singapore and Germany had less number of multi and mega authored papers, while Japan, Taiwan, China, Thailand, South Korea and Brazil had more number of multi and mega-authored papers. As judged by the values of collaborative coefficient it is observed that the sub-discipline of public, environmental and occupational health had more number of mega authored papers as compared to other sub-fields. Papers published in domestic collaboration are almost twice the papers written in international collaboration. Proportion of domestically as well as internationally co-authored papers increased significantly in 2001-2010 as compared to 1991-2000. The study also indicates that among all the countries USA is the most partner collaborating country for all countries involved in JE research. Highest numbers of collaborating institutions are from India and Liverpool University (UK) had the highest number of internationally collaborative papers followed by Centre of Disease Control and Prevention (USA).

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